Essays on Climate Change and Adaptation in Developing Countries

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Contents

Introduction 1

Overview of papers and co-authorship 12

Part I: The relationship of climate change, violence and agriculture 13

Paper 1: Genocidal risk and climate change: Africa in the twenty-first century 13

Part II: Behavioral aspects of adaptation in SIDS 43

Paper 2: Gender differences in stereotypes of risk preferences: Experimental evidence from a matrilineal and a patrilineal society 43

Paper 3: Eliciting preferences for public goods in non-monetized communities: Accounting for preference uncertainty 78

Paper 4: Cooperation and punishment patterns in a small-scale society: A comparison between second-party punishment and third-party punishment 103

Eidesstattliche Erklärung 150

Curriculum Vitae 151

Introduction

Climate change is an inevitable and urgent global challenge. According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2014), average global surface temperature has increased by about 0.8 °C between 1880 and 2012. For the 21st century global warming exceeding 2 °C on average relative to the period 1850 - 1900 is projected by most scenario models. The IPCC-report concludes that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

Climate change and sustainable development are closely connected. Climate change is expected to impact the availability of basic needs like freshwater, food security, and energy, while efforts to combat climate change, both through adaptation and mitigation, will similarly inform and shape the global development agenda (UN, 2015). The distribution of climate change impacts and vulnerabilities is considered to be uneven across countries, and low-latitude, less-developed areas are generally at greatest risk due to both higher sensitivity and lower adaptive capacity (IPCC, 2007, 2014). Thus, developing countries will be among those most adversely affected and least able to deal with the anticipated shocks to their social, economic and natural systems (UN, 2015). Moreover, these highly vulnerable countries will carry a greater part of the global costs of climate change although the rising CO_2 emissions are mainly the responsibility of industrialized countries (e.g., Mertz et al., 2009).

To address these issues, the United Nations (UN) aim to define a new vision for a post-2015 development agenda by agreeing upon a set of sustainable development goals (SDGs) at the climate change conference held at the end of the year 2015 in Paris. The proposed SDGs include SDG 13: 'Take urgent action to combat climate change and its impact'. Besides 'strengthen the resilience and adaptive capacity' and 'integrating climate change measures into national policies, strategies and planning', one major target of SDG 13 is to 'promote mechanisms for raising capacity for effective climate change-related planning and management in developing countries, including focusing on women, youth and local and marginalized communities' (see SDG-proposal, UN, 2015).

The United Nations Framework Convention on Climate Change (UNFCCC) and post-2015 development agenda identified five key issues that are relevant for achieving the proposed SDG 13 (see CAFOD, 2014, p. 2-3):

- **Low carbon development:** the aim is to promote low carbon development pathways that will meet the development needs of current and future generations, while at the same time decoupling economic growth from increased dependency on fossil fuel usage and enabling an overall reduction in greenhouse gas emissions.
- **Mitigation:** the primary goal is to agree on legally-binding emission reduction targets. The post-2015 agenda can support mitigation by addressing the way a number of relevant sectors are structured e.g. energy, agriculture or transport, among other sectors.
- **Adaptation, risk and resilience:** the aim is to integrate adaptation, climate resilience and risk management into existing development processes and discussions on poverty, food security, health, resilient cities and infrastructure.
- **Finance:** one of the cornerstones to creating change within a global development framework as well as a binding climate deal is sufficient finance for tackling the massive transitions toward low carbon development and climate resilient development. There is an urgent need for sufficient public funds and innovative sources, as well as private finance.
- **Technology:** the UNFCC calls for technology transfer in "all relevant sectors" and the Rio Declaration emphasizes that countries should cooperate to share scientific and technological knowledge, and enhance development through the transfer of technologies.

In my thesis I address the issue of adaptation, risk and resilience in the context of developing countries. In particular, I provide (1) a better understanding of the macroeconomic relationship of climate change, violence and agriculture and (2) insights into the microeconomic dimension of adaptation, that is, analyzing behavior and related decision making processes of individuals exposed to the risks of climate change.

My thesis consists of two parts. The first part contributes to (1) by providing a literature review of studies explaining certain forms of violence and especially the connections

between climate change and violence as well as an empirical study about the connections of climate variables (temperature and rainfall) and agricultural production in sub-Sahara Africa. The microeconomic dimension of adaptation in (2) is addressed in the second part of my thesis by analyzing case study data from vulnerable small-scale societies in developing countries. In the remaining three papers I use household surveys and economic field experiments to examine people's risk preferences and stereotypes (second paper), people's willingness to pay for local public goods that dampen the adverse effects of climate change (third paper) and underlying mechanisms that promote human cooperation (fourth paper). All three studies focus on decision making processes that are relevant for adaptation and demonstrate that societal and cultural characteristics of a society and the respective economic system are key drivers of human behavior.

The behavioral research of the second part of my thesis can be broadly categorized into two groups: (1) Artefactual field experiments, which are the same as conventional lab experiments but with a non-standard subject pool (second and fourth paper) and (2) framed field experiments/questionnaires, which are identical to artefactual field experiments but with field context in either the commodity, task, or information set that the subjects use (third paper) (see Harrison and List, 2004). The main advantage of doing experiments with a non-standard subject pool is to improve the external validity of findings that are based on participants from Western, educated, industrialized, rich and democratic (WEIRD) societies (see Henrich et al., 2010). Moreover, Henrich et al. (2010) make a compelling argument that conditions in tribal societies are relatively novel within evolutionary history and that data from non-Western small-scale societies are essential for testing hypotheses about human psychology, especially in the domains of preferences and decision-making. The findings of this thesis contribute to the origins of human decision-making processes and, therefore, are of general interest for the scientific community.

Part I of the thesis

Agriculture is an important sector for many developing countries, contributing more than a fifth to their gross domestic product and employing more than a quarter of their total labor force (World Bank, 2012). The vulnerability of the agricultural sector to both climate change and variability is well established in the literature (see IPCC, 2014). Moreover, climate change will have significant impacts on the forms of migration that compromise human security (see IPCC, 2014), and several studies already have shown that climate change increases the risk of violent conflict (e.g., Barnett and Adger, 2007; Burke et al., 2009; Hsiang et al., 2013). However, an empirical study about the relationship of climate change and the risk of genocide is missing so far.

In the first paper, *Genocidal risk and climate change: Africa in the twenty-first century* (Exenberger and Pondorfer, 2014), my co-author and I provide a literature review of studies explaining certain forms of violence and especially the connections between climate change and violence as well as an empirical study about the connections of climate variables (temperature and rainfall) and agricultural production in sub-Sahara Africa. Further, we also provide an assessment of institutional risk factors given the historical record of sub-Sahara African states with respect to genocide and projections about the future development of agricultural production for the first half of the twenty-first century to also assess environmental risk. In doing, so we are able to identify countries of joint risk (mainly countries in the Great Lakes and the Horn of Africa region). To successfully prevent the occurrence of genocides, research, policy, and activism will have to join forces to identify the places and groups at risk and address these risks by, for example, raising the costs of violence, improving dispute settlement, and identifying viable alternatives.

Part II of the thesis

Small Island Development States (SIDS) in the South Pacific and in the Indian Ocean are particularly threatened by impacts of future climate change and associated triggered coastal processes. Scientific evidence for an increased frequency and severity of storms

and storm surges as well as sea level changes in connection with climate change continuously augments (e.g., IPCC, 2014) and international discussions about the need for adaptation measures gain momentum (UN, 2015).

To combat climate change, people living in SIDS face many challenges including the decision to invest in adaptation strategies. Each of these adaptation strategies are associated with different risk levels since the benefits and outcomes are uncertain to the local population. To provide optimal adaptation strategies, it is then essential to understand how people make decisions under risk and uncertainty and, further, to analyze the underlying factors that determine people's risk attitudes. In the context of small-scale societies it is particularly important to consider the different role of men and women in the adaptation process (see SDG 13; UN, 2015). In many traditional small-scale societies, women often face social, economic and political barriers that limit their adaptive capacity. Often these barriers are based on cultural specific stereotypes of women's behavior. Beyond statistical discrimination, incorrect stereotypes further worsen suboptimal decision making and the associated welfare and efficiency losses. This is especially so when stereotypes are internalized, thus lowering the self-esteem and confidence of the stereotyped group (Correll, 2001; Crocker and Major 1989; Jones et al., 1984; Rosenberg, 1979). So far, no study exists that investigates gender differences in stereotypes of risk preferences in a small-scale society.

In the second paper, *Gender Differences in Stereotypes of Risk Preferences: Experimental Evidence from a Matrilineal and a Patrilineal Society* (Pondorfer et al., 2014.), I, together with my co-authors, use cross-cultural data collected from controlled economic field experiments to examine gender differences in risk preferences and, more importantly, stereotypes about risk preferences of men and women. To assess the importance of culture for gender differences we collected data from two island societies that are very similar along many important dimensions (i.e., climate conditions, economic system, educational level, etc.) but have opposite cultures when it comes to women's social status: the patrilineal Palawan in the Philippines and the matrilineal Teop in Papua New Guinea. We find no gender differences in actual risk preferences, but evidence for culture-specific stereotypes. We are the first to show that men from a patrilineal society (the Palawan)

overestimate women's actual risk aversion and men from the matrilineal society (the Teop) underestimate women's actual risk aversion. Hence, men in both societies use female sex as a significant signal for risk preferences, but in opposite directions. In the context of adaptation to climate change, these findings suggest that particular attention should be given to women's adaptive capacities. For example, since men in traditional societies often rely on women in terms of food provision, biased perceptions of women's risk level could lead to wrong assumptions about future food supply.

Besides individual risk preferences, it is important to understand how people value certain adaptation strategies and in what form they can contribute to them. Some elements of adaptation to climate change response are, in effect, public goods. In the context of SIDS, these include, for example, conservations of important habitats, implementation of storm protection or building dams to combat sea level rise. The concept of valuation is a prominent method in environmental and resource economics to measure the value of these public goods. The motivation for valuation studies is to generate a better and more comprehensive informational base for the policy formulation and decision taking process. One fundamental question when valuing public goods in developing countries is the choice of the appropriate payment vehicle. Since regular cash-income does not exist for the majority of the population and market integration is low, households in rural areas have less experience with monetary exchanges. In these cases labor time may be a more appropriate payment vehicle. A common finding of studies using labor time as payment vehicle is that households are more often willing to contribute working time as compared to money (see Gibson et al., 2015 for a recent overview). However, so far empirical evidence is missing if the labor time elicitation format reduces respondent's uncertainty of contributions.

In the third paper, *Eliciting preferences for public goods in non-monetized communities: Accounting for preference uncertainty* (Pondorfer and Rehdanz, 2015), my co-author and I use household data collected from a field survey to analyze and compare uncertainty of people's stated willingness to contribute (WTC) time and money for a local public good in a non-monetized small-scale community in Papua New Guinea. We do so by establishing an open-ended method for eliciting people's WTC, the Range-WTC-

method, which elicits the upper and lower bound of a person's WTC. We find that uncertainty is reduced when respondents are asked for labor time contribution instead of monetary contributions. Thus, we provide empirical evidence that, indeed, labor time is preferred to money in the elicitation of stated WTC in non-monetized communities.

Public goods are characterized as non-excludable and non-rivalrous, and thus, are subject to the free-rider problem. In the context of adaptation this means, that people may benefit from the implementation of local adaptation measures without contributing to its implementation (conservation of e.g., natural habitats or construction of e.g., sea walls). In order to successfully implement local adaptation strategies which appear in the form of public goods, it is then particularly relevant to understand the underlying mechanisms of human cooperation.

According to evolutionary and economic theories, humans, like other animals, are expected to behave selfishly, maximizing material gains for themselves (Alexander, 1987; Dawkins, 2006; Fehr and Fischbacher, 2003). Nevertheless, human cooperation occurs in all known societies and is common between genetically-unrelated individuals and where repeated interactions may be uncommon. Altruistic punishment is one of the most prominent theories that have been proposed to explain the existence of human cooperation. Altruistic punishment is based on the idea that individuals exhibit strong reciprocity (Gintis, 2000; Fehr and Gächter, 2002; Fehr et al., 2002). That is, individuals are willing to cooperate with others and to punish defectors, at a personal cost, even when it is implausible to expect that these costs will be repaid. In a cross-cultural project Henrich et al. (2006) showed that individuals in small-scale traditional (e.g., foragers) as well as large-scale complex societies (e.g., college students) engage in second-party punishment (punish as active party) and third party punishment (punish as by standers). It is proposed that second-party punishment may be sufficient to explain cooperation in small-scale societies, while third-party punishment is a necessary condition if a society becomes more complex (Marlowe et al. 2008, 2010). However, the focus of these studies is on costly punishment with respect to deviations of a distribution norm across these societies. None of the conducted experimental economic games is adequate to examine the level of cooperation in the form of a collective action problem (e.g.,

prisoner's dilemma in its simplest form). Further, they neglect the issue of anti-social punishment (i.e., punishment of cooperators). The existence of anti-social punishment is correlated with the lack of norms of civic-oriented behavior (Herrmann et al., 2008). Anti-social punishment may then be widespread in small-scale societies where norms of civic cooperation are weak, and thus, should be considered when investigating the effectiveness of altruistic punishment in maintaining cooperation.

In the fourth paper, *Cooperation and punishment patterns in a small-scale society: A comparison between second-party punishment and third-party punishment* (Pondorfer, 2015) I use data from a controlled field experiment to compare second-party punishment and third-party punishment and, further, to address the issue of anti-social punishment in a small-scale community in Papua New Guinea. I find that second-party punishment promotes cooperation significantly more than third-party punishment in the context of a collective action problem. The data provides also evidence that third-party punishment is even destructive since the level of cooperation drops below the baseline condition in which punishment mechanisms are not existent. Furthermore, the data reveals that anti-social punishment is endemic and seems to have a spiteful component. For the successful implementation of adaptation strategies, this means, that local characteristics and respective social norms should be taken into account before requesting individuals in small-scale communities to contribute to a local public good of any form.

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Overview of papers and co-authorship

This thesis includes the following four articles (current publication status of working papers in square brackets):

Exenberger, A., and Pondorfer, A. (2014). Genocidal risk and climate change: Africa in the twenty-first century. *The International Journal of Human Rights*, *18*(3), 350-368.

Pondorfer, A., T. Barsbai, & Schmidt, U. (2014). Gender differences in risk preferences and stereotypes: Experimental evidence from a matrilineal and a patrilineal society *Management Science*, forthcoming.

Pondorfer, A., & Rehdanz, K. (2015). Eliciting preferences for public goods in non-monetized communities: Accounting for preference uncertainty (No. 2010). *Kiel Working Paper*

Pondorfer, A., (2015). Cooperation and punishment patterns in a small-scale society: A comparison between second-party punishment and third-party punishment, *mimeo*.

Each co-author contributed significantly to the concept, design and content of the articles.

Part I: The relationship of climate change, violence and agriculture

Paper 1: Genocidal risk and climate change: Africa in the twenty-first century[1]

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Abstract

Climate change is often related to various adverse effects, among those are endangering food security and raising the risk of conflict. Some scholars go as far as identifying climate change as the main driver of civilizational crisis. But empirical evidence is rather inconclusive so far, particularly about its relationship to violence, and even more so, genocide. In this paper, we provide a literature review of studies explaining certain forms of violence and especially the connections between climate change and violence as well as an empirical study about the connections of climate variables (temperature and rainfall) and agricultural production in sub-Sahara Africa. Further, we also provide an assessment of institutional risk factors given the historical record of sub-Sahara African states with respect to genocide and projections about the future development of agricultural production for the first half of the twenty-first century to also assess environmental risk. In doing so, we are able to identify countries of joint risk and promising directions of further research. In this context, we chose sub-Sahara Africa as our focus area for various reasons: firstly, because of widespread poverty, institutional weakness and dependence on rain-fed agriculture, sub-Sahara Africa is the macro region where the effects of climate change will very likely play out most adversely; further, it also assembles a pronounced historical record of violent conflict, notably including genocidal episodes; finally, mutual enforcement and endogeneity issues are particularly viable there, not the least in the form of a large potential impact of technological and institutional improvements.

Keywords: Genocide, Climate Change, Sub-Sahara Africa, Institutions, Agriculture
JEL classification: O13, Q54, Q10, N47

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1. Introduction

In 2007, timely connected to the Stern report on the economics of climate change and the fourth assessment report of the International Panel on Climate Change (IPCC) (Stern, 2006; IPCC, 2007), Jürgen Zimmerer stressed the issue of 'environmental genocide' in an editorial of the *Journal of Genocide Research* and called for a 'fresh and wider look at the causes of genocide' (Zimmerer, 2007, p. 350). Because works about climate and genocide remain nevertheless scarce, debate is still necessary, given the potential large-scale effects of climate change on societies world-wide, especially on poor regions lacking adaptive capacities and characterized by low opportunity costs of violence. For example, the United Nations Development Program (UNDP) predicted '[m]ajor losses in agricultural production leading to increased malnutrition and reduced opportunities for poverty reduction. Overall, climate change will lower the incomes and reduce the opportunities of vulnerable populations. … Developing countries are likely to become more dependent on imports from the rich world, with their farmers losing market shares in agricultural trade' (UNDP, 2007, p. 90). But overall, while there is no doubt among scientists that accelerated climate change (especially global warming) is taking place and wide compliance that there is a considerable anthropogenic component to it, scientifically sound agreement has not thus far been achieved either about the relationships between observed changes and more complex environmental processes (like the occurrence of storms, for example) or of any related social processes.

One of the most distressing social processes is genocide. As basic understanding of this violent act, we glean from the UN Genocide Convention of 1948 (intended destruction, in whole or part, of a national, ethnical, racial or religious group) with two relevant extensions: first, we limit our interest to mass killings and neglect other forms of genocidal violence (like the destruction of culture or systematic discrimination); secondly, we also add political groups as potential targets of violence (a phenomenon usually referred to as 'politicide'). Thus, we end up with a practical understanding of 'genocide' as geno- and/or politicidal mass killings. Further, because of the crucial role of intentionality, we usually observe genocide as a policy choice, more viable under certain conditions (particularly polarizing forces), sometimes even being 'disturbingly

rational' (Anderton, 2010). Consequently, while ideology plays an important role and psychopathic perpetrators have their place in genocide studies, most of the time people solved conflicts without turning to genocide, mainly because it simply did not make sense as a promising strategy from the viewpoint of potential perpetrators. Thus, the influence of climate change altering the framework in which political strategies are placed becomes increasingly relevant. In this context, we understand climate change as anthropogenic, continuous and sustainable warming (rise in average surface temperature) with associated phenomena (sea level rise, more frequent and more severe droughts and other extreme weather events, generally enlarged weather variability, etc.), which is increasing the relevance of water availability and hence the role of rainfall especially in rain-fed subsistence agriculture. While climate change may result in extreme weather events, it is itself a long-run trend originating in the industrial revolution and increasingly effective in the last half-century.

In theory, direct and indirect causal links between climate change and conflicts are manifold (Buhaug et al., 2008; Zhang et al., 2011; Scheffran et al., 2012). It is often claimed that a changing climate will induce armed conflicts connected to increasingly scarce resources and flows of refugees from desertification and sea level rise. It is likely however, that there is a relationship between food security and violence; however, such a relationship is likely to be complex, strongly related to distributional and marginalization patterns and nonlinear. As Gleditsch (2012, p. 6) puts it, 'the effect plays out in interaction with exogenous conflict-promoting factors'. Thus, it is hardly a surprise that empirical research about the conflict-climate-nexus is not able to provide clear evidence. Quite the contrary, results are either inconclusive (sometimes to the point of counterevidence) or sceptical about connections (remaining statistically insignificant). Hence, there is indeed a need of further research of all kinds: cross-country, case studies and systemic analysis. Our largely empirical contribution brings two strands of empirical literature together: the study of mass violence and climate change and the study of the effects of climate change on agricultural production and hence results in a comparative assessment of institutional and agricultural risks on a country-basis. Although this work is essentially explorative and it is not possible to predict genocides from its results (also because of the large relevance of contingency in

this context), this will allow us both to look at a certain kind of combined danger and, thus, to contribute to genocide prevention by identifying countries where potential scarcity induced crisis (a climate-related decrease of agricultural production) correlate with institutional factors of genocidal violence (regime types and forces of path-dependence).

Overall, the relationship between food security and violence is complex, strongly related to distributional and marginalization patterns, nonlinear, and self-enforcing. Further, while political and socio-economic factors are likely to be more relevant than climatic ones, there is especially a considerable and often overlooked combined risk. At the same time, projections are very sensitive to assumptions about technological development and to political and economic improvements. This paper aims to contribute to all these issues. In this context, we choose sub-Sahara Africa (SSA) as our specific case for two obvious reasons: first, it is a macro region with a diverse history of mass violence; second, its agricultural potential will be most negatively affected by climate change. Although the factors of influence regarding the investigated relationships are complex and not at all African 'by nature' (but much more linked to specific patterns of colonial extraction, prominently land use patterns, export-oriented production, and the discrimination of certain population groups), they are particularly related to a high degree of vulnerability, connected with poverty and bad governance which result in a lack of resilience on the local and national level (UNDP, 2007). Further, climate-change-related losses are suggested to be especially substantial in the case of smallholder farmers, still dominating SSA agriculture, where both cash-crop and subsistence production will be affected, limiting the capacity to achieve and sustain food security by a loss of available revenue as well as a loss of food. Finally, expert assessments support special emphasize on Africa. The geno-/politicide database of the Political Instability Task Force (PITF), for example, contains 128 out of 273 country-years from Africa, constituting fifteen postcolonial SSA episodes.[1] Further, the NGO Genocide Watch provides a more extended list with more than a third of all cases after 1945 being from Africa. This also holds for their most recent 'countries at risk'-list, published in April

[1] See the PITF homepage, especially http://www.systemicpeace.org/inscr/PITF GenoPoliticides 2014.xls.

2012: three out of nine 'extermination' cases are from SSA (Congo Kinshasa, Somalia, Ethiopia), as well as six out of eleven 'preparation' cases (Nigeria, Chad, Equatorial Guinea, Congo Brazzaville, Central African Republic, Guinea Bissau).[2] In sum, if there is a problem, it is very likely that it is urgent and relevant to Africa and this contribution provides information about which cases deserve or even require a second, more detailed look.

This analysis proceeds as follows: the next section provides a review of studies about mass violence and especially on connections with climate change; in the following section, we assess genocidal risk as the correlation between agricultural risk (the projection of increased food insecurity based on an cross-country analysis of the influence factors of agricultural production in SSA) and institutional risk (vulnerabilities related to political, economic and conflict-related factors); finally, we draw some conclusions and provide an outlook with respect to further research, which is especially necessary in the form of comparable in-depth case studies (while this paper is largely about quantitative cross-country evidence). These conclusions confirm that the understanding of the issue is still insufficient, but that it is very likely that vulnerability is self-enforcing, that the interplay of political, socio-economic and climate factors is especially relevant, and that results are very sensitive to assumptions about technological development. What is beyond the scope of this paper, however, is a detailed assessment of the impact of colonial patterns, particularly of land use, although these issues are certainly relevant to explain differences in vulnerabilities to climate change dynamics.

2. The empirics of mass violence and climate change

2.1 Quantitative cross-country studies about mass violence

There is a large and ever-increasing body of empirical literature about factors influencing the vulnerability to or the outbreak, intensity and duration of mass violence (sometimes in a binary form on the basis of conflict-years, sometimes in the continuous form of probabilities). A growing cottage industry of data mining and processing about

[2]See the Genocide Watch homepage, especially http://genocidewatch.net/alerts-2/new-alerts/. The Central African Republic has recently been added to the list of emergencies.

conflicts has developed over the previous decades. Works begin from rather different perspectives, such as the study of interstate or civil war, of geno- and politicides, or of what Rummel (1994) termed 'democide'. The factors usually stressed encompass the economy (greed versus grievance), politics (autocracy versus democracy), demography (young men), culture (ethnic, linguistic, or religious fragmentation), geography (insurgency promoting terrain), and ideology (communism or racism) (e.g., Krain, 1997; Collier and Hoeffler, 1998; Fearon and Laitin, 2003; Busby et al., 2013). In a recent quantitative cross-country civil war study, Collier et al. (2009) summarize and recall influencing factors usually found to carry explanatory power: besides poverty and primary commodity exports (where nonlinearity and endogeneity have to be considered), they particularly find peace (long times of peace between episodes of war), social fractionalization (actually linguistic and religious), and the implicit French security umbrella (being a former colony of France) to be statistically significant factors. Besides identifying and quantifying these factors of influence, the general and empirically well-grounded conclusion from this work is that civil war dynamics usually are more driven – from the perspective of (potential) rebels and in reaction thus also the governments – by appropriating resources than by overcoming injustice.

Quantitative studies about genocide have learned from these kinds of exercises. In her path-breaking study about political upheaval escalating (or not) into geno-/politicide between 1955 and 2001, Harff (2003) departed from the challenge 'to identify general conditions under which governments, and rival authorities in internal wars, choose such a strategy' and identified six risk factors, which in combination raise the probability of escalation from about 3 percent (in absence of all risks) to about 90 (in presence of all six).[3] Harff's (2003) risk factors include a history of prior genocide, an exclusionary ideology from the elite, an autocratic government, a ruling elite from an ethnic minority, low trade openness, and a high magnitude of political upheaval. There is also a swing effect, most dramatically observed in Rwanda and Burundi: 'Case studies suggest that the more intense the prior struggle for power and the greater the perceived threat the

[3] But there is large uncertainty and the 95%-confidence interval in the presence of all risk factors is ranging from 67 to 98 %. However, Harff (2003) was also able to 'postdict' episodes (genocides and non-genocides alike) with a remarkable accuracy of 74 %.

excluded group poses to the new regime, the more likely they are to become victims of geno-/politicide' (Harff, 2003, p. 61). Finally, active discrimination against ethnic minorities contributes importantly to an explanation of the emergence of ethnic conflicts but much less to an explanation of why these conflicts escalate to genocide. However, there are also missing suspects in Harff's (2003) narrative: particularly poverty, which is relevant for upheaval but seemingly not for its escalation, external political links, which seem to be dominated by economic considerations, analysis of any colonial heritage, and a discussion about the relevance of post-colonial extractive patterns.

Easterly et al. (2006) analyze the influence of income and (Western style) democracy levels in 163 episodes of mass killings of unarmed civilians from 1820 to 1998. Generally, the results show that the occurrence and especially the number of victims increase with a decrease in income; this occurs to an even greater degree in cases of (Western style) democracy though, in their analysis, the relationship with democracy is subject to several important qualifications (about data quality, statistical significance, and causal relationships). In their words: 'We find that episodes of mass killing are more likely at intermediate levels of income and less frequent at the highest levels of democracy' (Easterly et al., 2006, p. 146). In an excellent review of the democide- and the geno-/politicide-literature by Wayman and Tago (2010) the focus is on the onset of mass killings and the role of military governments. These authors also provide a methodological discussion about the implications connected to the respective datasets and definitions. They also raise doubts about the relevance of political indicators, especially in case of geno-politicides. In this context, case study evidence is more reassuring: a qualitative comparative study of Rwanda and Botswana, for example, clearly supports the relevance of political inclusiveness (a democratic mediation of the political process) with respect to genocide occurrence (Mayersen and McLoughlin, 2011). While it is obvious that the discovery of diamonds in Botswana has supported wealth creation in comparison to Rwanda, it is not obvious from the onset that mining diamonds supports wealth dispersion (indeed, resources of this kind had the opposite effect in many other countries); instead, it was the political institutions of Botswana that ensured wealth dispersion.

2.2 The climate-violence nexus

While the empirical literature about violence is able to identify some causal factors, the literature about the relationship between climate change and violence is less conclusive. Barnett and Adger (2007, p. 644) summarize that 'it is important to stress that climate change will not undermine human security or increase the risk of violent conflict in isolation from other important social factors'. A more recent and more detailed study explicitly shows that for civil wars in Africa, climate related factors are at best marginal compared to socio-economic, political, and geographic factors: 'there is no direct, short-term relationship between drought and civil war onset, even within contexts presumed most conducive to violence. At the same time, the analysis solidifies claims of recent scholarship on the importance of ethnically inclusive institutions for maintaining peace' (Theisen et al., 2011, p. 105).

On the other hand, given the high vulnerability of African societies to the forces of climate change, especially with respect to agricultural production (due to limited capacity in general and the large relevance of rain-fed agriculture in particular), one may go as far as comparing the African present with the European past. In this context, some scholars have claimed that climate change, via its impact on agro-economic systems, was the main driver of social and political upheaval in Europe between 1500 and 1800, peaking in the 'crisis of the seventeenth century' (Zhang et al., 2011; Tol and Wagner, 2010).[4] This is in line with claims in the IPCC assessment report of 2007 and the Human Development Report of 2007-08 regarding more recent connections. These reports suggest that a loss of agricultural potential of 16.6 % is predicted for SSA until the year 2080, even if potential positive effects from carbon fertilization are taken into account (these numbers are fully in line with our results). Further, regional impacts are diverse, although positive outcomes on the country level remain a rare exception in Africa applying only to Egypt and possibly Kenya (see Cline, 2007).

Nonetheless, endogeneity remains an issue, and not just a technical one, because socio-economic development is strongly linked to adaptation capacity. While industrialization

[4] Tol and Wagner (2010) also found that conflict was more likely in Europe in periods of cooling, but less likely so in the industrial era.

contributes (or at least has contributed) to growth and democracy (on the local level) and to climate change (on the global level), it also increases the resources available and improves the capacity for adaptation to its adverse effects, although with considerable distributional consequences.[5] Consequently, no effect of climate change on economic growth is found in countries with an income above the global median, while the impact is large in countries below the median, thus strongly affecting most of SSA (Dell et al. 2008). Further, democracies are better able to organize environmental protection (Li and Reuveny, 2006). Additionally, these dynamics give way to vicious or virtuous circles of mutual enforcement. Devitt and Tol (2012, p. 141) conclude that the 'the impact of civil war and climate change … are sufficiently strong to keep a number of countries in Africa in deep poverty with a high probability'. Two particular channels of negative influence have been pointed out: a deterioration of public resources to support the population and a reduction of the opportunity costs of rebellion. Particularly, 'armed conflict is more likely to occur in states where existing institutions and mechanisms for conflict resolution cannot provide people with the assurance that climate-induced economic problems will be resolved without recourse to violence' (Koubi et al., 2012, p. 117). However, empirically there is only weak support for a mediating effect of political institutions and no support for a direct climate-conflict-nexus via economic growth. Relationships are obviously more complex. Butler and Gates (2012) argue that there is indeed a positive relationship between resource abundance, not scarcity, and conflict, given that there is a 'property rights bias' (differences in the access to property rights); they find that this relationship is intensified if differences in resource endowments are large. By applying a broader concept of conflict, Hendrix and Salehyan (2012) and Miguel et al. (2004) show that large deviations in rainfall result in increased social conflict in Africa; violent conflict is especially correlated to wetter years while non-violent is to drier ones. A particularly relevant factor is the marginal status of a group: 'Environmental issues can be catalysts to low-level conflict in marginalized communities, but the critical factor is the extent of political and economic

[5] Gartzke (2012) argues that industrial development is at the same time promoting climate change but diminishing the likelihood of interstate war.

marginalization. Small, politically insignificant ethnic groups experience most conflicts related to environmental pressures' (Raleigh, 2010, p. 69).

Overall, while there is a complex and rather indirect relationship between climate change and violence, further conditions have to be met to let a situation of stress escalate into large-scale killing and even more so genocide. What most studies have in common is that they stress historical, political and economic reasons for the occurrence of genocide: a history of violence, a rather exclusionary political process, and rather poor and exclusionary economic performance. In this context, a recent work by Busby et al. (2013) seems to be particularly worth mentioning. By using the method of geographically mapping different insecurity risk factors in Africa, mainly on a sub-national level, they are able to show the large differences of vulnerabilities in geographic space and also the clustering of their occurrence. They especially focus on a combination of climatic and socio-economic factors, including both the aggregate and the household levels. Aside from several methodological caveats they extensively discuss in their study, the regions they identify as particularly problematic largely overlap with the countries identified in the rest of this paper.

3. Assessing genocidal risk

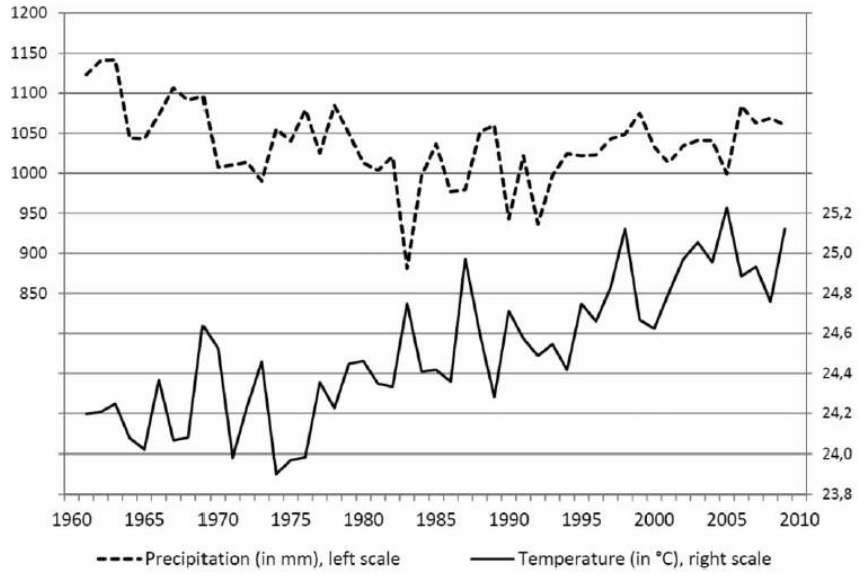
3.1 Agricultural production and climate change in sub-Sahara Africa

We now turn to the effects of climate change on agricultural production in Africa by estimating an agricultural production function including labor, livestock, fertilizer, capital, land, and irrigation as well as precipitation, temperature, and the incidence of droughts as input factors.[6] For the sample period 1961-2009 we assemble 2,190

[6] We estimated the function $\log(Y_{it}) = \beta 0 + \beta 1\log(L_{it}) + \beta 2\log(V_{it}) + \beta 3\log(F_{it}) + \beta 4\log(K_{it}) + \beta 5\log(M_{it}) + \beta 6\log(R_{it}) + \beta 7\log(PRC_{it}) + \beta 8\log(TEMP_{it}) + \beta 9\log(Drought_{it})$, with $\beta 0 = \log(A)$, i.e. productivity, i denoting country and t denoting year. Y represents the agricultural output (measured as the FAO index in value terms), while L, V, F, K, M and R refer to input factors, i.e. labor, livestock, fertilizer, capital, land and irrigation. PRC, TEMP and Drought denote the climatic factors precipitation, temperature and incidence of droughts. Considering the fact that there are unobserved country specific and time varying effects, a two-way error component regression model (two-way fixed effects) is chosen for the analysis. The methodology is based on Solow (1956) and Benhabib and Spiegel (1994). For agricultural production functions see, for example, Hayami and Ruttan (1970), Craig et al. (1997), Fulginiti et al. (2004), and

observations for 46 sub-Sahara African countries.[7] There is considerable variation in all variables and a large degree of heterogeneity across the countries, pointing to the relevance of idiosyncrasies supporting the use of a fixed-effects-model. However, there is also a clear temperature trend and the five-year-average in the period 2005 to 2009 is 0.67 ° Celsius higher than the 30-year-average in the period 1961 to 1990 while rainfall development, unsurprisingly much more volatile, is more U-shaped with particularly bad years in 1983, 1992 and 1990 (see Figure 1).

Figure 1: Mean annual temperature and precipitation in sub-Sahara Africa, 1961-2009



Source: Tyndall Centre for Climate Change Research (2013).

Barrios et al. (2008). A detailed description of the methodology can be found in Exenberger and Pondorfer (2011).

[7] All agricultural inputs are taken from the FAOSTAT database (http://faostat.fao.org/), the agricultural output data Y is measured in international US$, indexed with relation to a base period 2004-06. We newly introduce the variable R, which is irrigated area in thousands of hectares, including areas equipped for full and partial control irrigation, equipped lowland areas, pastures, and areas equipped for spate irrigation. Climate data (normalized average annual rainfall and temperature on country level) is taken from the Tyndall Centre for Climate Change Research and Ian Harris from East Anglia University (http://www.cru.uea.ac.uk/~timm/cty/obs/TYN_CY_1_1.html). Data about the droughts is taken from the international disaster database (http://www.emdat.be/).

Table 1: Agricultural production and climate change in sub-Sahara Africa

Dependent variable: agricultural production; time period: 1961-2009					
VARIABLES	(1)	(2)	(3)	(4)	(5)
Tractors	0.035	0.034	0.034	0.035	0.035
	(0.034)	(0.033)	(0.033)	(0.034)	(0.031)
Fertilizer	0.027 **	0.029 **	0.029 **	0.027 **	0.029 **
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Livestock	0.274 ***	0.265 ***	0.265 ***	0.273 ***	0.265 ***
	(0.043)	(0.042)	(0.042)	(0.043)	(0.043)
Labor	0.298 *	0.300 **	0.302 **	0.301 *	0.262 *
	(0.150)	(0.146)	(0.147)	(0.151)	(0.151)
Land	0.794 ***	0.788 ***	0.786 ***	0.792 ***	0.730 ***
	(0.220)	(0.214)	(0.214)	(0.219)	(0.226)
Irrigation					0.046
					(0.036)
Precipitation		0.159 ***	0.155 ***		0.162 ***
		(0.050)	(0.051)		(0.048)
Temperature		-1.334 *	-1.322 *		-1.222 *
		(0.677)	(0.671)		(0.637)
Drought			-0.016	-0.027 *	
			(0.015)	(0.015)	
Constant	-10.138 ***	-9.996 ***	-9.996 ***	-10.133 ***	-9.283 ***
	(1.818)	(1.740)	(1.739)	(1.813)	(1.844)
No. of observations[a]	1,894	1,894	1,894	1,894	1,894
R^2	0.823	0.829	0.829	0.823	0.831
No. of countries	46	46	46	46	46
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects[b]	Yes	Yes	Yes	Yes	Yes
Cluster	country	country	country	country	country
F-test[c]	23.63	25.02	22.68	21.74	22.36

Notes: robust standard errors in parentheses; ***, ** and * constitute significance at the 1%, 5% and 10% level, respectively.

[a] 296 observations were dropped because of missing data about tractors and fertilizers.

[b] Time effects are significant (Wald test).

[c] The F-test refers to the input variables (time effects and input variables were tested separately).

Table 1 presents the results of the multivariate standard regression, explaining the relevance of production factors influencing agricultural output. In model 1, a standard specification was estimated without climate variables and irrigated area.[8] As expected, all

[8] For other examples of aggregate agricultural production functions in Africa, see for example (Frisvold and Ingram, 1995; Barrios et al., 2008).

inputs have a positive sign (thus are stimulating output), and, except for modern capital (tractors), all inputs are statistically significant with land being particularly relevant. Equally, the coefficient of traditional capital formation (livestock) is higher than the coefficients of modern inputs (tractors, fertilizers); this is linked specifically to investment and educational opportunities. Rainfall and temperature are also significant (although only weakly in case of temperature). Further, in all models testing for rainfall (2, 3 and 5), rainfall emerges as a more relevant factor of production than the modern inputs, underlying the prevalence of rain-fed agriculture. Thus, decreases in rainfall experienced by large parts of sub-Sahara Africa during the sample period reduced agricultural output while the effect of temperature was comparably marginal. There is also the expected negative effect of droughts on production, though this is not significant (despite model 4 when other climate variables are skipped). In model 5, irrigation is also included, but with weak results (to be explained by its little prevalence in sub-Sahara Africa).

3.2 Countries at risk, part I

The PITF database contains fifteen postcolonial episodes of geno-/politicides in sub-Sahara Africa. There are many more contested cases, including most prominently killings in the context of the African World War, the Communist regime in Ethiopia, continuing violence in Somalia and Ethiopia, the Eritrean-Ethiopian war, the Sierra Leonean civil war, and the Mozambiquean war of independence. To avoid discussion about the inclusion of contested cases, we stick to the restricted list of fifteen given in table 2. While there is hardly any doubt that the occurrence of mass violence is much more wide-spread in sub-Sahara Africa than in only these cases, the problem is to identify *intended* and *discriminate* killing, which is indispensably necessary to make it genocidal.

Table 2: Genocidal episodes in sub-Sahara Africa

Episode	duration (years)	killings (total)	brief description
Extreme cases (killings > 10,000 per month)			
Rwanda, 1994	0,3	750,000	Rwandan genocide
Nigeria, 1967-70	2,7	1,225,000	Famishing strategy during Biafra war
Burundi 1993	0,3	48,000	Political struggle by massacre
Burundi 1988	0,1	12,000	Political struggle by massacre
Large cases (killings between 1,000 and 10,000 per month)			
Uganda, 1980-86	5,2	240,000	Anti-opposition government violence
Angola, 1998-2002	3,3	120,000	Civil war related genocidal campaigns
Angola, 1975-94	19,1	546,000	Civil war related genocidal campaigns
Uganda, 1971-79	8,3	216,000	Anti-opposition government violence
Rwanda, 1963-64	0,6	12,150	Civil war related genocidal campaigns
Burundi, 1965-73	8,3	129,750	Hutu-Tutsi political struggle
Smaller cases (killings < 1,000 per month)			
Somalia 1988-91	2,8	29,150	Anti-rebellion government violence
Congo Kinshasa, 1964-65	1,0	6,150	Civil war related genocidal campaigns
Congo Kinshasa, 1977-79	2,8	14,150	Anti-rebellion government violence
Ethiopia, 1976-79	3,5	13,500	Anti-opposition government violence
Equatorial Guinea, 1969-79	10,5	31,300	Anti-opposition government violence

Source: PITF (2012).

Rwanda, Burundi, Angola, Uganda, and Congo Kinshasa faced recurring genocidal violence.[9] The two largest cases presented are also connected to agriculture. In the case of the Rwandan genocide in 1994 (and also Burundi in 1993), there is hardly any doubt that the redistribution of land played a role in the killings, and thus, at least partially also

[9] What we call "genocidal violence" here, is a summary of geno-/politicides according to the PITF definition: "Genocide and politicide events involve the promotion, execution, and/or implied consent of sustained policies by governing elites or their agents […] that result in the deaths of a substantial portion of a communal group or politicized non-communal group. In genocides the victimized groups are defined primarily in terms of their communal (ethnolinguistic, religious) characteristics. In politicides, by contrast, groups are defined primarily in terms of their political opposition to the regime and dominant groups" (see PITF, 2013).

in their motivation.[10] But other factors clearly dominated and, aside from serious population pressure, there is not much sign of a relevant climate-induced deterioration of living conditions before the genocides.[11] Further, in the still heavily contested case of the Biafra war (1967-70), starvation clearly was part of the military strategy of the Nigerian army to break secessionist resistance. Nevertheless, in both cases a factor related to climate became an instrument of, rather than a reason for, of killing.[12]

Based on historical, economic, and political reasons for mass violence, we assemble seven data series (form the years 1975 to 2009) in three categories to characterize SSA countries. The three categories are: (1) the historical record of violence (data on the number of conflict years and average conflict intensities in conflict years); (2) the presence of economic difficulties (data on the number of years in recession, the average contraction in these years, and the 2009 log-level of GDP per capita in PPP$); (3) the presence of political suppression and exclusion (polity2 and polcomp scores, i.e. the degree of autocracy and the level of political competition). An overview of common characteristics of the countries concerned is given in Table 3. The table is already ordered by ascending levels of institutional risk: when all four of these risk factors are present, the country is ranked at the top; where none are present, the country is ranked at the bottom[13].

[10] In an interview study of 340 Rwandan households, it is shown that besides male sex and Tutsi ethnicity also (higher) age and (larger) land ownership was a relevant risk factor for being killed (see Verwimp, 2003). The same is shown for Burundi in 1993 by making use of a representative sample of 7,520 households (see Bundervoet, 2009).

[11] From table 2, only the episode in Burundi, starting in October 1993, had a possible connection to bad weather, not even climate. In October and November 1993, the two first months of the wet season, rainfall fell short by three quarters compared to a 30-year-average.

[12] This may also be the case in Ethiopia in the 1970s and even more in the 1980s, when repression by the Communist regime and secessionist war were also connected to a deterioration of food security.

[13] A factor is regarded as being 'present', when the country performance is below the sample median.

Table 3: Countries at risk in sub-Sahara Africa

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Congo Kinshasa	25	3.6	231	20	-4.0	-5.1	2.4
Djibouti	4	1.0	2,061	21	-2.5	-4.4	3.3
Liberia	13	2.9	397	16	-4.2	-2.8	3.8
Rwanda	10	3.5	1,031	11	1.1	-5.8	1.6
Cote d'Ivoire	6	2.0	1,343	21	-0.4	-6.9	1.7
Mauritania	5	3.0	1,574	15	0.3	-5.9	1.8
Congo Brazzaville	6	2.0	2,220	13	1.1	-4.6	2.4
Uganda	30	2.9	1,152	12	1.2	-3.5	2.9
Burundi	15	3.7	368	20	0.2	-3.1	2.9
Sierra Leone	11	3.0	873	14	-0.3	-2.9	3.0
Ethiopia	21	5.3	684	15	1.2	-3.1	3.4
Nigeria	26	2.0	2,034	18	0.4	-0.9	3.4
Swaziland	0	-	3,440	13	1.3	-9.5	1.2
Eritrea	0	-	592	12	0.8	-6.5	2.0
Gabon	0	-	10,280	19	-1.1	-6.0	2.2
Tanzania	0	-	1,189	10	1.7	-3.8	2.5
Guinea	2	1.0	826	15	-0.1	-4.7	3.3
Cameroon	1	1.0	1,811	13	0.3	-5.9	3.6
Togo	0	-	734	18	-1.7	-4.7	3.6
Burkina Faso	0	-	902	14	1.0	-4.6	3.7
Zimbabwe	12	1.8	143	21	-2.9	-2.1	3.8
Angola	31	6.4	4,754	17	1.7	-4.5	3.8
Chad	24	3.8	1,276	16	0.9	-4.0	3.9
Guinea-Bissau	0	-	818	16	1.5	-2.1	3.7
Central African Republic	6	1.5	648	20	-1.2	-2.3	3.8
Niger	8	1.0	534	19	-0.4	-1.3	3.9
Kenya	6	1.5	1,206	15	0.4	-2.5	4.1
Mozambique	12	6.0	759	12	1.4	-1.7	4.7
Mali	6	1.0	999	11	2.1	0.3	4.9
Senegal	8	1.0	1,492	13	0.5	1.0	7.8
Lesotho	0	-	1,311	13	2.1	-0.3	3.9
Malawi	0	-	653	19	-0.8	-2.3	4.3
Zambia	0	-	1,765	22	-0.5	-1.7	4.4
Comoros	0	-	916	24	-1.1	0.3	4.8
Ghana	2	1.0	1,239	11	1.0	-0.3	5.1
Benin	0	-	1,116	14	0.5	0.4	5.5
Madagascar	0	-	753	20	-0.7	1.1	5.6

Table 3 (Continued)

Cape Verde	0	-	3,779	6	2.9	3.2	5.8
Gambia	1	1.0	1,465	16	1.3	1.7	6.0
Botswana	0	-	8,868	11	4.2	7.0	9.0
Namibia	0	-	4,733	18	0.1	6.0	9.0
Mauritius	0	-	9,484	3	3.6	9.8	9.8

Notes and sources:

(1) conflict years: number of years in 'civil conflict' between 1975 and 2009; MEPV database (Monty G. Marshall, Major episodes of political violence, 1946-2008, http://www.systemicpeace.org).

(2) conflict intensity: average intensity (from a low 1 to a high 10) in these years of 'civil conflict'; MEPV database.

(3) income: GDP per capita in 2009 in PPP$ (base year 2005, using chain rule); PWT database (Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, May 2011, http://pwt.econ.upenn.edu/php_site/pwt_index.php).

(4) recession years: number of years with negative income growth between 1975 and 2009; PWT database.

(5) economic performance: average annual income growth (geometric mean) between 1975 and 2009; PWT database.

(6) democracy: average of the polity2 score between 1975 and 2009, i.e. the difference between the democracy and autocracy score (from an autocratic -10 to a democractic +10); Polity IV database (Monty G. Marshall and Keith Jaggers, Polity IV Project: Political Regime Characteristics and Transitions, 1800-2010, http://www.systemicpeace.org/polity/polity4.htm).

(7) political competition: average of the 'polcomp' score, between 1975 and 2009, which is denoting regulation and competitiveness of political participation (from a low 1 to a high 10); Polity IV database.

Thus, we see that the countries regarded as particularly at risk share a combination of several risk factors: a history of recurring conflict, a large vulnerability to economic crisis, a lack of democracy, and a more exclusive political process, which all raise the risk of violence. And while Djibouti, Côte d'Ivoire, Mauritania, and Congo Brazzaville are certainly debatable (as the 'violence factor' is hardly developed), the overall picture is clear. This is further supported when the occurrence of genocidal episodes (see Table 2) is surveyed: most of these occurrences happened in impoverished countries in some kind of political or economic crisis, while no events (excepting perhaps Uganda in 1980) happened in a democratic environment; further, none happened in times of economic prosperity and only three events occurred under competitive (but highly conflictual) political conditions.

3.3 Countries at risk, part II

For the second part of the risk section, we use our estimation for a projection of agricultural production until 2050.[14] We use the IPCC-SRES scenarios A1B and A2[15] and develop three projection scenarios (see Table 4).[16] Further, we simulate future climate change impacts by using the Hadley Centre Global Environmental Model applied to our data from the Tyndall Centre for Climate Change Research.[17] In the pessimistic scenario, A2, livestock growth is low, agricultural area not expanding, and population increase is fast. Further, elasticities and the stock of modern inputs are fixed (no technical improvements and adaptation). In the more optimistic scenario, A1B, livestock growth is higher, agricultural area enlarges and population growth is lower. The third scenario A1B_TT, finally, allows for irrigation and adaptation by enlarged elasticities (representing the 'technology trend' we added to the base scenario). This scenario is quite visionary, but helps to see how small changes in assumptions affect projections. Finally, model 2 (see Table 1) is used to show how agricultural production will develop under rain-fed conditions in the first two scenarios, while model 5 is taken to catch improvements in the third scenario.

[14] A comparable approach is used by Devitt and Tol (2012), but their story is about civil war and drought risk as well as the effects of civil wars and climate change on economic growth until 2100.

[15] See IPCC (2000). The A1 scenario family assumes a future world of rapid economic growth and convergence, increased interactions and low population growth (A1B referring to a 'balanced' use of fossil and non-fossil sources of energy). The A2 scenario family assumes a heterogeneous world of self-reliance, in which economic growth is slower, but population growth larger.

[16] We use population projections from Gaffin et al. (2004), applying the same quantitative procedure for all countries in our sample. Concerning agricultural land, we apply FAOSTAT data and constant area for the A2 scenario, a continued trend (with respect to the average growth 1990-2010) for the A1B1 scenario, and an accelerated trend (1.5 times the average growth 1990-2010) for the A1B1_TT scenario. Concerning livestock, we apply a linear trend and assume an increase by 50 % until 2050 (with respect to the average stock 2005-09) for the A2 scenario, and an increase by 150 % for the A1B1 and A1B1_TT scenarios. Concerning tractors, fertilizers and irrigation, we assume constant stocks (only in the A1B1_TT scenario, the elasticity of fertilizer and irrigation is constantly increasing to 0.1 in 2050, which is not overly optimistic; because Barrios et al. (2008), for example estimated a coefficient of 0.078 in Asian countries for the use of fertilizers in the period 1961-2000).

[17] Temperature and rainfall projections are calculated as comparisons of 30-year averages (from 14 years before until 15 years after the respective year) with base period averages (1961-90), calibrated with Tyndall Centre for Climate Change Research data. Projections are based on Falloon and Betts (2006), Stott et al. (2006), Johns et al. (2006) and Martin et al. (2006).

Table 4: Summary of the assumptions used for projections

	A2	A1B1	A1B1_TT
Tractor	fixed stock	fixed stock	fixed stock
Fertilizer	fixed stock	fixed stock	fixed stock + increasing elasticity (0.1 in 2050)
Area equipped for irrigation	none	none	fixed area + increasing elasticity (0.1 in 2050)
Livestock	livestock increases by 1.5 (base 2005-09)	livestock increases by 2.5 (base 2005-09)	livestock increases by 2.5 (base 2005-09)
Agricultural area[a]	fixed area (base 1990-2009)	continuing trend (base 1990-2009)	continuing trend with higher growth rate
Population[b]	increasing	less increasing	less increasing
Time effects[c]	constant trend	constant trend	constant trend

Notes and Sources:

[a] In countries with negative annual growth during 1990-2009, the agricultural area was fixed in all three scenarios.

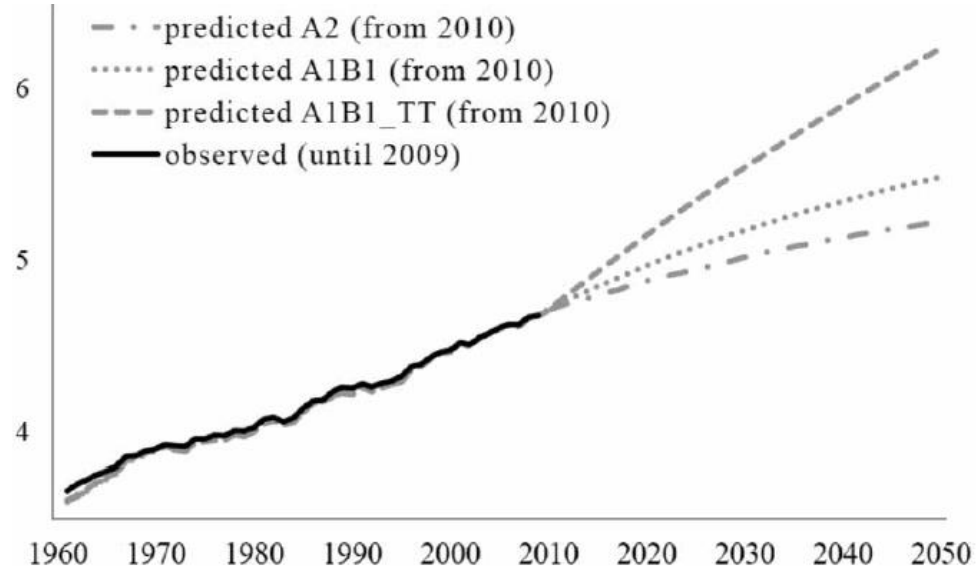
[b] Data for population projections were taken from Gaffin et al. (2004).

[c] Time effects were projected by using a linear spline model with different growth rates prior to 1975 and after 1975: $\beta t = \beta_0 + \beta_1 t + \beta_2(t - 1975)*D_{1975}$, where D_{1975} denotes a dummy variable, which is 1 from 1975 and 0 otherwise; see Schmalensee et al (2008).

As Figure 2 shows, overall production increased from 1961 to 2009. However, simulation results under A2, A1B, and A1B_TT follow different paths. While growth rates are declining in all scenarios over time (by almost half between 2020 and 2050, and respectively one third in the case of A1B_TT), production is increasing rather slowly in A2, faster in A1B, and quickly with adaptation in A1B_TT. Hence, while an expansion of labor power is not very influential, the intensification of the use of even basic technologies strongly impacts food production and, hence, the chances of food security in sub-Sahara Africa regarding average per capita production. This was already mentioned by the IPCC in 2007, which concluded that climate change will further shift the focus of food insecurity to sub-Saharan Africa but also that the impact of the applied socio-economic pathways (SRES scenario) on the numbers of people at risk of hunger is significantly greater than the impact of climate change..[18]

[18] These particular conclusions are made 'with high confidence' in a statistical sense (IPCC, 2007).

Figure 2: Estimated and predicted agricultural production in sub-Sahara Africa (log value index), 1960-2050



Source: own calculations.

Table 5: Average annual growth rates of population and agricultural production in sub-Sahara Africa, 1970-2050

	Population		Production			
	A2	A1B1	observed	A2	A1B1	A1B1_TT
	2010-50	2010-50	1970-2009	2010-50	2010-50	2010-50
Country group with …						
… high vulnerability	2.0	1.6	1.99	1.52	2.18	4.02
… medium vulnerability	1.6	1.3	2.42	1.33	2.10	4.12
… low vulnerability	1.1	0.8	1.83	1.10	1.62	3.56
TOTAL	**1.5**	**1.2**	**2.11**	**1.30**	**1.95**	**3.90**

What is more relevant with respect to risk, however, is a comparison we make by splitting the sample in three groups according to the combined average level of income and food supply between 1998 and 2002.[19] This is done to grasp the country's capacity to meet demands by domestic production and imports (the latter certainly being

[19] The data used to construct a multiplicative index are taken from Angus Maddison (GDP) and FAOSTAT (nutritional energy); see http://www.ggdc.net/MADDISON/oriindex.htm and http://faostat.fao.org/ respectively.

dependent on income). Table 5 reports means of the projection results for these three groups, the first being the group with the highest vulnerability (i.e. with rather low levels of GDP per capita and nutritional energy supply per head per day).

All reported numbers are to be taken with great caution because projections contain many uncertainties. But the general trends are clear: the rather pessimistic A2 scenario produces unfavorable results for all groups (the least for the countries with low vulnerability), pointing to an increasing risk in the future; the rather optimistic A1B scenario, on the other hand, points to improvements in all groups and large improvements in the A1B_TT scenario. However, when country-level data is investigated, certain countries of particular risk can be identified. Under the A2 scenario, most countries will likely face a deterioration of food supply on a per capita level and this is the more the case, the worse the situation in the country already is. But some regions face this problem also under the A1B scenario, most notably Angola (where only 77 % of population growth is met by increased production), Somalia (87 %), and Congo Kinshasa (89 %).

Two further caveats are necessary. The first is that in all cases distribution is crucial because, while production would in many countries be sufficient to assure food security, malnourishment is prevalent due to unbalanced access. Take the obvious example of Angola, a relatively wealthy country: if the income generated by its rich resources were more equally distributed, current and foreseeable food insecurity problems could completely vanish. The second caveat is that no matter which scenario is applied, technology is absolutely crucial and could result in significant improvements. However, as confirmed by our analysis, this does not mean that it's necessary for Africa to achieve a high-tech agro-industry; in order to achieve food security, it would be sufficient to apply appropriate techniques to improve yields in a low-tech- and small-scale-farming environment.

4. Conclusions and outlook

A qualitative summary of our overall results is given in Table 6. The risks are denominated as 'high', 'high-medium', 'medium', and 'low' respectively. The order of countries reflects the risk classes, a preference for empirically well-grounded institutional risk within these classes, and, finally, a comparative assessment of idiosyncratic factors. All countries not mentioned in this list do not come up with more than medium risk in no more than one of the two dimensions.

Table 6: Institutional and environmental risks in sub-Sahara Africa in the twenty-first century

	Institutional risk	Environmental risk
Congo Kinshasa	high	high
Somalia	high-medium[a]	high
Liberia	high	medium
Angola	medium	high
Burundi	high-medium	high-medium
Ethiopia	high-medium	high-medium
Mauritania	high-medium	medium
Sierra Leone	high-medium	medium
Uganda	high-medium	medium
Chad	medium	high-medium
Eritrea	medium	high-medium
Djibouti	high	low
Rwanda	high-medium	low
Nigeria	high-medium	low
Côte d'Ivoire	high-medium	low
Congo Brazzaville	high-medium	low
Burkina Faso	medium	medium
Guinea	medium	medium
Madagascar	low	high-medium
Zambia	low	high-medium

Notes:

[a] In the case of Somalia, we lack comparable data with respect to the institutional risk factors; hence, we assessed the risk to be 'high-medium' for obvious reasons (Somalia being a failed state affected by various historical and ongoing inter- and intra-national conflicts).

We draw three conclusions from these results. First, understanding relationships between climate change and violence, very probably transmitted via socio-economic

tensions and political moderation, is still insufficient. It is likely, however, that there is a relationship between food security and violence, but it is also likely that this relationship is complex, strongly related to distributional and marginalization patterns, and nonlinear. Our results also confirm that those countries already vulnerable to violence will most likely remain so and their relative position may deteriorate because of adverse dynamics. Further, communities so marginal that they are virtually invisible and hence not reflected in comparative quantitative data (to which this study was restricted) may be particularly affected. When looking at the presence of risk factors from the perspective of potential perpetrators, it is highly likely that the costs of adaptation to climate change are high compared to the political and economic costs of violence and particularly of genocide.

Secondly, evidence clearly shows that climatic factors are very unlikely to influence the outbreak, intensity, and duration of violence directly, while political, and socio-economic factors are much more relevant. However, because of the interference of state capacity there is a considerable combined risk. Increasingly adverse effects from climate change, such as a deterioration of food security, and its negative consequences for economic growth and institutional quality, which are also empirically better grounded, may lead to a vicious cycle resulting in certain forms of violence possibly resulting in genocidal episodes. Feasibility also plays a role in genocides, in the sense that the larger the magnitude of political upheaval, the greater the willingness to take 'extreme measures' and the opportunity to seek 'final solutions' (Harff, 2003; Krain, 1997).

Thirdly, projections of future agricultural production, in the peripheral environment of SSA the most relevant factor for political stability and economic prosperity directly affected by climate change, are very sensitive to assumptions about technological development, which are consequently crucial. Thus, there is much to be gained even from low-tech improvements. Development, especially in poor countries, would considerably change the actual outcome and peace-building efforts may even completely offset negative effects of climate change. But the complex interaction and the relevance of feasibility also allow for a specific corridor (at a low level) of development, in which the risk of violent outbreaks may increase. Equally, the experiences of past decades raise

concerns about a proper utilization of agricultural technologies and good governance practices in Africa – but not because of African backwardness, but because of the rational decisions of people confronted with specific challenges, existential constraints, and very diverse incentive structures. In the end, the developmental path a country or a society follows, including the degree of violence in general or the occurrence of genocide in particular, is crucially dependent on individual and collective decisions made by the stakeholders involved (including the international community), providing – or denying – the means to combat adverse developments and the effects of climate change.

Hence, further research is necessary; the study of climate change and violence is only just beginning. We would especially welcome comparative case studies of the countries at risk identified in this study and systematic work willing to prudently generalize insights from these studies,[20] as well as further interdisciplinary collaborative quantitative cross-country analysis. While case studies are particularly relevant because they allow a more detailed look at the actual means of transmission of climate change to the probability of conflict and genocide, among those the ones identified by cross-country analysis, the crucial factors moderating transmissions are institutional and not necessarily idiosyncratic (Hofmann, 2014). Therefore, we also need institutional approaches to comparatively analyze the effects of climate change on the political and socio-economic sphere and further on the outbreak and continuation of organized and unorganized violence. In particular, we need interdisciplinary studies about threshold conditions and baseline shifts. We also need studies at the largest systemic level to understand how the international system and the global economy affect climate change and the means of adaptation and how these dynamics interact with local patterns (Kent, 2014). Finally, better data is welcome in all these fields, especially more decentralized and nuanced data on institutions of land-use and the settlement of conflict.

Overall, when facing climate change, violence is not a first-best-solution on the societal level, but it may be rational from a perpetrator perspective. Further, insufficient institutions are certainly the more serious problem to tackle when striving to prevent

[20] Although Sudan is excluded in our analysis and Kenya does not figure prominently because of its relatively positive agricultural outlook on average, a rather connected example for a study combining theoretical and empirical work is provided by Scheffran et al. (2014) in this volume.

genocide. But climate change has important and mutual interconnections with bad institutions. Of particular relevance are connections to marginalization and vulnerability and the organization of conflict regulation on the local level when previously marginal groups are affected (Levene and Conversi, 2014). This article has contributed to the identification of countries at risk. Although some of these are 'usual suspects' (like in the Great Lakes and the Horn of Africa region), the picture has certainly become clearer and more nuanced with respect to the degree of risk. But for successful prevention to occur, research, policy, and activism will have to join forces to identify the places and groups at risk and address these risks by, for example, raising the costs of violence, improving dispute settlement, and identifying viable alternatives. The task is mighty indeed, but the benefits certainly outweigh the costs.

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Part II: Behavioral aspects of adaptation in SIDS

Paper 2: Gender differences in stereotypes of risk preferences: Experimental evidence from a matrilineal and a patrilineal society[1]

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Abstract

We use a controlled experiment to analyze gender differences in risk preferences and, more importantly, stereotypes about risk preferences of men and women across two distinct island societies in the Pacific: the patrilineal Palawan in the Philippines and the matrilineal Teop in Papua New Guinea. We find no gender differences in actual risk preferences, but evidence for culture-specific stereotypes. Like men in Western societies, Palawan men overestimate women's actual risk aversion. By contrast, Teop men underestimate women's actual risk aversion. We argue that the observed differences in stereotypes between the two societies are determined by the different social status of women.

Keywords: Gender roles, culture, stereotype, experiment, risk aversion

JEL classification: C93, D81, J15, J16

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1. Introduction

Evidence from Western societies suggests that women are more risk averse than men.[1] Such differences have important implications for economic outcomes such as occupational choice, investment and consumption choices, or insurance coverage. Findings from rural and traditional societies, however, cannot confirm the verdict of systematically different risk preferences of women and men (e.g., Binswanger, 1980; Henrich and McElreath, 2002). Even novel and rare experimental work conducted in societies where the roles of women and men are mirror images in specific aspects of social norms provide only mixed results. Gneezy et al. (2009) observe gender differences in competition but not in risk preferences among the patriarchal Maasai in Tanzania and the matrilineal Khasi in India. Gong and Yang (2012) find that women are more risk averse than men in patriarchal and matrilineal societies in China but the gender gap is smaller in the latter one. These findings suggest that gender differences in risk preferences cannot unequivocally be attributed to nature. Rather such differences may also be culture-specific and evolve during socialization.[2]

In this study we go beyond the analyses of gender differences in risk preferences and examine gender differences in stereotypes about risk preferences of men and women. We do so by comparing two traditional island societies which mainly differ in the social status of women: the patrilineal Palawan in the Philippines and the matrilineal Teop in Papua New Guinea.

Stereotypes play an ambiguous role in decision making. On the one hand, by highlighting differences between groups, they allow easy processing of information and

[1] See Eckel and Grossman (2008b), Croson and Gneezy (2009) and Bertrand (2011) for reviews of the experimental literature as well as Charness and Gneezy (2012). Women have also been shown to be more socially oriented, more selfless, less willing to compete and less willing to negotiate than men. However, according to Filippin and Crosetto (2014) gender differences in risk preferences are task-specific and less ubiquitous than usually claimed.

[2] See Gneezy et al. (2009, pp. 1644) for an intriguing discussion of the nature-nurture debate. Booth and Nolen (2012) also provide evidence for the role of nurture within a Western society. They show that English girls in an all-girls group or attending a single-sex school are less risk-averse than girls in coeducational schools.

categorization of people (Brewer 1999)..[3] On the other hand, stereotypes are necessarily selective and highlight only the most distinctive features of a group (Hilton and von Hippel, 1996). They may hence be associated with biased assessment of an individual's actual risk preferences and ultimately lead to statistical discrimination. Whether one sex is, rightly or wrongly, stereotyped as more risk averse, has important and potentially adverse consequences for the opportunities, choices, and outcomes of an individual with that sex (e.g., Ball et al., 2010; Roth and Voskort, 2014). In an economic transaction with another party, it is often the risk preference perceived by the other party – not the typically unobservable true risk preference – that matters.

For instance, Wang (1994) finds that investment brokers offer women lower risk investment options (with lower expected returns) than men, which is consistent with the stereotype that women are more risk averse than men. Women may then make different and potentially suboptimal investment decisions compared to a situation in which they would receive unbiased advice. Stereotypes may also cause the underrepresentation of women in higher management positions. Johnson and Powell (1994) find no differences in decision quality and risk propensity between female and male managers and argue that the exclusion of women from such positions may be based on false stereotypes derived from observations of the non-managerial population. Heilman (2001) comes to a similar conclusion arguing that gender stereotypes bias the evaluation of work performance against women and thus hamper women from climbing up the organizational ladder. Relatedly, Eckel and Grossman (2002) note that employers may offer women lower initial wages in employment negotiations and bargain more aggressively if they expect women to be more risk averse and hence more willing to accept a given offer than men. In the context of developing countries, gender stereotypes may explain why microcredits are primarily given to women rather than men (Morduch 1999): If women are expected to be more risk averse, the perceived chances of debt retirement are higher.

[3] Stereotyping can be taken as the most cognitive component of category-based reactions, i.e. reactions to people from groups perceived to differ significantly from one's own (Eagly and Chaicken, 1998; Petty and Wegener 1998).

While women in Western societies are often more risk averse than men, men perceive women to be even more risk averse than they actually are (e.g., Eckel and Grossman, 2002; Daruvala, 2007; Eckel and Grossman, 2008a; Grossman and Lugovskyy, 2011). Men's biased perception persists even if information about women's actual risk preferences is provided (e.g., Grossman, 2013).[4] Beyond statistical discrimination, incorrect stereotypes further worsen suboptimal decision making and the associated welfare and efficiency losses. This is especially so when stereotypes are internalized, thus lowering the self-esteem and confidence of the stereotyped group (Correll, 2001; Crocker and Major, 1989; Jones et al., 1984; Rosenberg, 1979).[5] For instance, Carr and Steele (2010) show that concerns about their risk stereotype increase women's risk aversion in financial decisions. Following Akerlof and Kranton's (2000) identity model, the internalization of risk stereotypes may also explain women's occupational sorting into jobs that require relatively less risk taking.

Despite the wealth of literature on gender stereotypes, the existence of culture-specific stereotypes has, to our knowledge, not been investigated so far. This is somewhat surprising given the expected importance of culture in explaining the presence of stereotypes (Fiske, 2000). We use a simple gamble choice task based on the design of Eckel and Grossman (2002, 2008a) to measure a subject's risk preference. To examine gender stereotypes in the patrilineal society of Palawan and the matrilineal society of Teop, each subject is asked to predict the gamble choice of another female and male subject from the same society. We are hence able to examine whether a person's sex is considered as a signal of risk preference in each society. Stereotypes change with the social structure and norms of a society, in particular with the status of groups (Crocker et al. 1998, Fiske 2000). We therefore expect gender stereotypes to be culture-specific. Specifically, we expect men from the patrilineal Palawan to exhibit different stereotypes about female risk preferences than men from the matrilineal Teop. In order to address

[4] Similar evidence exists for the stereotype that women are less talented and interested in mathematics and science. In spite of equal performance, men are much more likely to be hired for an arithmetic task than women even if information on performance is provided (Reuben et al., 2014).

[5] This argument is similar to the stereotype threat theory (Steele, 1997).

the internalization of stereotypes, we also analyze women's self-confidence and engagement in economic activities that are typically performed by men.

We find no significant gender differences in actual risk preferences in each of the two island societies. However, consistent with our expectation of culture-specific stereotypes, we are the first to show that men from a patrilineal society (the Palawan) overestimate women's actual risk aversion and men from the matrilineal society (the Teop) underestimate women's actual risk aversion. Hence, men in both societies use female sex as a significant signal for risk preferences, but in opposite directions. Men's biased perception of women's risk preferences implies suboptimal opportunities and choices for women. The fact that these biases are culture-specific suggests that stereotypes are not universal by nature, but (co)determined by nurture.

2. Subject pool: The patrilineal Palawan and the matrilineal Teop

Most explorations of gender differences in risk preferences are based on experiments conducted in what Henrich et al. (2010) call WEIRD (Western, educated, industrialized, rich, and democratic) societies. They make a compelling argument that these societies are relatively novel within evolutionary history and that data from non-Western small-scale societies are essential for testing hypotheses that relate to the human condition.

To assess the importance of culture for gender differences in stereotypes, we conduct experiments with subjects from small-scale societies where culture and its influence on the social order of a society play a more prominent role in daily life than in modern societies. We are thus more able to disentangle the role of culture from other factors related to economic development that may potentially confound the relationship between culture and stereotypes.

To isolate the effect of culture and women's social status on stereotypes, the ideal experiment would randomly assign different gender roles to otherwise identical societies. Such an experiment is, however, not feasible. To get as close as possible to this ideal experiment, we resort to the second best approach and conduct a cross-cultural study. Specifically, we study two societies that are very similar along many important

dimensions but have opposite cultures when it comes to women's social status: the patrilineal Palawan in the Philippines and the matrilineal Teop in Papua New Guinea.

Both the Palawan and the Teop are originally indigenous tribes and live in small-scale island societies located in the Pacific Ocean. They share the same geo-ecological conditions and their remote location has limited exposure to external cultural influences. We can therefore exclude the possibility that differences in geography or climate drive differences in risk preferences, and possibly gender differences in risk preferences, too. This setting is an improvement relative to the literature initiated by Gneezy et al. (2009), which compares patriarchal and matrilineal societies that do not necessarily share geo-ecological conditions. In our two study societies, the social status of women and men is based on social norms that regulate land ownership and resource-related user rights. These norms are in favor of men among the patrilineal Palawan and in favor of women among the matrilineal Teop. The following paragraphs provide more details on each society.

The Palawan are an indigenous ethnic group of the Palawan archipelago in the Philippines. Our subjects were recruited from small coastal settlements located in the Rizal area in the south of Palawan Island. Their main source of livelihood is farming and fishing. Although the household is not strictly organized along patriarchal ideology, the husband is the publicly acknowledged head of a household and main decision-maker. As such, he is expected to be the breadwinner for the family. Conversely, the wife is credited primarily for her ability to have children, take good care of them and her husband, and manage the household finances (Alcantara, 1994). Men hold user rights over land and other resources including those provided by the sea. Traditional leadership in Palawan communities is based on the blood line. Community members who have "royal" blood are eligible for leadership, but only if they are men (Limsa, 2014).

The Teop form a unique language group of Bougainville Island in Papua New Guinea and represent a matrilineal and matrilocal island society. Our subjects were recruited from small coastal settlements located in the northern part of the main island. Similar to the Palawan, the mainstay of the Teop is farming. This subsistence pattern is

supplemented by fishing, hunting and foraging (Reagan and Griffin, 2005). Women's social position in Bougainville culture has its origin in land. The matrilineal kinship structure gives women considerable power over material resources and activities that are economically and ritually important. Women's prerogative over land includes defining land boundaries, giving permission to hunt or to harvest timber, and the exclusive right to veto decisions on land-related matters. While male relatives have rights to ownership, their rights are limited and conditional on female relatives' permission (Saovana-Spriggs, 2003). Moreover, unmarried, divorced, or widowed brothers and sons reside in the home of their female relative. Even married men who live with their wife's family are expected to spend much of their time in their mother's or sister's household. Still, there are some predominantly male domains. Women hardly participate in politics and do not physically take part in tribal or civil conflicts. Priesthood also remains a male profession. Moreover, the Teop rely on big men (chieftains) to enforce norms in everyday life (Cochrane 1970).

3. Experimental design and procedure

Our experimental design closely follows Eckel and Grossman (2002, 2008a). We implement a simple and incentivized task for measuring risk preferences. This task is particularly adequate for a subject pool with limited numerical skills (Dave et al. 2010, Charness et al., 2013). Subjects are shown five gambles and asked to choose which of the five they wish to play for real. The gambles include one sure thing with the remaining four increasing linearly in expected payoff and risk as measured by the standard deviation of expected payoff. All are 50/50 gambles. Table 1 provides an overview of the gamble choices, the payoffs associated with each possible outcome, expected payoffs, and the standard deviations of expected payoffs. The gambles are represented in a way that is easy for subjects to understand. The use of 50/50 gambles keeps the task as simple as possible.[6]

[6] See Eckel and Grossman (2008b) for a discussion on advantages and disadvantages of measures of risk preferences.

This design can also be used to measure a subject's gender stereotypes about risk preferences in a simple way. After subjects choose their most preferred gamble, we ask them which of the five gambles an unidentified female and male subject from their society had chosen for her- and himself. Hence, the sex of the other person is the only information that a subject has to make a prediction of that person's gamble choice. We use monetary incentives to encourage subjects to spend effort on their prediction.

Table 1: Gambles, expected payoff, and risk (for the Teop in Papua New Guinea)

Gamble	Probability (%)	Option A	Option B	Expected payoff	Variance	Standard deviation
1	50/50	4 Kina	4 Kina	4 Kina	0	0
2	50/50	6 Kina	3 Kina	4.5 Kina	2.25	1.5
3	50/50	8 Kina	2 Kina	5 Kina	9	3
4	50/50	10 Kina	1 Kina	5.5 Kina	20.25	4.5
5	50/50	12 Kina	0 Kina	6 Kina	36	6

Gambles increase linearly in expected payoff and risk as measured by the standard deviation of expected payoff. 1 Kina ~ 0.4 US$. Gambles for the Palawan in the Philippines were adjusted based on purchasing-power parity.

The experimental procedure is the same for sessions conducted in the two societies. In each society we collected data from several villages.[7] For each session, we recruited adult subjects in advance and asked them to come to a central place in the village (school, church or community places).[8] After answering a short questionnaire, all subjects received a payment as an appreciation for completing the questionnaire and a show up fee to hold endowment effects constant. Together, these payments amounted to about US$ 1, equivalent to about a quarter of the daily minimum wage in each country.[9]

Subjects were then asked to move one by one into a private area where the experiment was conducted. The experimenter read out the instructions and explained the tasks. In

[7] Specifically, we recruited subjects from five (three) villages of the matrilineal (patrilineal) Teop (Palawan).

[8] Village heads and our local assistant helped us recruit the subjects from the adult population in the villages. No more than two persons were recruited from the same household to minimize contamination and learning between subjects.

[9] To make endowment effects and stakes comparable across the two societies, we adjusted payments based on purchasing power parity (see, http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=699).

the first task, subjects were asked to choose their preferred gamble. Each gamble was presented as a pair of money cards (see appendix Figure A1). The chosen pair was then put into a bag and shuffled.

Before subjects could draw their card from the bag, they were asked to complete the second task. In this task, subjects were shown two closed envelopes, one containing the gamble choice of an unidentified female subject and one containing the gamble choice of an unidentified male subject. Subjects were then asked to predict which gamble the other female and male subject had chosen for her- or himself.[10] For each correct prediction, they received an additional payment.[11] Subjects were told that pairs in the envelopes were changed after each participant such they could not use any information they could have potentially received from previous participants. As a final step, subjects drew one card form the bag with their chosen gamble and received their payment.[12] On average, this additional payment summed up to about US$ 1.

To ensure that all subjects fully understood the instructions and could communicate with the experimenters, we hired local assistants. They translated our experimental instructions into the local language. Different assistants translated the instructions back into English, so we could check for accuracy. All instructions were read aloud to the subjects, first in English by the experimenter then in the local language by the assistant.[13]

4. Results

4.1 Subject characteristics

[10] We changed the order of presenting the envelopes after each subject.

[11] Assuming that each subject has a distribution of risk preferences in the society in mind, our incentive system implies that each subjects should predict the mode of her (his) assumed distribution. We can, however, not control whether subjects indeed behave like this or whether there exist systematic deviations which, if culture-specific, could bias our results.

[12] For more details, see the experimental instructions in the Appendix.

[13] A male experimenter and a female assistant conducted each session to control for potential gender effects related to the experimental setup.

Table A1 in the appendix summarizes the main socio-economic and demographic characteristics of the subjects from the two societies. In total, 103 people from the patrilineal Palawan (49 men, 54 women) and 96 people from the matrilineal Teop (48 men, 48 women) participated in the study. Several observations are noteworthy. First, the average age (41-42 years) is about the same across society and sex ($p = 0.49$).[14] Second, households of Teop people are larger than those of Palawan people (6.03 versus 4.83, $p < 0.01$). The difference can be explained by the fact that married Teop men are still counted as members of their mother's household even if they reside elsewhere. Third, reflecting the different social status of women in the two societies, Teop women have a significantly higher educational attainment than Palawan women ($p < 0.01$). While all Teop women in the sample have completed some form of formal education, about one quarter of Palawan women have no formal education at all. However, Teop men and Palawan men do not significantly differ in their educational background ($p = 0.42$). Fourth, wealth, as measured by the number of comparable assets households own, is only marginally larger in Teop than in Palawan ($p = 0.08$).[15] We can find no significant differences in wealth between men and women within societies ($p = 0.20$ for Teop and $p = 0.50$ for Palawan). Fifth, farming and fishing are the main economic activities in both societies. However, wage labor, in particular as a secondary activity, is more prevalent in Palawan. Sixth, due to the strong presence of Christian missionaries in Bougainville all Teop subjects are Christians, while about 35 percent of Palawan subjects are Muslims.

4.2 Actual risk preferences

Figure 1 shows the mean gambles that women and men choose for themselves separately for the patrilineal Palawan and the matrilineal Teop. Table 2 lists the distribution of gamble choices by sex and society in more detail. Across sex, Palawan subjects are considerably less risk averse than Teop subjects. The mean gamble choice is

[14] All tests of socio-economic and demographic differences in means are conducted using a Wilcoxon rank-sum test. Our results are robust to using a t-test.

[15] We considered the following six assets which are of comparable value and use across the two societies: torch, lamp, chair, generator, mobile phone, radio.

3.43 among Palawan subjects and 2.73 among Teop subjects. The difference is statistically significant ($p < 0.01$).[16] About 55 percent of the Palawan choose the risky gambles 4 and 5, compared to 31 percent of the Teop. By contrast, 44 percent of the Teop people select the less risky gambles 1 and 2, compared to 23 percent of the Palawan.[17]

Figure 1: Mean gamble choices

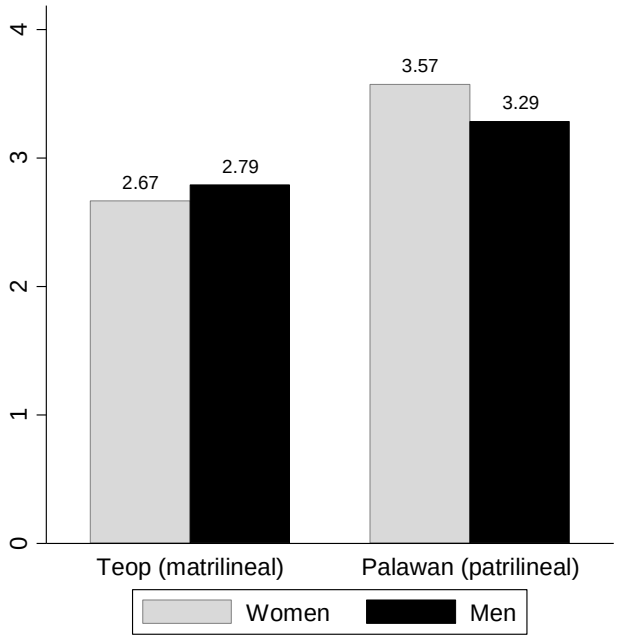


Table 2: Summary of own gamble choice

Gamble	Teop (matrilineal)			Palawan (patrilineal)		
	All subjects (%)	Men (%)	Women (%)	All subjects (%)	Men (%)	Women (%)
1	22 (23%)	11 (23%)	11 (23%)	16 (16%)	8 (16%)	8 (15%)
2	20 (21%)	8 (17%)	12 (25%)	8 (8%)	7 (14%)	1 (2%)
3	24 (25%)	13 (27%)	11 (23%)	22 (21 %)	9 (18%)	13 (24%)
4	22 (23%)	12 (25%)	10 (21%)	29 (2%)	13 (27%)	16 (30%)
5	8 (8%)	4 (8%)	4 (8%)	28 (27%)	12 (24%)	16 (30%)
Total	96 (100%)	48 (100%)	48 (100%)	103 (100%)	49 (100%)	54 (100%)
Mean (s.d.)	2.73 (1.28)	2.79 (1.29)	2.67 (1.28)	3.43 (1.38)	3.29 (1.41)	3.57 (1.34)

Gambles increase linearly in expected payoff and risk as measured by the standard deviation of expected payoff (see Table 1). Figure 1 shows the mean gamble choices by sex and society.

[16] All tests of gender differences in means are conducted using a Wilcoxon rank-sum test. Our results are robust to using a t-test.

[17] Palawan men's mean gamble choice is significantly higher than those of Teop men and women (3.29 vs. 2.79, $p = 0.07$ and 3.29 vs. 2.69, $p = 0.03$). The same is true for Palawan women's mean gamble choice (3.57 vs. 2.79, $p < 0.01$ and 3.57 vs. 2.67, $p < 0.01$).

Although the Palawan and Teop appear to have different risk preferences, we observe no gender differences in risk preferences within the two societies. We cannot reject the hypothesis that the gamble choice of Palawan (Teop) women equals the gamble choice of Palawan (Teop) men at usual significance levels (3.57 vs. 3.29, $p = 0.31$ for Palawan; 2.67 vs. 2.79, $p = 0.61$ for Teop).

To ensure that these findings are not confounded by different background characteristics of subjects across sex or society, Table 3 presents results from a simple regression model. We use ordinary least squares as expected payoff (and risk) increase linearly with gambles.[18] Columns 1-4 pool data from Palawan and Teop subjects and provide a sense of data patterns across the two societies. Columns 5-7 and 8-11 split the data by society, permitting the explanatory variables to have heterogeneous effects in each society. We include village-fixed effects in columns 5-11. Estimation with village fixed effects only exploits variation within villages and eliminates all village-level heterogeneity (e.g., village economy, village leadership, village geography, or demographic composition). It can hence not be the case that some village-specific oddities drive our results. For each sample, we show three standard specifications. The first specification only controls for the sex of the subject. The second specification adds controls for age, education[19], and wealth. The third specification additionally controls for religion, wage labor, and other potentially relevant socio-economic variables. In addition to these three standard specifications, we present a fourth specification for the pooled sample and the Palawan sub-sample in which we include an interaction of the gender and Muslim dummy (columns 4 and 11).

[18] Our results are robust to using alternative estimators such as ordered probit (results are available upon request).

[19] Note that we failed to record the educational level of two subjects. We allocated these missing values to educational level two (elementary), the most common category. All results are robust to allocating these two subjects to any other education category or to excluding them from the sample (results are available on request).

Table 3: Own gamble choice (OLS regression results)

	Pooled data				Teop (matrilineal)			Palawan (patrilineal)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Male	0.12	0.16	-0.27	-0.27	0.04	0.06	-0.37	-0.32	-0.24	-0.48	-0.27
	(0.26)	(0.26)	(0.31)	(0.31)	(0.26)	(0.29)	(0.32)	(0.28)	(0.28)	(0.59)	(0.62)
Palawan	0.91***	0.86***	1.12***	1.01***							
	(0.26)	(0.27)	(0.32)	(0.33)							
Palawan*male	-0.41	-0.37	-0.38	-0.12							
	(0.38)	(0.38)	(0.40)	(0.46)							
Muslim			-0.55*	-0.23					-0.70*	-0.76*	-0.44
			(0.32)	(0.42)					(0.36)	(0.38)	(0.46)
Muslim*male				-0.72							-0.72
				(0.65)							(0.73)
Age		-0.00	0.01	0.01		0.01	0.01		-0.01	-0.00	-0.00
		(0.01)	(0.01)	(0.01)		(0.01)	(0.02)		(0.01)	(0.01)	(0.01)
Elementary		-0.01	-0.32	-0.28		0.12	0.28		0.65	0.26	0.25
		(0.38)	(0.45)	(0.46)		(0.54)	(0.59)		(0.45)	(0.79)	(0.80)
High school		-0.56*	-0.54	-0.55		-0.77	-0.70		0.40	0.18	0.15
		(0.33)	(0.35)	(0.35)		(0.49)	(0.53)		(0.44)	(0.59)	(0.59)
Above high school		-0.34	-0.37	-0.41		-0.34	-0.28		0.15	-0.08	-0.19
		(0.34)	(0.35)	(0.35)		(0.51)	(0.55)		(0.35)	(0.47)	(0.51)
Wealth		-0.02	-0.01	-0.01		-0.07	-0.08		0.00	0.05	0.05
		(0.09)	(0.09)	(0.09)		(0.13)	(0.13)		(0.14)	(0.16)	(0.16)
Wage labor			0.32	0.32			0.42			0.15	0.16
			(0.32)	(0.32)			(0.64)			(0.45)	(0.45)
Constant	2.67***	3.09***	2.29***	2.32***	3.14***	3.56***	2.87**	3.73***	3.70***	3.07***	2.99***
	(0.18)	(0.53)	(0.78)	(0.78)	(0.29)	(0.81)	(1.36)	(0.26)	(0.57)	(0.92)	(0.92)
Linear combination of	-0.29	-0.21	-0.65	-0.39							
Male + Palawan*male	(0.27)	(0.28)	(0.40)	(0.46)							
Other controls	no	no	yes	yes	no	no	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	yes	yes	yes	yes	yes	yes	yes
Observations	199	199	199	199	96	96	96	103	103	103	103
R2	0.07	0.09	0.15	0.16	0.07	0.11	0.16	0.02	0.07	0.13	0.15

The table reports OLS estimates. The dependent variable is subject's own gamble choice (compare Table 1). Gambles increase linearly in expected payoff and risk as measured by the standard deviation of expected payoff. Other controls include household size, being a household head, marital status and fishing as main economic activity. Robust standard errors in parentheses. *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

In no specification do we find evidence for significant gender differences in risk preferences. Consistent with previous experimental work in the lab (Holt and Laury, 2000) and the field (Henrich and McElreath, 2002), sex, age, economic status and other characteristics do not predict risk preferences and the inclusion of these variables has no significant effect on the gender coefficient. In other words, differences in socio-economic and demographic background do not confound the (lacking) association between gender and risk taking. We only find that among the Palawan Muslims tend to be more risk averse than non-Muslims. This finding, however, cannot explain why the Teop are generally more risk averse than the Palawan.[1] In general, our findings are in line with results from previous cross-cultural studies that point towards the importance of culture for explaining variation in behavior (e.g., Weber and Hsee, 1998; Henrich et al., 2012; Nelson, 2014; Rieger et al., 2014).

4.3 Stereotyping about risk preferences

In addition to choosing a gamble for themselves, subjects also made a prediction of the gamble choice of an unidentified female and male subject. Table 4 presents the distribution of predictions of others' gamble choices by sex and society.

In line with the previous finding that Palawan subjects are less risk averse than Teop subjects, they also perceive themselves to be less risk averse. On average, all (female and male) Palawan subjects make significantly higher predictions of the gamble choice of both women and men than Teop subjects (3.36 vs. 2.81, $p < 0.01$ for women; 3.19 vs. 2.94, $p = 0.10$ for men).

[1] We checked for systematic gender differences within the Muslim and non-Muslim sub-samples and found no significant differences. We also checked whether there are significant differences in the relationship between socio-economic characteristics and risk preferences for Muslims by interacting each characteristic with a Muslim dummy. There appear to be no systematic differences. None of the interactions turn out to be significant at the ten percent level (results are available upon request).

Table 4: Predictions of others' gamble choices

Teop (matrilineal)						
	Predictions by all subjects		Predictions by men		Predictions by women	
Gamble	For men (%)	For women (%)	For men (%)	For women (%)	For men (%)	For women (%)
1	13 (14%)	25 (27%)	6 (13%)	8 (18%)	7 (15%)	17 (35%)
2	23 (24%)	14 (15%)	13 (27%)	3 (7%)	10 (21%)	11 (23%)
3	26 (27%)	18 (19%)	15 (31%)	12 (27%)	11 (23%)	6 (13%)
4	25 (26%)	26 (28%)	9 (19%)	17 (38%)	16 (33%)	9 (19%)
5	9 (9%)	10 (11%)	5 (10%)	5 (11%)	4 (8%)	5 (10%)
Total	96 (100%)	93 (100%)	48 (100%)	45[a] (100%)	48 (100%)	48 (100%)
Mean (s.d.)	2.94 (1.19)	2.81 (1.38)	2.88 (1.18)	3.18 (1.27)	3.00 (1.22)	2.46 (1.41)

Palawan (patrilineal)						
	Predictions by all subjects		Predictions by men		Predictions by women	
Gamble	For men (%)	For women (%)	For men (%)	For women (%)	For men (%)	For women (%)
1	14 (14%)	9 (9%)	8 (17%)	6 (12%)	6 (11%)	3 (6%)
2	12 (12%)	14 (14%)	3 (6%)	7 (14%)	9 (17%)	7 (13%)
3	28 (27%)	29 (28%)	15 (31%)	18 (37%)	13 (24%)	11 (20%)
4	36 (35%)	33 (32%)	19 (40%)	13 (27%)	17 (32%)	20 (37%)
5	12 (12%)	18 (18%)	3 (6%)	5 (10%)	9 (17%)	13 (24%)
Total	102 (100%)	103 (100%)	48[a] (100%)	49 (100%)	54 (100%)	54 (100%)
Mean (s.d.)	3.19 (1.21)	3.36 (1.18)	3.13 (1.18)	3.08 (1.15)	3.26 (1.25)	3.61 (1.16)

Gambles increase linearly in expected payoff and risk as measured by the standard deviation of expected payoff (see Table 1).

[a] Predictions by Teop (Palawan) men for women (men) do not sum to total observations of 48 (49) because of three (one) missing values. We failed to record these predictions during the experimental sessions.

Gender stereotyping is best assessed by comparing actual and perceived risk preferences for each sex. For this purpose, we define the prediction error as the difference between an individual's prediction of the gamble choice and the average actual gamble choice of a given sex:

$$prediction\ error_{i,\ sex} = prediction_i(gamble\ choice_{sex}) - average(actual\ gamble\ choice_{sex})$$

A prediction error of zero implies that stereotypes about risk preferences are on average correct. Accordingly, non-zero prediction errors are associated with incorrect stereotypes. Negative prediction errors correspond to overestimating, positive prediction errors to underestimating the risk aversion of a given sex. As argued above, the larger the bias in perception, the larger the degree of suboptimal decision making and the associated efficiency and welfare losses.

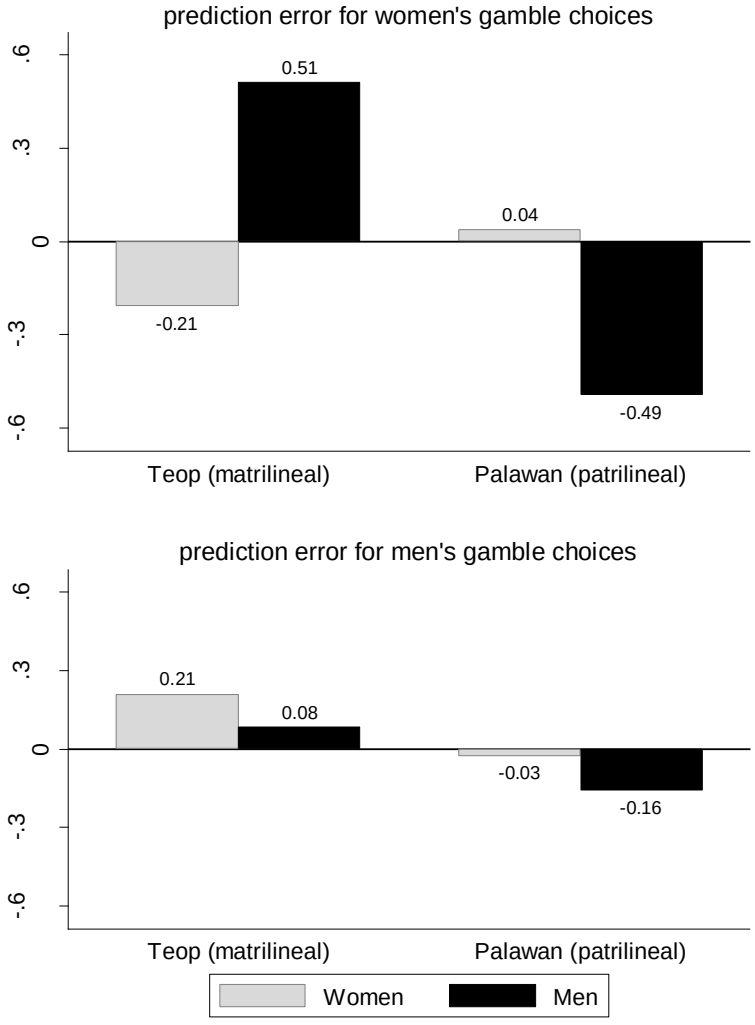
Figure 2 shows the mean prediction error for women's gamble choices (upper part) and men's gamble choices (lower part) by sex of the predictor and society. Consistent with the culture-specific social status of women, there are considerable differences in men's stereotypes about women's risk choices across the two societies. Men from the patrilineal Palawan overestimate women's actual risk aversion. Their mean prediction error for women's gamble choices of -0.49 is significantly different from zero ($p < 0.01$).[1] By contrast, men from the matrilineal Teop underestimate women's actual risk aversion. Their mean prediction error for women's gamble choices of 0.51 is also significantly different from zero ($p < 0.01$). Hence, men's perception of women's risk preferences is considerably biased in both societies but in opposite directions. The magnitude of the bias is considerable, amounting to almost half a standard deviation of women's actual risk preferences.

When it comes to women's stereotypes about men's risk choices, there are no such differences between the two societies. While Teop women slightly underestimate men's actual risk aversion, their mean prediction error of 0.21 is not significantly different form zero ($p = 0.24$). Palawan women correctly assess men's risk preferences. Their mean prediction error is close to zero (-0.03; $p = 0.88$).

[1] We use a one-sample t-test to test whether prediction errors differ significantly from zero.

Men and women in both societies have relatively accurate perception of their own sex' risk preferences. All prediction errors are relatively small and not significantly different from zero. Accordingly, gender differences within societies only exist for stereotypes about women's risk preferences. The mean prediction error of Palawan (Teop) men is significantly different from the prediction error of Palawan (Teop) women (-0.49 vs. 0.04, $p < 0.01$ for Palawan; 0.51 vs. -0.21, $p < 0.01$ for Teop).

Figure 2: Mean prediction errors for women's and men's gamble choices



The prediction error is defined as the difference between an individual's prediction of the gamble choice of an unidentified subject of a given sex and the average actual gamble choice of that sex. Positive (negative) prediction errors correspond to underestimating (overestimating) the risk aversion of that sex.

To assess the robustness of these results against potential confounders, we regress a subject's prediction error for a given sex on the subject's own sex and several control variables. We start with a model that pools data from the two societies. To identify culture-specific gender differences in stereotypes, all specifications include a dummy variable for belonging to the Palawan society, a dummy variable for being male, and their interaction.

Table 5 presents the results for prediction errors for women's risk choices using the same model specifications as in Table 3 above.[2] All our previous results hold. There are significant gender differences in stereotypes about women's risk preferences. According to column 1, men from the matrilineal Teop underestimate women's risk aversion. The positive and significant coefficient of the male dummy implies that Teop men, compared to Teop women, overestimate the gamble choice of women by about 0.7. By contrast, men from the patrilineal Palawan overestimate women's risk aversion. Combined with the coefficient of the male dummy the highly significant coefficient of the interaction implies that Palawan men, compared to Palawan women, underestimate the gamble choice of women by about 0.5. Both the size and statistical significance of the point estimates are robust to controlling for age, education, wealth, religion, wage labor and other socio-economic control variables as well as for a subject's own gamble choice and prediction error for men's risk preferences (columns 2-4). The stability of the gender coefficient across columns indicates that important observable characteristics cannot explain gender differences in stereotypes. Our results are essentially the same when we analyse the data separately for the Teop sub-sample (columns 4-6) and Palawan sub-sample (columns 7-11). The only exception is that the male dummy becomes marginally insignificant in the third specification for the Teop sub-sample ($p = 0.102$ column 7).

[2] The results shown in Table 5 are robust to various alternative specifications such as estimation with clustering standard errors at the village level instead of simple robust standard errors (see Table A2 in the appendix), or estimation with a random effects model or ordered probit instead of OLS (results are available upon request). One may also be concerned that our dependent variable is bounded from below and above and at different values for each society (as the average actual gamble choice for women/men differs between the two societies). We address this concern by estimating separate Tobit models for each society, in which we use society-specific bounds. Our results are robust to this check (results available are upon request). One may also worry that subjects did not genuinely try to predict other subjects' gamble choices, but just used their own gamble choice or the mean gamble choice (3) as their prediction. Given that the average actual gamble choice for women/men differs between the two societies, such predictions may systematically bias our results. However, our results are robust to excluding subjects who used their own or the mean gamble choice from the sample (results are available upon request).

Table 5: Stereotyping about women's risk choices (OLS regression results)

	Pooled data				Teop (matrilineal)			Palawan (patrilineal)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Male	0.72**	0.66**	0.63**	0.63**	0.71**	0.66**	0.75	-0.52**	-0.49**	-0.63*	-0.72*
	(0.28)	(0.29)	(0.32)	(0.32)	(0.29)	(0.31)	(0.45)	(0.24)	(0.23)	(0.34)	(0.39)
Palawan	0.25	0.17	0.21	0.25							
	(0.26)	(0.27)	(0.34)	(0.34)							
Palawan*male	-1.25***	-1.16***	-1.21***	-1.31***							
	(0.36)	(0.37)	(0.37)	(0.40)							
Muslim			-0.05	-0.16						-0.21	-0.33
			(0.25)	(0.34)						(0.32)	(0.38)
Muslim*male				0.26							0.27
				(0.50)							(0.52)
Age		0.01	0.01	0.01		0.02	-0.00		0.00	0.01	0.01
		(0.01)	(0.01)	(0.01)		(0.02)	(0.02)		(0.01)	(0.01)	(0.01)
Elementary		0.18	0.32	0.31		-1.33	-1.35		1.01*	1.43**	1.43**
		(0.48)	(0.50)	(0.50)		(0.95)	(1.03)		(0.58)	(0.60)	(0.61)
High school		0.11	0.36	0.37		0.09	0.13		0.91*	1.47***	1.48***
		(0.38)	(0.38)	(0.39)		(0.56)	(0.57)		(0.52)	(0.46)	(0.47)
Above high school		-0.01	0.22	0.24		-0.06	-0.03		0.77	1.25***	1.30***
		(0.40)	(0.41)	(0.41)		(0.63)	(0.66)		(0.51)	(0.42)	(0.46)
Wealth		-0.08	-0.05	-0.05		0.08	0.08		-0.23**	-0.17	-0.17
		(0.08)	(0.08)	(0.08)		(0.12)	(0.12)		(0.10)	(0.12)	(0.12)
Wage labor			0.18	0.18			-0.03			-0.06	-0.07
			(0.26)	(0.26)			(0.80)			(0.29)	(0.29)
Gamble choice			0.11	0.11			0.10			0.09	0.09
			(0.08)	(0.08)			(0.13)			(0.11)	(0.10)
Prediction error (men)			0.17**	0.18**			0.13			0.22**	0.22**
			(0.08)	(0.08)			(0.14)			(0.11)	(0.11)
Constant	-0.21	-0.41	-1.21	-1.23	-0.09	-0.85	-0.57	0.06	-0.35	-1.55*	-1.54*
	(0.20)	(0.54)	(0.75)	(0.75)	(0.38)	(1.06)	(1.48)	(0.24)	(0.62)	(0.81)	(0.81)
Linear combination of	-0.53**	-0.50**	-0.58*	-0.67*							
Male + Palawan*male	(0.23)	(0.23)	(0.30)	(0.34)							
Other controls	no	no	yes	yes	no	no	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	yes	yes	yes	yes	yes	yes	yes
Observations	196	196	195	195	93	93	93	103	103	102	102
R2	0.08	0.10	0.18	0.18	0.08	0.14	0.21	0.06	0.17	0.31	0.32

The table reports OLS estimates. The dependent variable is the prediction error for women's gamble choice, which is defined as the difference between an individual's prediction of the gamble choice of an unidentified female subject and the average actual gamble choice of women. Positive (negative) prediction errors correspond to underestimating (overestimating) women's risk aversion. Other controls include household size, being a household head, marital status and fishing as main economic activity. Gamble choice is an individual's own gamble choice. Prediction error (men) is the prediction error for men's gamble choice. Robust standard errors in parentheses. *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 6: Stereotyping about men's risk choices (OLS regression results)

	Pooled data				Teop (matrilineal)			Palawan (patrilineal)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Male	-0.13	-0.12	0.02	0.01	-0.09	-0.13	-0.37	-0.20	-0.07	0.36	0.54
	(0.24)	(0.25)	(0.29)	(0.29)	(0.25)	(0.27)	(0.34)	(0.25)	(0.24)	(0.40)	(0.48)
Palawan	-0.23	-0.24	-0.44	-0.49							
	(0.24)	(0.26)	(0.34)	(0.34)							
Palawan*male	-0.01	0.02	0.21	0.34							
	(0.34)	(0.35)	(0.38)	(0.42)							
Muslim			-0.05	0.10						0.24	0.51
			(0.25)	(0.37)						(0.30)	(0.40)
Muslim*male				-0.35							-0.63
				(0.50)							(0.53)
Age		-0.01	-0.01	-0.01		0.01	0.02		-0.02**	-0.02	-0.02
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Elementary		-0.18	-0.22	-0.20		-1.21**	-0.82		0.17	-0.27	-0.27
		(0.45)	(0.44)	(0.45)		(0.58)	(0.54)		(0.70)	(0.84)	(0.86)
High school		-0.18	-0.04	-0.04		0.16	0.41		-0.23	-0.63	-0.66
		(0.34)	(0.33)	(0.33)		(0.48)	(0.45)		(0.65)	(0.69)	(0.70)
Above high school		-0.50	-0.35	-0.38		-0.00	0.29		-0.91	-1.13*	-1.24*
		(0.35)	(0.35)	(0.35)		(0.54)	(0.47)		(0.64)	(0.62)	(0.63)
Wealth		0.04	0.08	0.07		0.04	0.03		0.14	0.15	0.15
		(0.08)	(0.08)	(0.08)		(0.12)	(0.13)		(0.11)	(0.11)	(0.11)
Wage labor			0.26	0.26			1.62***			-0.14	-0.13
			(0.27)	(0.27)			(0.49)			(0.32)	(0.33)
Gamble choice			0.15**	0.15**			0.01			0.23**	0.21**
			(0.07)	(0.07)			(0.10)			(0.09)	(0.09)
Prediction error (women)			0.17**	0.17**			0.10			0.25**	0.26**
			(0.07)	(0.07)			(0.10)			(0.12)	(0.12)
Constant	0.21	0.64	0.06	0.09	0.37	-0.28	-1.11	0.23	1.05	0.48	0.46
	(0.18)	(0.54)	(0.76)	(0.77)	(0.32)	(0.92)	(1.12)	(0.24)	(0.74)	(0.97)	(0.99)
Linear combination of	-0.13	-0.10	0.23	0.35							
Male + Palawan*male	(0.24)	(0.24)	(0.31)	(0.37)							
Other controls	no	no	yes	yes	no	no	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	yes	yes	yes	yes	yes	yes	yes
Observations	198	198	195	195	96	96	93	102	102	102	102
R2	0.01	0.03	0.12	0.12	0.03	0.09	0.22	0.03	0.12	0.26	0.27

The table reports OLS estimates. The dependent variable is the prediction error for men's gamble choice, which is defined as the difference between an individual's prediction of the gamble choice of an unidentified male subject and the average actual gamble choice of men. Positive (negative) prediction errors correspond to underestimating (overestimating) men's risk aversion. Other controls include household size, being a household head, marital status and fishing as main economic activity. Gamble choice is an individual's own gamble choice. Prediction error (women) is the prediction error for men's gamble choice. Robust standard errors in parentheses. *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

As documented above, among the Palawan, Muslims are significantly more risk averse than non-Muslims. To check whether Muslims also have systematically different stereotypes about women's risk choices, we included an interaction of the gender and Muslim dummy (columns 4 and 11). Our results remain unchanged. Hence, religion in the form of Islam does not drive our results.

Table 7 presents the results for prediction errors for men's risk choices using the same specifications as above. In line with the descriptive findings, we do not find evidence for significant gender differences in stereotypes about men's risk preferences. Neither the male dummy nor the interaction with the Palawan dummy turn out to be significant (columns 1-4). In addition, the point estimates of both coefficients are much smaller and relatively close to zero. The picture is the same when we look at the Teop sub-sample (columns 4-6) and Palawan sub-sample (columns 7-11).

5. Discussion

In this section we briefly discuss why only male stereotyping about women's risk preferences is biased and why the direction of the bias differs between the patrilineal and the matrilineal society. We also explore the relationship between stereotypes and economic decisions. In particular, we look at occupational patterns and self-confidence in the two main subsistence activities, farming and fishing, which require different attitudes towards risk. Finally, we present an interpretation of not finding gender differences in actual risk preferences.

Although social norms that regulate the status of women differ between matrilineal and patrilineal societies, the division of labor is similar across the Palawan and Teop. In both societies, women do the housekeeping, gardening and childcare. Men are the main providers of the family. Their activities usually include outside tasks that require a higher degree of risk taking and physical strength such as fishing, hunting, logging, house building, etc. Moreover, communal activities like leadership and religious services are dominated by males. Hence, women's behavior in risky tasks and public activities is hardly or not at all observable to men. As a consequence, men in both societies are

more likely than women to make biased assessments of the other sex' risk behavior. This may explain why only men's stereotypes about women's risk preferences are biased and why there is no biased assessment of men's risk preferences in both societies.

The opposite direction of this bias between the two societies can be explained by the different social status of women. Women in matrilineal societies enjoy more prestige and respect than women in patrilineal societies. Importantly, they also have more control over resources and hence better abilities to insure themselves against potentially adverse consequences of risk taking. These differences may explain why women's risk aversion is underestimated by men from the matrilineal Teop and overestimated by men from the patrilineal Palawan.

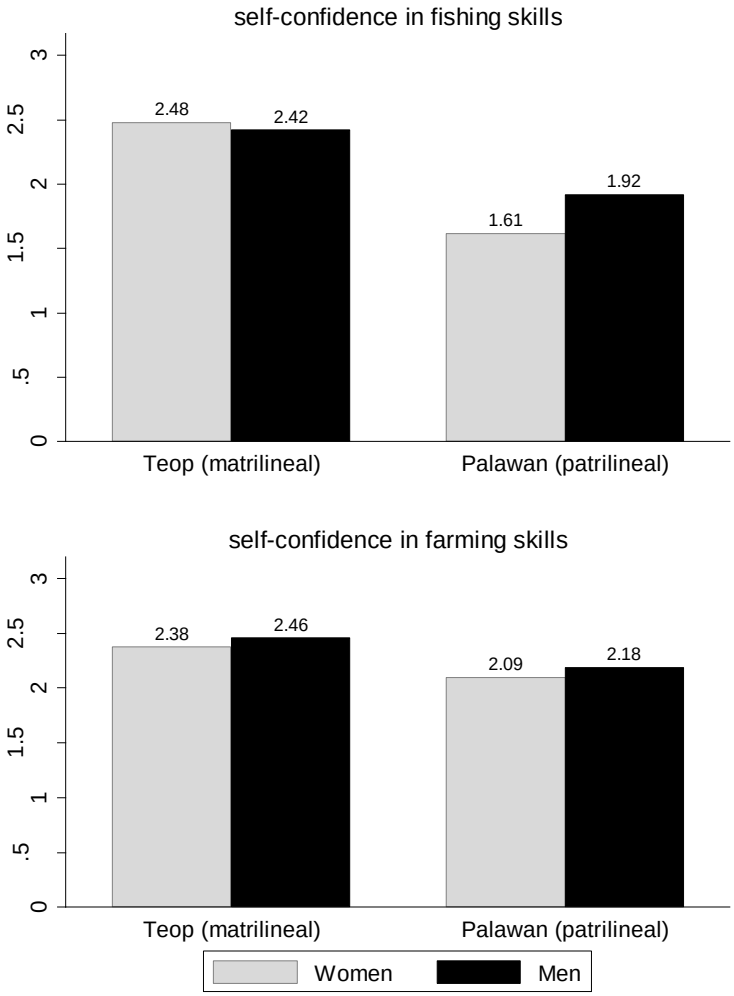
We cannot directly test the effects of men's misperception of women's risk preferences on women's economic decisions. We can, however, provide suggestive evidence on how this misperception correlates with women's self-confidence in farming and fishing and their economic activities.

To measure self-confidence in fishing and farming, we asked all subjects to assess their fishing and farming skills relative to those of other villagers on a three-point scale as worse (1), about the same (2), or better (3). Fishing is a task that is associated with more risk, competition and uncertainty in outcomes than farming in this geo-ecological setting. Figure 3 shows the mean self-confidence in fishing (upper part) and farming (lower part) by sex and society. Teop women and men are equally self-confident in their skills in both tasks. By contrast, Palawan women are significantly less confident in their fishing skills than Palawan men (1.61 vs. 1.92, $p = 0.01$). There is no significant gender difference in agricultural skills. Hence, among the patrilineal Palawan, men's overestimation of women's risk aversion is associated with lower levels of women's confidence in a risky task like fishing. This result is consistent with internalized stereotypes, which may be the result of different socialization patterns in the two societies (Andersen et al. 2013).

These patterns of self-confidence are reflected in the patterns of economic activities across the two societies. While 42 percent of women from the matrilineal Teop engage in fishing as their main or secondary economic activity, the corresponding figure is only

13 percent for women from the patrilineal Palawan (see Table A1 in the appendix). Likewise, the women-men ratio in fishing among the Teop is twice as high as the ratio among the Palawan.

Figure 3: Self-confidence in fishing and farming skills



Subjects assessed their fishing and farming skills relative to those of other villagers on a three-point scale as worse (1), about the same (2), or better (3).

Finally, our result of no gender differences in risk preferences provides further evidence for the impact of nurture. In line with previous experimental work conducted in traditional and rural societies (Binswanger, 1980; Henrich and McElreath, 2002; Gneezy

et al., 2009) sex is not a significant predictor of risk preferences. This may suggest that cultural factors that drive gender differences in Western and industrialized societies do not apply to traditional societies. This difference could potentially be explained by comparing the division of labor between traditional and Western societies after the industrial revolution. Sexual stratification coincided with increasing productiveness, specialization and complexity of society. The introduction of wage labor, the increasing scale of production and the mechanization of agriculture has led to long-lasting changes in gender roles. With the expansion of economic opportunities and separation of work from the home, men became economically less dependent on women, while women became more dependent on men (Hartmann, 1976; Goldin, 1995). This development has caused gender differences in employment, income and wealth and may explain why women in modern societies are more risk averse than men.

Nevertheless, one should not overinterpret our results as they are based on subjects from only two societies. While our research and econometric design rules out many potential confounders, it remains difficult to identify culture as the only relevant explanation for the observed differences in gender stereotypes. For firm conclusions, more evidence from other paired patrilineal and matrilineal societies is needed.

6. Conclusion

Using a simple gamble choice task developed by Eckel and Grossman (2002, 2008a), we analyze gender differences in risk preferences and stereotypes in a patrilineal and a matrilineal island society in the Pacific. We find no gender differences in actual risk preferences among the patrilineal Palawan and the matrilineal Teop. However, we find considerable evidence for culture-specific stereotypes about women's risk preferences. Similar to men in Western societies, Palawan men overestimate women's actual risk aversion. By contrast, Teop men underestimate women's actual risk aversion.

This suggests that nurture, which is reflected in the different social status of women in the two societies, affects men's stereotypes about women's risk taking. As perceived, not actual risk preferences guide economic transactions with another party, men's biased

perception of women's risk preferences likely has adverse consequences for women. It may result in worse opportunities, choices and outcomes for women, thus reducing efficiency and welfare.

Our findings may provide important information for policy makers. If gender stereotypes are driven by nurture, or an interaction between nature and nurture, policy makers may focus on promoting more equitable gender models. Less biased socialization and education may then pave the way for a more equal treatment of women and men.

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Appendix

Figure A1: Subject's gamble choice

Each gamble (see Table 1) was presented as a pair of money cards. Gambles increase linearly in expected payoff and risk as measured by the standard deviation of expected payoff.

Table A1: Subject characteristics

	Teop (matrilineal)			Palawan (patrilineal)		
	All subjects	Men	Women	All subjects	Men	Women
	mean (s.d.)	mean (s.d.)	mean (s.d.)	mean (s.d.)	mean (s.d.)	mean (s.d.)
Age (years)	42.06 (13.68)	44.23 (13.56)	39.90 (13.59)	40.65 (15.16)	40.61 (15.84)	40.69 (14.66)
Household size	6.03 (2.11)	5.92 (2.10)	6.15 (2.14)	4.83 (2.12)	4.55 (1.88)	5.07 (2.30)
Wealth (index)[a]	2.74 (1.12)	2.88 (1.06)	2.60 (1.18)	2.38 (1.17)	2.45 (1.10)	2.31 (1.24)
	percent	percent	percent	percent	percent	percent
Education[b]						
No school	2.08 %	4.17 %	0.00 %	18.45%	8.16 %	27.78 %
Elementary	43.75 %	47.92 %	39.58 %	41.75%	46.94 %	37.04%
High school	40.63 %	37.50 %	43.75 %	34.95%	40.82 %	29.63 %
Above high school	13.54 %	10.42 %	16.67 %	4.85 %	4.08 %	5.56 %
Main activity						
Farmer	86.46 %	89.58 %	83.33 %	60.19 %	51.02 %	68.52 %
Fisher	2.08 %	4.17 %	0.00 %	15.53 %	26.53 %	5.56 %
Wage labor	2.08 %	2.08 %	2.08 %	12.62 %	6.12 %	18.52 %
Other	9.38 %	4.17 %	14.59 %	11.66 %	16.33 %	7.40 %
Secondary activity						
Farmer	28.13 %	18.75 %	37.50 %	36.89 %	28.57 %	44.44 %
Fisher	54.17 %	66.67 %	41.67 %	11.65 %	16.33 %	7.41 %
Wage labor	5.21 %	8.33 %	2.08 %	25.24 %	24.49 %	25.93 %
Other	12.49 %	6.25 %	18.75 %	26.22 %	30.61 %	22.22 %
Religion						
Christian	100 %	100 %	100 %	50.49 %	57.14	44.44 %
Muslim				34.95 %	32.65	37.04 %
Other/no religion				15.02 %	10.21	18.52 %
Observations	96	48	48	103	49	54

[a] The wealth index is defined as the sum of assets owned. We consider the following six assets: torch, lamp, chair, generator, mobile phone, radio.

[b] Note that we failed to record the educational level of two participants. We allocate these observations to education level two (elementary), the most common category.

Table A2: Stereotyping about women's risk choices (OLS regression results using clustered standard errors)

	Pooled data				Teop (matrilineal)			Palawan (patrilineal)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Male	0.72**	0.66**	0.63**	0.63**	0.71*	0.66**	0.75	-0.52**	-0.49**	-0.63**	-0.72**
	(0.25)	(0.25)	(0.25)	(0.25)	(0.31)	(0.31)	(0.51)	(0.07)	(0.06)	(0.09)	(0.15)
Palawan	0.25	0.17	0.21	0.25							
	(0.14)	(0.13)	(0.13)	(0.13)							
Palawan*male	-1.25***	-1.16***	-1.21***	-1.31***							
	(0.25)	(0.25)	(0.25)	(0.26)							
Muslim			-0.05	-0.16						-0.21	-0.33
			(0.13)	(0.17)						(0.15)	(0.35)
Muslim*male				0.26**							0.27
				(0.11)							(0.40)
Age		0.01**	0.01	0.01		0.02	-0.00		0.00	0.01	0.01
		(0.00)	(0.01)	(0.01)		(0.02)	(0.01)		(0.01)	(0.01)	(0.01)
Elementary		0.18	0.32	0.31		-1.33	-1.35		1.01	1.43	1.43
		(0.54)	(0.57)	(0.57)		(0.95)	(0.76)		(1.04)	(0.62)	(0.60)
High school		0.11	0.36	0.37		0.09	0.13		0.91	1.47**	1.48**
		(0.46)	(0.43)	(0.43)		(0.56)	(0.69)		(0.54)	(0.19)	(0.21)
Above high school		-0.01	0.22	0.24		-0.06	-0.03		0.77	1.25**	1.30**
		(0.54)	(0.45)	(0.45)		(0.63)	(0.84)		(0.56)	(0.16)	(0.21)
Wealth		-0.08	-0.05	-0.05		0.08	0.08		-0.23	-0.17	-0.17
		(0.11)	(0.11)	(0.11)		(0.12)	(0.14)		(0.17)	(0.20)	(0.20)
Wage labor			0.18	0.18			-0.03		-0.06	-0.07	-0.06
			(0.19)	(0.19)			(0.66)		(0.10)	(0.11)	(0.10)
Gamble choice			0.11**	0.11**			0.10		0.09	0.09	0.09
			(0.03)	(0.03)			(0.07)		(0.09)	(0.09)	(0.09)
Prediction error (men)			0.17**	0.18**			0.13		0.22**	0.22**	0.22**
			(0.07)	(0.07)			(0.14)		(0.04)	(0.05)	(0.04)
Constant	-0.21	-0.41	-1.21**	-1.23**	-0.09	-0.85	-0.57	0.06	-0.35	-1.55**	-1.54**
	(0.14)	(0.39)	(0.36)	(0.36)	(0.15)	(1.06)	(0.87)	(0.04)	(0.63)	(0.22)	(0.21)
Other controls	no	no	yes	yes	no	no	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	yes	yes	yes	yes	yes	yes	yes
Observations	196	196	195	195	93	93	93	103	103	102	102
R2	0.08	0.10	0.18	0.18	0.08	0.14	0.21	0.06	0.17	0.31	0.32

The table reports OLS estimates. Clustered standard errors in parentheses. *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. For more details, see caption of Table 5.

Experimental instructions (for the Teop in Papua New Guinea)

Thank you for participating in this study. Here you have the 5 Kina for answering the questions in the interview you did. This is your money.

Now we will play two small games and ask you some short questions. In the game you can earn some extra money. There is no right or wrong answer in this game and you cannot lose any money. The money will be paid in cash immediately after we have finished. How much money you make depends to a large extend on your choices.

Now I am going to explain you how we play the first game. Please listen carefully and hold your questions until I have finished the explanations.

Part 1: Participant's Pair Selection

We will play the game using 5 different pairs of money-cards.

Please have a look at these pairs of money-cards. As you can see, each pair has different amounts of money on its cards.

Pair number 1 has one card with 4 Kina and another card with 4 Kina.

Pair number 2 has one card with 6 Kina and one card with 3 Kina.

Pair number 3 has one card with 8 Kina and one card with 2 Kina.

Pair number 4 has one card with 10 Kina and one card with 1 Kina.

Pair number 5 has one card with 12 Kina and one card with nothing on it.

You can choose from these 5 different pairs one pair you would like to play. After you have chosen a pair, I will separate the cards and put them into this empty bag and mix them up. After mixing the cards you draw one card from the bag and earn the amount of money which is on the card.

For example, let us consider you would choose pair number ___. I will separate the cards and put them into this empty bag. Now I am going to mix the cards. Then you would draw one card from the bag. In this case you would win ___.

Here is another example, let us consider this time you would choose pair number ___. Again, I will separate the cards and put them into this empty bag. Now I am going to mix the cards. Then you would draw one card from the bag. In this case you would win ___.

So to summarize, the money you earn depends on which pair of money-card you chose and which card you draw from the bag. You are free to choose any of the 5 different pairs of money-cards but only one of them. Now I finished my explanations. Do you have any questions?

Okay, now take your time, look at the pairs, and select the one you would like to play.

Part 2: Participant's Guess

Before we draw your card we will play the second game which is a guessing game. In this game you can also make some extra money.

Here I have two envelopes. Each envelope contains one pair that other people from villages in Teop had chosen to play. They played exactly the same game as you do here with us.

We also asked them which pair out of these 5 different pairs they would like to play. However, these people are not here today and after each game played, I change the pairs in the envelopes.

Inside this envelope there is a pair that a man from Teop had chosen to play. Which pair out of these 5 pairs do you think did this man choose? If your guess is correct you get 1 Kina. Please make your guess.

Inside this envelope there is a pair that a woman Teop had chosen. Which pair out of these 5 pairs do you think did this woman choose to play? If your guess is correct you get another 1 Kina. Please make your guess.

Part 3: Payout

Okay, now we look if your guesses were correct and we will play out the pair that you have chosen. First we compare your guesses with the pairs from the envelopes

Now we are going to play out the pair that you have chosen.

This is the money you have won.

Okay, my assistant will ask you a few questions on your views about some issues. This takes only 5-10 minutes. After finishing the questions you get your money.

Please don't talk about the game with your neighbors or other participants until we are finished the study here. Everyone should have the same chance to make his or her own choice in this game.

Ethical aspects of the study

The surveys and experiments used in this paper do not involve deception and the anonymity of the subjects was guaranteed. There was no danger of physical or psychological damages to be expected from participants. All people voluntary participated in the studies and were told to leave at any point of time if they feel uncomfortable with the situation. Moreover, prior the field research was conducted, the research teams were requested to give a presentation of the research methods and goals to the local communities and regional authorities. In all cases the request was granted approval. Our research project was also supported by the regional government of Bougainville and by the Teop Council of Elderly.

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Paper 3: Eliciting preferences for public goods in non-monetized communities: Accounting for preference uncertainty[1]

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Abstract:

One major challenge when conducting contingent valuation studies in developing countries is the choice of the appropriate payment vehicle. Since regular cash-income does not exist for the majority of the population and market integration is low, households in rural areas have less experience with monetary exchanges. In these cases labor time may be a more appropriate payment vehicle. A common finding of studies using labor time as payment vehicle is that households are more often willing to contribute working time as compared to money. However, so far empirical evidence is missing if the labor time elicitation format reduces respondent's uncertainty of contributions.

In this study we analyze and compare uncertainty of people's stated willingness to contribute (WTC) time and money for a local public good in a non-monetized small-scale community in Papua New Guinea. We do so by establishing an open-ended method for eliciting people's WTC, the Range-WTC-method, which elicits the upper and lower bound of a person's WTC. We find that uncertainty is reduced when respondents are asked for labor time contribution instead of monetary contributions. Thus, we provide empirical evidence that, indeed, labor time is the preferred to money in the elicitation of stated WTC in non-monetized communities.

Keywords: contingent valuation, non-monetized community, payment vehicles, preference uncertainty

JEL classification: D81, Q51, Q56

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1. Introduction

A large literature exists that investigates people's preferences for environmental goods and services that are not traded on markets, but only few of them elicit preferences in the context of developing countries. Because of lack of sufficient data for revealed preference studies, these studies mostly rely on stated preference approaches. An issue which is then of major importance is the elicitation of the willingness to pay (WTP) posing many challenges.[1]

One such challenge is the choice of the payment vehicle. Since regular cash-income does not exist for the majority of the population and the exchange of goods and services is augmented through barter or work exchange, the role of money in the rural developing setting is likely to be different from that of an urban developed setting. It is, therefore, argued that contributions in the form of work time may seem more realistic for rural households in non-monetized communities (see for instance Hardner, 1996; Hung et al., 2007; Casiwan-Launio et al., 2011). According to previous findings, comparing labour time and money contributions, acceptance rates for the willingness to contribute (WTC) time are higher than for money (see Gibson et al. (2015) for a recent overview). These studies then conclude that the labor time payment vehicle is a valuable alternative to money in a rural developing setting.[2]

It is plausible to assume that people that are mainly engaged in subsistence activities have fewer difficulties in quantifying their disposable time budget as compared to disposable cash-income. However, to our knowledge, there is no empirical evidence, if respondents are actually more certain about their contribution when using labor time as the payment vehicle. In this study we, therefore, analyze and compare uncertainty of people's stated WTC time and money for a local public good in a non-monetized small-scale community in Bougainville, Papua New Guinea. We do so by establishing an

[1] For a detailed discussion of the challenges associated with contingent valuation studies in developing countries, see Whittington (2002).

[2] Usually these studies convert labour time contributions into monetary contributions using information on local wage rates.

open-ended method for eliciting people's WTC, the Range-WTC-method, which elicits the upper and lower bound of a person's WTC.[3]

The main justification for using Range-WTC instead of classical Point-WTC is the literature on preference uncertainty. Most of the contingent valuation studies that compare WTC time and money in developing countries use the open-ended method and elicit the WTC as a single point (see Swallow and Woudyalew, 1994; Hardner, 1996; Echessah, 1997; Kamuanga et al., 2001; Arbiol et al., 2013; Vandolia et al., 2014).[4] A drawback of estimating the WTC as a single point is that it does not account for the uncertainty of preferences. Preference uncertainty may be caused by incomplete knowledge about the features of the object under evaluation or simply by the fact that a person is unsure about her own preferences (March, 1978; Gregory et al., 1993; Jacowitz and Kahnemann, 1995; Ariely et al., 2003). Due to vagueness of preferences, people often have only regions of indifference instead of well-defined indifference curves (Loomes, 1988; Butler and Loomes, 2007; 2011), a fact that challenges the existence of a single Point-WTP (Wang et al., 2007; Hanley et al., 2009; Dost and Wilken, 2012). As a consequence, the classical CV method may impose unrealistic cognitive demands on respondents. It was this point that at an early stage prompted Dubourg et al. (1997) to argue in favour of analysing WTP confidence intervals.

The present paper contributes to the existing literature in various ways. To our knowledge, we are the first to show that uncertainty decreases when respondents are asked for time contributions instead of money. Thus, we provide empirical evidence that the use of working time as a payment vehicle can produce more reliable welfare estimates than the use of money. Further, we improve techniques of existing contingent valuation studies that compare labor time and monetary payment vehicles. While Wang et al. (2007) have shown that Range-WTP is better than Point-WTP for predicting purchase probabilities of consumer goods, Kniebes et al. (2014) were the first to test in

[3] There are two widely used methods – numerical certainty scale and polychotmous choice – for estimating preference uncertainty adjusted willingness to pay in contingent valuation (for a review see Akter et al., 2008). However, these methods are mostly applied in the context of dichotomous choices, while we aim to consider preference uncertainty in the context of an open-ended method.

[4] Other studies used closed-ended methods, for example Hung et al. (2007) and O'Garra (2009).

a contingent valuation study if the Range-WTP is consistent with theoretical expectations eliciting WTP for non-market goods. We take a step forward and apply the Range-WTP method among respondents of a non-monetized community in a developing country. In doing so, we account for the uncertainty of respondent's preferences. This setting is an improvement relative to the literature initiated by previous CV-studies, which compare payment vehicles by eliciting the WTC as a single-point.

The remainder of the paper is organized as follows: Section 2 provides an overview of the elicitation approach. Section 3 includes a short description of the study area (3.1), outlines the survey design and sampling strategies (3.2) and the methodology used in the analysis (3.3). Section 4 provides the empirical analysis and results. Section 5 concludes.

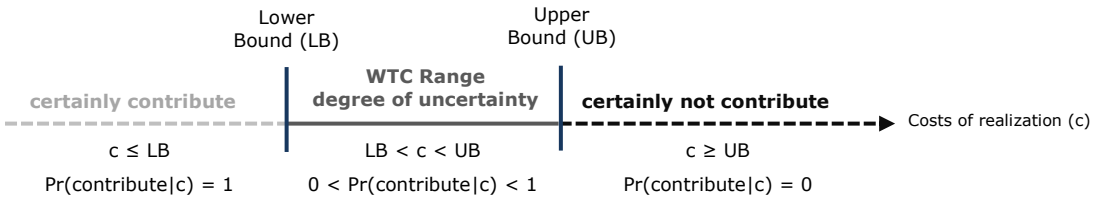
2. The elicitation approach

Building upon previous work in marketing science (Wang et al., 2007; Dost and Wilken, 2012), we follow first advances of Kniebes et al. (2014) in non-market environmental valuation and establish the open-ended method, the Range-WTP method, for eliciting preferences for non-market goods in non-monetized communities. This measure is designed specifically to reflect the effects of uncertainty in purchase decisions.

Figure 1 illustrates the concept of the Range-WTC. Contrary to point-based WTC measures, the range concept introduces two thresholds: the lower bound (LB) below which respondents would definitely contribute (choice probability of 1) and an upper bound (UB) beyond respondents would no longer contribute (choice probability of 0). In the interval between the LB and UB, respondents are indecisive about contributing (choice probability between 0 and 1).[5] The difference between these thresholds is the WTC range and is indicative of the degree of uncertainty (Wang et al., 2007; Schlereth et al., 2012; Kniebes et al., 2014; Maier et al., 2014).

[5] The procedure assumes that contribution probability decreases linearly between the LB and UB.

Figure 1: WTP as a range (adapted from Wang et al., 2007; Dost and Wilken, 2012; and Kniebes et al., 2014)



In a set-up involving 175 customers, Wang et al. (2007) test the range approach in an experimental elicitation of consumers' reservation prices for chocolate and red wine. They assume linear decreasing purchase probabilities between the lower bound (100%), indifference range (50%) and upper bound (0%). A lottery ensures incentive compatibility, e.g. if the randomly drawn lottery price is lower than the lower bound, then the respondent must buy the good at the drawn lottery price. They conclude that the WTP-range performs better than point-based methods in terms of predictive performance while yielding valuable information about uncertainty in product valuation. In line with Wang et al. (2007), Dost and Wilken (2012) also provide empirical evidence that "traditional" point-based methods measure expected WTP and neglect individual uncertainty, which exists even for daily-use products, such as glasses of caffè latte. They argue that point-based methods produce biased pricing which results in poor estimates of production capacities. Because this effect tends to grow with the variance caused by consumer uncertainty, they particularly recommend range-based methods for new or unfamiliar products, as well as public goods. Related, Kniebes et al. (2014) are the first to test if the Range-WTP is consistent with theoretical expectations eliciting WTP for non-market goods. In their CV study they test theoretical validity and reliability of the two open-ended elicitation formats, the traditional approach of eliciting a single value and the Range-WTP. Using data from two large-scale surveys on the perceptions of solar radiation management, a little-known technique for counteracting climate change, they find evidence that the Range-WTP method clearly outperforms the Point-WTP method.

We follow the approach of Kniebes et al. (2014) and apply the range-based method for eliciting contributions to a hypothetical public good. In doing so, we are interested in comparing the degree of uncertainty between monetary and labor time contributions in a non-monetized economy.

3. Methodology and data

3.1 The study area

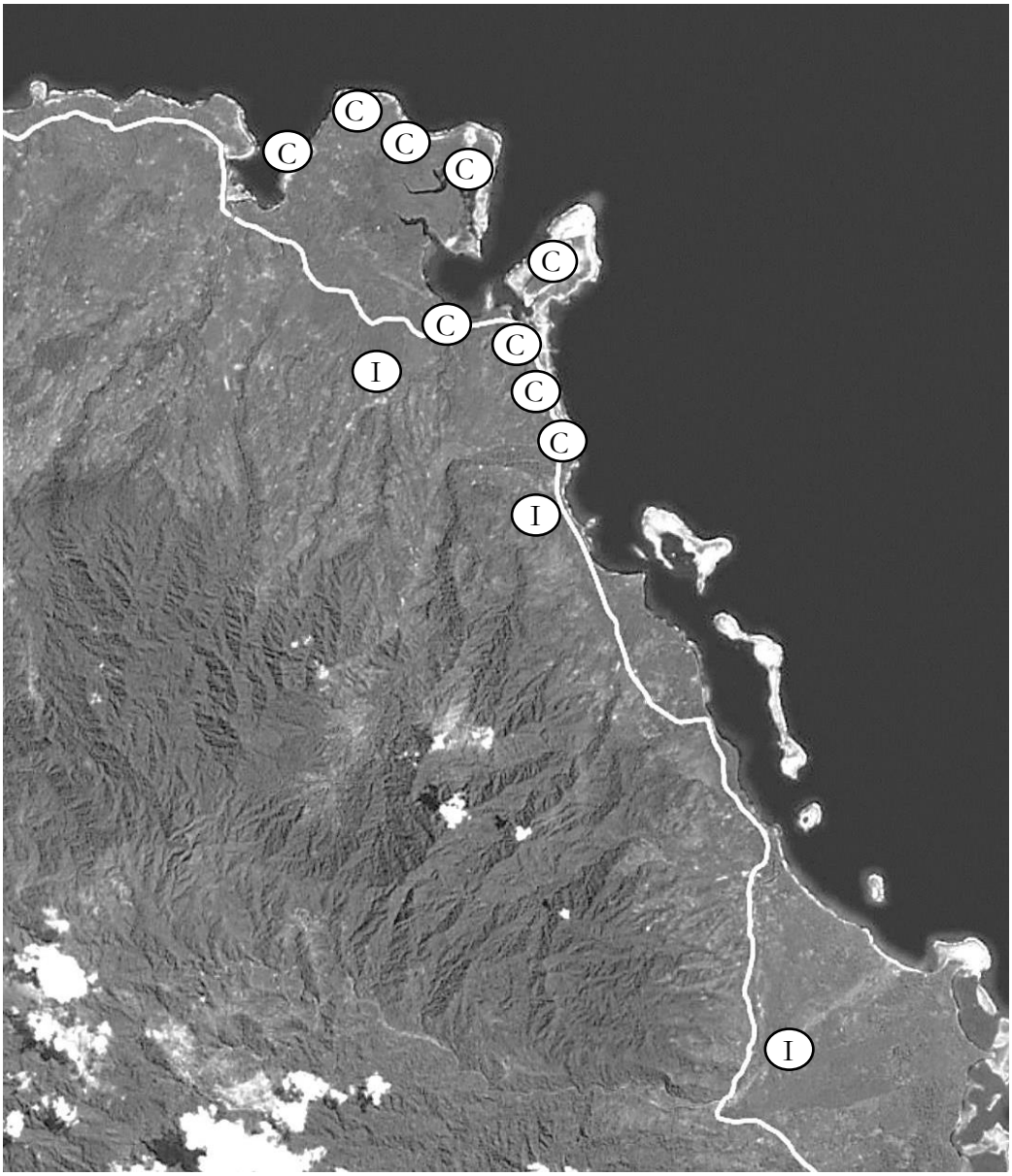
The data for our analysis comes from a survey conducted in coastal villages in the northeastern part of Bougainville Island, Papua New Guinea, in October to November 2014. Bougainville is located in the Pacific Ocean and is exposed to a large number of natural hazards including earthquakes and tsunamis.[6] In combination with low adaptive capacities and economic development opportunities this makes the island state and its many coastal communities particularly vulnerable. So far, protective measures like tsunami evacuations routes have not been implemented. Alerts through warning systems are available via mobile phone but are more or less rejected by the local population perhaps due to lack of knowledge.

We recruited respondents from small settlements of the Teop society at Tinputz district. Figure 2 displays a map of the area and the villages included in the study. Teop people live in villages that vary in size from 50 to 200 people, and are either located along the coast or inland in the hills.[7] Their subsistence is based on horticulture and pig husbandry, supplemented by fishing, hunting and foraging (Regan and Griffin, 2005). Some of the surplus from the subsistence sector is sold on markets. Cocoa and copra are the main commercial crops. These crops are harvested several times a year and sold to intermediaries in one of the larger capitals at the coast. At present, there are hardly any possibilities for engagement in wage labor on Bougainville except for government occupations. Thus, regular cash-income does not exist for the majority of the population.

[6] See http://earthquake.usgs.gov/learn/glossary/?termID=150.

[7] In our sample, 83 % of the respondents live in coastal villages (including one offshore island) while 17 % live in inland villages (see also Figure 2).

Figure 2: Map of the study area (northeastern part of Bougainville island)



C = coastal and offshore island villages
I = inland villages
Source: ESRI, own illustration

3.2 Survey design and sampling

The questionnaire was structured as follows: First, respondents were informed about how tsunamis arise and the possible consequences of such an event for coastal communities living in this area. Then, they were made aware of the fact that people's life could be saved by evacuating them in case of emergency.[8] We visualized an example of such an evacuation route (see Figure A1 in the appendix) and gave details about the necessary tasks associated with its implementation. Then, respondents were asked to imagine a hypothetical situation in which the evacuation route would be constructed in their village. Next, respondents were asked for their willingness to contribute to support the construction of the route in terms of labor time and money. The questions for monetary and labor time contributions were presented in randomized order as to not bias results. We choose the following elicitation format: Respondents were always asked first to state a lower bound (LB) and an upper bound (UB) of their willingness to contribute money and labor time (measured in hours). The lower bound was elicited by asking respondents to state the amount of money (hours) that they would definitely be willing to contribute to support the construction of the evacuation route. The upper bound was elicited by asking respondents to state the amount of money (hours) at, or above, which they would definitely not be willing to contribute to support the construction. In addition to the elicitation of the willingness to contribute, we collected socio-economic and demographic characteristics of the respondents.

A total of 195 participants – 102 male and 93 female - voluntarily participated in the interviews across multiple villages. Recruitment was done by drawing a random sample from a residence list. In some cases these lists were already available, in some other cases we asked local village chiefs to prepare one. Each respondent was given the questionnaire in a face-to-face interview which was conducted by local research assistants supervised by the researchers. Before the interviews were conducted, the survey was discussed among focus groups and then pretested with a small sample of randomly selected respondents.

[8] The English translation of the information provided to the respondents is presented in Table A1 in the appendix.

3.3 Methodology

To test if the payment vehicle has an effect on preference uncertainty we first present descriptive statistics of the LB and the UB for each payment vehicle separately. Subsequently, we compare LB's and UB's to the average local wage level and the average daily working hours by applying mean comparison tests (t-test). This is done to identify a possible reference point which may be used by respondents to categorize contributions into a certain and uncertain part.

To compare uncertainty between labor time and monetary contributions independent from conversion issues and level of contributions, we had to convert the information obtained from the survey participants. We, therefore, specify uncertainty as the relative deviation of the LB from the UB. We test the statistical difference of uncertainty by applying a mean comparison test (t-test).[9] Finally, to confirm the robustness of the results, we run ordinary least square regressions where we control for socio-economic and regional characteristics of the respondent and the study area. The regression analysis also allows us to investigate factors that determine the uncertainty of contributions.

4. Empirical analysis and results

4.1 Descriptive statistics for the two payment vehicles

Table 1 provides summary statistics of the respondents' age, education level, main activity as well as the household income and the size of the household they are living in. In addition to statistics for the sample as a whole, the table also provides information by gender. It is interesting to note, that there are few differences between men and women regarding education, age and monthly income, but significant differences with respect to main activities (χ^2, $p < 0.01$).[10] Women are less engaged in farming and fishing, but more engaged in housekeeping and teaching.

[9] The results presented in section 4.1 and 4.2 are robust to using Wilcoxon rank-sum test.

[10] Chi-square tests are used for testing socio-economic differences between men and women.

Table 1: Summary statistics of respondents

	All subjects	**Men**	**Women**
	mean (s.d.)	mean (s.d.)	mean (s.d.)
Age (years)	38.43 (12.49)	39.41 (13.33)	37.39 (11.53)
Household size	5.94 (3.09)	6.27 (3.59)	5.59 (2.41)
	percent	percent	percent
Education			
Less educated (below 8 years)	48.20%	46.10%	50.50%
More educated (above 8 years)	51.80%	53.90%	49.50%
Main activity			
Farmer	60.50%	69.60%	50.50%
Fisher	8.70%	11.80%	5.40%
Housekeeping	20.00%	7.80%	33.30%
Wage Labor	2.60%	2.90%	2.20%
Pupil/Student	3.60%	3.90%	3.20%
Teacher	2.10%	0.00%	4.30%
Other	2.50%	4.00%	1.10%
Monthly income			
Category 1 (0 to 30 Kina)	16.00%	15.70%	16.30%
Category 2 (31 to 200 Kina)	66.00%	63.70%	68.50%
Category 3 (above 200 Kina)	18.00%	20.60%	15.20%
Observations	195	102	93

Table 2 presents descriptive statistics of the lower bound (LB) and upper bound (UB) of money and labor time contributions, respectively. LB reflects the amount at which or below respondents would contribute for sure to support the construction while UB stands for the amount at or above which respondents reject to support the construction. The difference between UB and LB defines the degree of uncertainty.[11]

[11] Note that the number of observations differs slightly between the two payment vehicles due to missing values.

Table 2: Descriptive statistics of contributions by payment vehicle

	monetary contribution (Kina)		**labor time contribution (Hours)**	
	lower bound (LB)	upper bound (UB)	lower bound (LB)	upper bound (UB)
Mean	16.57	43.21	4.05	9.03
S.D.	32.34	47.26	4.05	9.65
Observations[#]	195	195	191	191

1 Kina = 0.37 US-Dollar

[#] Note that observations in the labor time payment vehicle do not sum up to 195 because of missing values.

Focusing on the monetary contributions first, the mean LB of 16.57 Kina corresponds well to the mean local daily wage of 18.42 Kina.[12] A one-sample t-test confirms that the average amount which participants would contribute for sure (LB) is statistically not distinguishable from the local average wage (16.57 vs. 18.42, $p = 0.43$). However, the mean UB of 43.21 Kina is about 2.6 times larger than the LB and statistically different from the local average (43.21 vs. 18.42, $p < 0.01$). Turning to labor time contributions, the mean LB of 4.04 h is about one hour lower than the mean local daily working hours of 4.99 h. The difference is statistically significant (4.04 vs. 4.99, $p < 0.01$). Similar to above, the mean UB of labor time contributions is about 2.2 times larger than the local average and statistically different from the mean of the daily working hours (9.05 vs. 4.99, $p < 0.01$).[13]

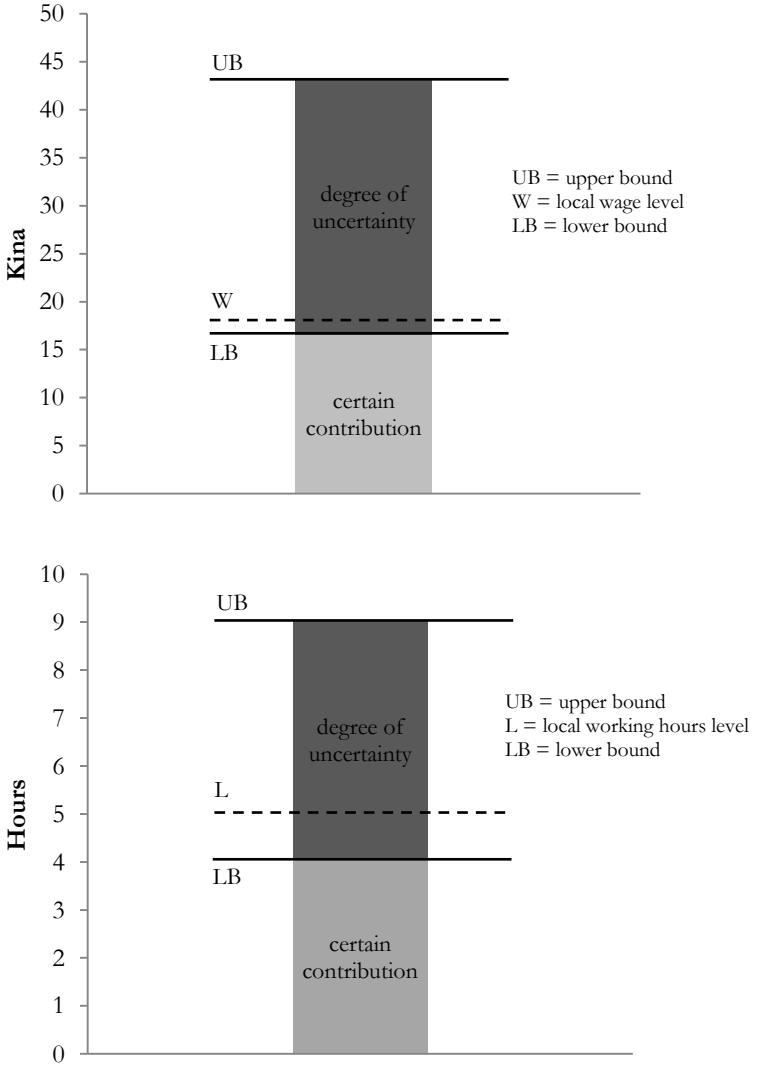
Figure 3 combines the mean values for LB and UB with the mean values of local wages and working hours separately for monetary (above) and labor time (below) contributions. The amount of money (hours) which participants would contribute for sure is at (below) the level of local wages (working hours). The difference between LB and UB indicates the degree of uncertainty. As Figure 3 demonstrates, the mean LBs are very close to local averages for wages and working hours. They seem to represent a reference point for respondent's answers: contributions below this point are more

[12] We asked respondents to state how much they would pay others for a full day of work; the average payment per day is 18.42 Kina (S.D. 6.66).

[13] We asked respondents to state how much they work on average during the day; respondents work 4.99 h on average (S.D. 3.27).

certain compared to contributions above this point. In other words, the size of the contribution is more certain when the costs for supporting the project are equal (lower) than earnings from daily wages (working hours).

Figure 3: Mean values of LB and UB by payment vehicle



4.2 Comparison of the two payment vehicles

To compare the two payment vehicles, monetary and labor time contributions, previous studies have converted labor time contributions into monetary contributions using information on local wage rates (see e.g. Gibson et al., 2015 or Vandolia et al., 2014). As the authors of these studies point out, the results are sensitive to alternative conversion factors. To compare uncertainty of monetary and labor time contributions independent from conversion issues, we define uncertainty as relative deviation of the LB from the UB:

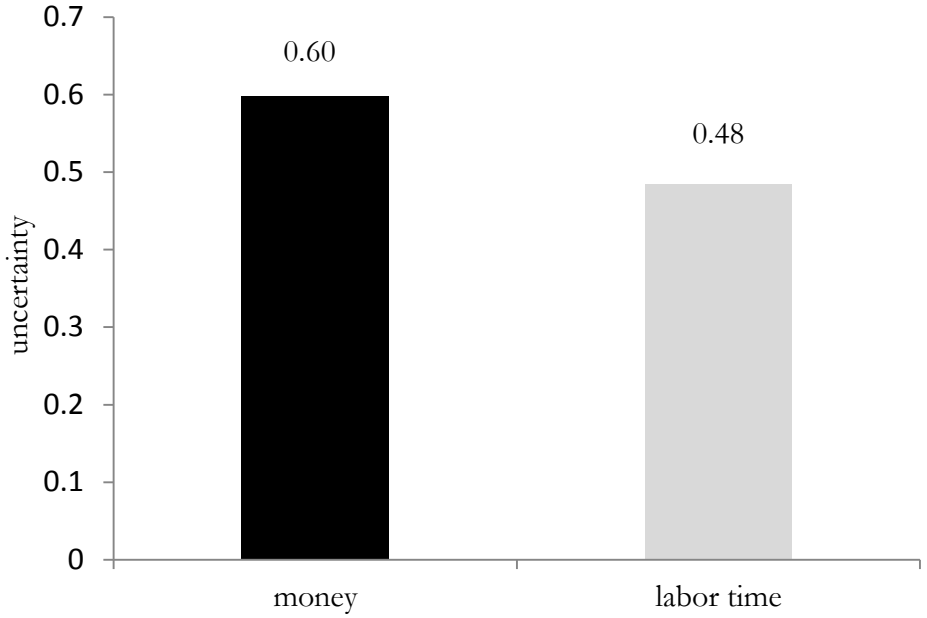
$$uncertainty_{i,j} = \frac{UB_{i,j} - LB_{i,j}}{UB_{i,j}}; \qquad i = 1,2,\dots,N; \;\; j = l,m \qquad (1)$$

with *j* being the payment vehicle (either labor (*l*) or monetary payment vehicle (*m*)) and *i* the respondent). This measure of uncertainty has the advantage that we can take into account the level of contribution of a respondent. A simple example illustrates the advantage: A difference between LB and UB of 10 cannot unambiguously be considered small or big; only a reference to the UB (equivalently, the LB) permits a classification of its size. If the UB is 20, the LB is half of the UB (20 – 10 = 10), so the degree of uncertainty is relatively big (20 – 10) / 20 = 0.5). In contrast, if the UB is 100, the LB amounts to 90, which makes the degree of uncertainty relatively small (0.1).

Before turning to an analysis on the level of the individual level, Figure 4 presents the mean values of the relative deviations for monetary and labor time payment vehicles. The mean level of uncertainty of labor time contributions is significantly smaller than the mean of monetary contributions (0.48 vs. 0.60, $p < 0.01$). Hence, uncertainty is reduced when people are asked for labor time contributions instead of monetary contributions.[14]

[14] The results are confirmed, when following the approach of earlier studies using the local minimum wage rate to convert labor time contributions into monetary contributions. The mean LBs for the two payment vehicles are statistically not different but the mean UBs are; i.e. uncertainty of monetary contributions is larger than uncertainty of labor time contributions.

Figure 4: Mean values of relative deviation of LB from UB by payment vehicles



To ensure that the differences in the means are not confounded by different background characteristics of respondents or geographical characteristics of individual villages, we specify the following linear regression model:

$$y_{i,j} = a + \gamma D_{i,j} + \beta x_i + \varepsilon_i; \qquad i = 1,2,\dots,N; \;\; j = l,m \qquad (2)$$

where $y_{i,j}$ represents the uncertainty of respondent *i* for payment vehicle *j* as defined in Eq. (1). The dummy variable D takes the value 1 for the labour payment vehicle and 0 for monetary payment vehicle. The parameter γ captures the difference in uncertainty between the two payment vehicles. The vector x_i contains a set of socio-demographic and regional characteristics including among others gender, age, education level, household size, marital status, and daily working hours. β is a vector of parameters to be estimated. The intercept is denoted by a and ε_i is the error term.

Table 3 presents results from a simple ordinary least square regression. The basic specification (1) controls for respondents' gender and the payment vehicle. Specification (2) extends the basic specification by participant's daily working hours. In specification (3) we add further demographic and socio-economic characteristics.[15] All specifications include village fixed effects and controls for interview effects (i.e., question order and enumerator effects).

Table 3: Regression results

	(1)	**(2)**	**(3)**
Payment vehicle (1=labor time, 0=money)	-0.110***	-0.110***	-0.109***
	(-0.021)	(-0.021)	(-0.021)
Gender (0=male, 1=female)	0.001	0.002	-0.005
	(-0.022)	(-0.021)	(-0.026)
Daily working hours		-0.013***	-0.014***
		(-0.003)	(-0.003)
Income (category 1 (low) to category 3 (high))			0.008
			(-0.018)
Education (1=more educated, 0= less educated)			-0.034
			(-0.023)
Age			0.002**
			(-0.001)
Constant	0.709***	0.808***	0.799***
	(-0.093)	(-0.095)	(-0.113)
Village fixed effects	Yes	Yes	Yes
Interview effects	Yes	Yes	Yes
Additional socio-economic controls	No	No	Yes
Observations[#]	364	364	364
R-sq	0.21	0.24	0.26

OLS-regression, robust standard errors in parentheses
Dependent variable: Uncertainty (relative deviation of LB from UB)
Interview effects: question order and enumerator effects.
Additional socio-economic controls: marital status, main activity, household size, and household head.
[#] Note that observations do not sum up to 386 (195+191) because of missing values. We only include non-missing observations with respect to socio-economic and demographic characteristics of the respondents.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[15] Due to missing observations for some socio-demographic characteristics the sample for specification (3) reduces from 386 to 363. For comparison, we estimate all specifications with this reduced sample.

The regression results confirm our earlier results based on descriptive statistics; significant differences in uncertainty exist between labor time and monetary contributions. The coefficient of the labor time dummy is negative and highly significant in all specifications. Thus, when respondents were asked for labor time contribution, uncertainty is reduced by about 11 percentage points compared to the elicitation using monetary contribution. In none of the specifications has gender an effect on uncertainty. Extending the model to control for further socio-demographic characteristics of respondents, longer working hours significantly reduce uncertainty independent of the payment vehicle; an additional working hour per day reduces uncertainty by 1.3 percentage points. Thus, people who work longer during the day compared to others are less uncertain about their contributions. All other socio-economic and demographic characteristics except for age have no significant impact on uncertainty.[16] Older respondents have significantly higher levels of uncertainty compared to younger ones.

To test the robustness of specification (3) we run regressions where we include additional factors that may influence uncertainty. More specifically, we would expect those that are more risk averse, those that live closer to the coast, and those that are afraid of a tsunami event in the future to be less uncertain.[17] Table 4 shows the results of the robustness analysis. We find sizeable effects for the new control variables. In particular, we find that that people in coastal villages (column 1), with higher levels of risk aversion (columns 2) and those with apprehension of a tsunami event (column 3) are significantly more certain about their contributions. These findings are as expected. However, the main finding remains: the coefficient of the payment vehicle dummy is significant, negative and of similar size compared to previous regression models. Thus, respondents are significantly less uncertain when they were asked for labor time contributions. The results for the other control variables are unchanged.

[16] We have also varied the specification of income and education, but the coefficients were never significant and more importantly, did not effect of our main variable of interest, the payment vehicle.

[17] We obtained information on risk preferences and subject's beliefs about tsunami events through the questionnaire. The variable *risk* had four possible answers ranged from "completely avoid to take risks" to "very willing to take risks". The variable *apprehension* also had four possible answers ranged from "not afraid at all" to "very afraid". Descriptive statistics of the variables are available upon request.

Table 4: Regression results

	(1)	**(2)**	**(3)**
Payment vehicle (1=labor time, 0=money)	-0.108***	-0.110***	-0.108***
	(-0.021)	(-0.02)	(-0.021)
Gender (0=male, 1=female)	-0.015	0.000	0.008
	(-0.026)	(-0.026)	(-0.026)
Daily working hours	-0.013***	-0.013***	-0.013***
	(-0.004)	(-0.003)	(-0.003)
Income (category 1 (low) to category 3 (high))	0.008	-0.002	0.000
	(-0.017)	(-0.018)	(-0.019)
Education (1=more educated, 0= less educated)	-0.026	-0.03	-0.03
	(-0.023)	(-0.023)	(-0.024)
Age	0.003**	0.002**	0.002*
	(-0.001)	(-0.001)	(-0.001)
Coast (1=coastal village/island, 0=hinterland)	-0.091**		
	(-0.040)		
Risk aversion (1=risk averse, 0=risk seeking)		-0.065***	
		(-0.024)	
Apprehension (1= very afraid, 0 = otherwise)			-0.107***
			(-0.031)
Constant	0.943***	0.729***	0.531**
	(-0.126)	(-0.110)	(-0.249)
Village fixed effects	No	Yes	Yes
Interview effects	Yes	Yes	Yes
Additional socio-economic controls	Yes	Yes	Yes
Observations[#]	364	364	355
R-sq	0.20	0.27	0.29

OLS-regression, robust standard errors in parentheses
Dependent variable: Uncertainty (relative deviation of LB from UB)
Interview effects: question order and enumerator effects.
Additional socio-economic controls: marital status, main activity, household size, and household head.
[#] Note that observations in specification 3 do not sum up to 364 due to missing values in the Apprehension variable, see also notes in Table 3.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion

In the context of rural households in developing countries, previous studies suggested the use of labor time as an alternative payment vehicle to money for the elicitation of WTC (see Hardner, 1996; Hung et al., 2007; Casiwan-Launio et al., 2011). The aim of this paper is to address the issue of uncertainty in the comparison of people's stated WTC time and money for a local public good in a non-monetized small-scale community.

Using the Range-WTC method in a contingent valuation study, we find strong evidence that the degree of uncertainty is reduced in stated WTC when respondents were asked for working time contributions instead of money. To avoid conversion issues we define uncertainty as the relative deviation of the amount at which or below respondents would contribute for sure from the amount at or above which respondents would not contribute.

We also analyzed factors determining the degree of uncertainty. In line with expectations, people who have a greater workload during the day (e.g., working close to the daily maximum), are less uncertain about their contributions. This effect holds for both payment vehicles. It can be argued that people who work relatively more have less additional time to allocate and are, therefore, more certain about their contribution. Similar, people with a higher work load are more likely to earn cash-income. These people might be, therefore, more certain about the value of money.

Furthermore, we find evidence that people use the local wage (working time) level as a reference point for dividing contributions into a certain and uncertain part. For both payment vehicles, contributions that lie below the local wage rates can be perceived as relatively certain while uncertainty is increasing with the distance to the local wage (working time) level. Our results provide, therefore, also valuable information to decision makers in non-monetized communities using cost-benefit analyses as one basis for decisions on environmental projects.

However, it is deterred to future research to generalize our findings to other cultural settings and to other public goods. Another promising direction is to address the issue

of uncertainty in the comparison of people's revealed and stated WTC time and money for a local public good. By applying the Range-WTC, one can then analyze the size of hypothetical bias that originates from uncertainty in both payment vehicles.

Acknowledgments

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Appendix

Table A1: Information Text

[*Read out the following text slowly and make sure that respondent understands everything*]

As you may know from own experience, earthquakes of different power occur frequently on Bougainville. For example, earlier this year there were several strong earthquakes within a few days that destroyed houses and other parts of villages in several areas of Bougainville.

For people like you living near the coast, earthquakes entail the additional threat of a tsunami. Earthquakes that occur in the open sea close to the coast can cause big waves (tsunami). If these waves arrive at the coast, they can cause devastating floods. Depending on the power and location of the earthquake, these floods can then destroy everything close to the coastline including beaches, trees, streets, houses and even whole villages. Further, a tsunami can put people's life in danger if they are not evacuated before the waves reach the coast.

Tsunamis cannot be prevented. However, in case of emergency people's lives can be saved by evacuating them. In order that people know where to go if a tsunami occurs, an evacuation route for your community could be built **[show picture of tsunami evacuation route]**. This evacuation route would enable people to reach a safe place (e.g. higher ground away from the coastline) in a short time. Signs will be needed along the evacuation route to direct people in case of emergency. They also help people to find the right way even if they are in a hurry. Further, to make evacuation possible for children, old people and disabled people, railings will need to be built at places that cannot be easily passed, for example bridges over streams or handrails along steep slopes.

In your community members could be saved from future events by implementing such an evacuation route. Constructing the evacuation route would include the following tasks:

- **Purchasing materials** for bridges and handrails (e.g. timber and ropes);
- **Purchasing weatherproof signs** that indicate the evacuation route;
- **Constructing the evacuation route.** This includes physical tasks like cutting bushes, constructing handrails and bridges, placing the signs along the route.
- **Cleaning up the route after construction.** This includes physical tasks like collecting and putting away groove, waste and other construction materials.
- **Providing food and water** for community members and other people who work on the construction

The construction of this route can be done by community members and other people. However, before any decision about planning or constructing of this route is made, we want to know what people in your community think about such a project. In the following we would like to know what you think about this evacuation route and if you would personally contribute to its construction.

[*Go on to the next page and start with questions B.02 to B.06*]

Table A2: Willingness to contribute elicitation

Please **assume** that the evacuation route will be constructed in the near future.

B.03	B.04
Would you be willing to contribute **money** to the construction of the evacuation route? 1 Yes → B.04 2 No → B.05	In the following we are asking for **two different things**: 1) **How much Kina would you for sure contribute** to support the construction of the evacuation route? (*Write down amount of Kina*) _____**Kina** 2) **At or above which amount of Kina would you for sure not support** the construction of the evacuation route? (*Write down amount of Kina*) _____**Kina** Naturally, **the amount of money** that you announce **in the first question** – the money you would give for sure – **is smaller than the amount of money in the second question** which represents a kind of **upper limit at which** you would **not support** the construction of the evacuation route (money you would not spend since it would be too much). Please be as realistic as possible. Remember that you have daily and monthly expenses for food (e.g., rice, tea, sugar) and other consumables (e.g., clothes, fuel, seeds). → *go on with B.05*

B.05	B.06
Instead of money, you could also contribute part of your time. Would you be willing to contribute **part of your time** to the construction of the evacuation route? 1 Yes → B.04 2 No → C.01	In the following we are asking for **two different things**: 1) **How many hours would you for sure contribute** to support the construction of the evacuation route? (*Write down number of hours*) _____**Hours** 2) **At or above which amount of hours would you for sure not support** the construction of the evacuation route? (*Write down number of hours*) _____**Hours** Naturally, **the number of hours** that you announce **in the first question** – time you would spend for sure – **is smaller than the number of hours in the second question** (time you would not spend since it is too much). Please be as realistic as possible. Remember that you have demands on your time for example subsistence activities (including planting, fishing, housekeeping, etc.) and social activities (like family affairs, meeting friends, community meetings, religious services etc.).

Figure A1: Picture of a tsunami evacuation route. This picture was shown to respondents during the interview

Ethical aspects of the study

The surveys used in this paper do not involve deception and the anonymity of the subjects was guaranteed. There was no danger of physical or psychological damages to be expected from participants. All people voluntary participated in the studies and were told to leave at any point of time if they feel uncomfortable with the situation. Moreover, prior the field research was conducted, the research teams were requested to give a presentation of the research methods and goals to the local communities and regional authorities. In all cases the request was granted approval. Our research project was also supported by the regional government of Bougainville and by the Teop Council of Elderly.

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Paper 4: Cooperation and punishment patterns in a small-scale society: A comparison between second-party punishment and third-party punishment

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Abstract:

This study examines the effectiveness of second-party punishment (punish as active party) and third-party punishment (punish as by-standers) by conducting economic field experiments in a small-scale society of Papua New Guinea.

Previous studies propose that second-party punishment is common in small-scale societies, while third-party punishment emerges if a society becomes larger and more complex. However, none of the existing studies investigate the effectiveness of second-party punishment and third-party punishment in maintaining cooperation in the form of a collective action problem (e.g., the prisoner's dilemma in its simplest form). Furthermore, previous studies restrict their analysis exclusively on altruistic punishment and neglect the phenomenon of anti-social punishment (i.e., punishment of cooperators).

Our results provide evidence that second-party punishment promotes cooperation more than third-party punishment and that third-party punishment is even detrimental for cooperation in a small-scale society. We also show that anti-social punishment is endemic and provide suggestive evidence that anti-social punishment is based on spiteful behavior.

Keywords: cooperation, prisoner's dilemma, punishment, economic field experiment, small-scale society

JEL Classification: C71, C93, D63, D64, H41

1. Introduction

The scale of cooperation in both contemporary and past human societies remains a puzzle for the evolutionary and social sciences. Cooperation among humans is remarkable given that many interactions in large modern societies are one-shot encounters between strangers. Cooperation in these instances cannot be explained by the benefits that accrue from repeated encounters (Akelrod, 1986; Coleman, 1990; Fehr and Fischbacher, 2003; Nowak, 2006; Nowak, 2012; Balafoutas et al., 2014).

Altruistic punishment (AP) is one of the most prominent theories that have been proposed to explain cooperation. The theory of AP proposes that cooperation can be sustained in groups if individuals are willing to punish non-cooperators even at a cost to themselves (Henrich and Boyd, 2001; Boyd et al., 2003; Gintis, 2003; Choi and Bowles, 2007). Previous research has shown that AP can explain why genetically unrelated individuals are often able to maintain high levels of socially beneficial cooperation (e.g, Fehr and Gächter, 2002; de Quervain et al, 2004; Gürerk et al., 2006; Rockenbach and Milinski, 2006).

Based on evidence from economic experiments conducted in western and industrialized societies, some authors propose that humans make use of AP because we exhibit strong reciprocity (Gintis, 2000; Fehr and Gächter, 2002; Fehr et al., 2002). Strong reciprocity may involve either second-party punishment, i.e. punishing those who defect on you, or third-party punishment, i.e. punishment those who defect on someone else, even if they are strangers to you (Fehr and Fischbacher, 2004).[1] Second party punishment appears to be motivationally stronger than third punishment. This is shown by the fact that emotions of anger and the willingness to retaliate are stronger when one is wronged, rather than when one observes others being wronged. On the other hand, third-party punishment, by making everyone a possible 'guardian' of the compliance by everybody else with social norms, ensures a much tighter control over the social order than second-party punishment. A high percentage of third-party punishers can limit the options of

[1] Strong reciprocity is defined as, 'a predisposition to cooperate with others and to punish those who violate the norms of cooperation, at personal cost, even when it is implausible to expect that these costs will be repaid either by others or at a later date' (Gintis et al., 2003, p.153).

defectors and could lower the costs of punishment if everyone shares the cost.[2] In a cross-cultural project Henrich et al. (2006) showed that both second-party punishment and third-party punishment appear widespread in human groups ranging from small-scale traditional societies (e.g., foragers) to large-scale complex societies (e.g., college students). These findings imply that rational choice theory is not appropriate for explaining the variations in human behavior across societies (Henrich et al., 2001, 2005; Boyd et al., 2003; Gintis et al., 2003). In particular, people are willing to spitefully punish stingy players and tend to be more generous than is necessary to avoid being punished (Henrich et al., 2004), and even punish as third parties.

Using data from Henrich et al. (2006), Marlowe et al. (2008, 2010) investigated if the willingness of third parties to punish norm violators exists among all, or even most societies where there is no government, law or police – societies more similar to those our ancestors lived in before agriculture. They show that people in larger, more complex societies engage in significantly more third-party punishment than people in small-scale societies. Marlowe et al. (2008, 2010) then infer that second-party punishment may be sufficient to explain cooperation in small-scale societies, while third-party punishment is a necessary condition if a society becomes more complex, with more anonymity that cheating becomes more tempting and more difficult to monitor.

The present study investigates cooperative behavior in the form of a collective action problem. By using experimental economic games, we want to test the hypothesis that second-party punishment promotes cooperation more than third party punishment in a small-scale society. Moreover, we are interested in studying the two possible directions of punishment: punishment of defectors (altruistic punishment) and punishment of cooperators (anti-social punishment).

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[2] Reputation offers an alternative solution to altruistic punishment because third parties could simply avoid interacting with those who have a bad reputation rather than paying a direct cost to punish (Gintis et al., 2001; Panchanathan and Boyd, 2004, 2005; Smith, 2005; Rockenbach and Milinski, 2006). However, with greater anonymity in larger populations, there is a greater likelihood of interacting with a stranger whose reputation is unknown. The lack of information on the history of past encounters prevents reputation to be efficient in maintaining cooperation. Third-party punishment then poses a possible solution to this problem because any third party may punish even a stranger who defects on someone else.

The present paper contributes to the existing literature in various ways. First, Henrich et al. (2006) and Marlowe et al. (2008, 2010) interpret their results with respect to deviations of a distribution norm, while we extend their analysis to deviations of a cooperation norm in a collective action problem.[3] From an evolutionary perspective, cooperation problems may be even more important than division problems since they permit efficiency gains. Thus, we can draw inference on the effectiveness of second-party punishment and third-party punishment in maintaining cooperation in a small-scale society. Secondly, Henrich et al. (2006) and Marlowe et al. (2008, 2010) restricted their analysis exclusively to altruistic punishment. In our analysis we consider the phenomenon of anti-social punishment, that is, people might punish not only defectors, but cooperators too.

Anti-social punishment is widespread in some societies but not in others (Herrmann et al., 2008; Beckmann et al., 2002). The underlying motivations for anti-social punishment are not clear. They may range from spitefulness, rejection of anti-conformist behavior, or (in repeated interactions) vengeance (for more details see Jensen, 2010). Existing studies in evolutionary theory even show that costly punishment no longer promotes cooperation when anti-social punishment is present (Rand et al., 2010; Rand and Nowak, 2011). In a cross-cultural study using economic experiments, Herrmann et al. (2008) find that the existence of anti-social punishment is correlated with the lack of norms of civic-oriented behavior. Anti-social punishment may then be widespread in small-scale societies where norms of civic cooperation are weak, and thus, should be considered when investigating the effectiveness of AP in maintaining cooperation. Third, the interplay between second party and third party punishment, and their psychological underpinnings, are still largely unexplored topics. The empirical evidence is limited to virtually one study (Fehr and Fischbacher, 2004). In the present study we can provide a rigorous comparison between the two mechanisms.

[3] Henrich et al. (2006) and Marlowe et al. (2008, 2010) conducted the following three experimental economic games: the ultimatum game (UG), the third-party punishment game (3PPG) and the dictator game (DG). The UG is used to examine second-party punishment. This is done by analyzing player 2's willingness to reject an offer made by player 1. The 3PPG is used to analyze third-party punishment. In this game, a third party (Player 3) can decide to punish a dictator (Player 1) who decides how much of the shared stake to give to Player 2. For more details about the experimental games, see supporting online material in Henrich et al. (2006).

To provide evidence, we implemented a series of anonymous, one-shot, prisoner's dilemma (PD) games among the Teop, a small-scale society located in Bougainville, Papua New Guinea. Centralized institutions for the enforcement of legal rules are largely absent in PNG, meaning that social norms almost exclusively regulate social life. In addition, PNG societies more closely resemble the human societies under which our social preferences evolved than the modern, complex societies in which most people at present live.[4] Therefore it is an ideal environment for studying the mechanisms of second-party punishment and third-party punishment in the context of a collective action problem.

Our experimental design consists of three treatments. In the baseline treatment two participants take part in a standard PD. This treatment is intended to measure the basic level of cooperation in the society. In the second-party punishment treatment (hereafter, 2PP) the PD is followed by a second stage where players can spend money to reduce the counterpart's payoff. In the third-party punishment treatment (hereafter, 3PP) we examined the willingness of a third party to punish deviations from cooperation norms in the PD.

We find that second-party punishment promotes cooperation significantly more than third-party punishment. However, we are the first to show that third-party punishment has detrimental effects for the effectiveness of maintaining cooperation in a small-scale society. The level of cooperation in the 3PP treatment is significantly lower than the level of cooperation in the baseline treatment. We also show that anti-social punishment is endemic in 2PP and 3PP. Defectors are significantly more punished than cooperators in the 2PP treatment, while the patterns of punishment are more complex in the 3PP treatment. Based on these findings we can speculate that anti-social punishment has a spiteful component.

The remainder of the paper is organized as follows: Section 2 provides an overview of the Teop society. Section 3 includes a description of the experimental design (3.1), and

[4] Henrich et al. (2010) make a compelling argument that WEIRD (Western, educated, industrialized, rich, and democratic) societies are relatively novel within evolutionary history and that data from non-Western small-scale societies are essential for testing hypotheses that relate to the human condition.

procedures (3.2). Section 4 provides the results for cooperation and punishment patterns. Section 5 provides a discussion of the results and concluding remarks.

2. Subject pool: the Teop society

The Teop society represents a unique Austronesian language group and is one of the 21 ethno-linguistic groups living in the island of Bougainville, an autonomous region of Papua New Guinea. Less than 10,000 people belong to the Teop. Our subjects were recruited from small settlements located in the northern part of the main island (see Figure A1 in the appendix).

Teop people live in villages that vary in size from 50 to 200 people, and are either located along the coast or in the hills. Their subsistence is based on horticulture and pig husbandry, supplemented by fishing, hunting and foraging (Regan and Griffin, 2005). Gardening is the main subsistence activity, but hunting provides a welcome addition to their diet. Sweet potatoes and taro are the main food. Most families raise chicken and a few pigs, which are an integral part of the gifts presented in the exchanges and ceremonies recurrent in village life (e.g. bride price, compensation fee).

Some of the surplus from the subsistence sector is sold on markets. Small outdoor markets are found occasionally along the roads, where women and children sell their garden produce, and other commodities such as string bags, betel nuts, and limes. Cocoa and copra are the main commercial crops. These crops are harvested several times a year and sold to intermediaries in one of the larger capitals at the coast.

Formal (centralized) institutions for the enforcement of legal rules and shared morality are largely absent in PNG. This means that social norms almost exclusively regulate social life (Bernhard et al., 2006). Teop is one of the tribal societies of Polynesia/Melanesia where these social norms are guarded by big men. Big men have a large group of followers within their clan or related groups. They possess exclusive knowledge and 'imposed discipline, upheld the traditional way of life and gave executive directions' (Cochrane, 1970, p. 137). Social disputes or problems of coordination between clans (wantoks) have traditionally been dealt with under the supervision or explicit intervention of big men.

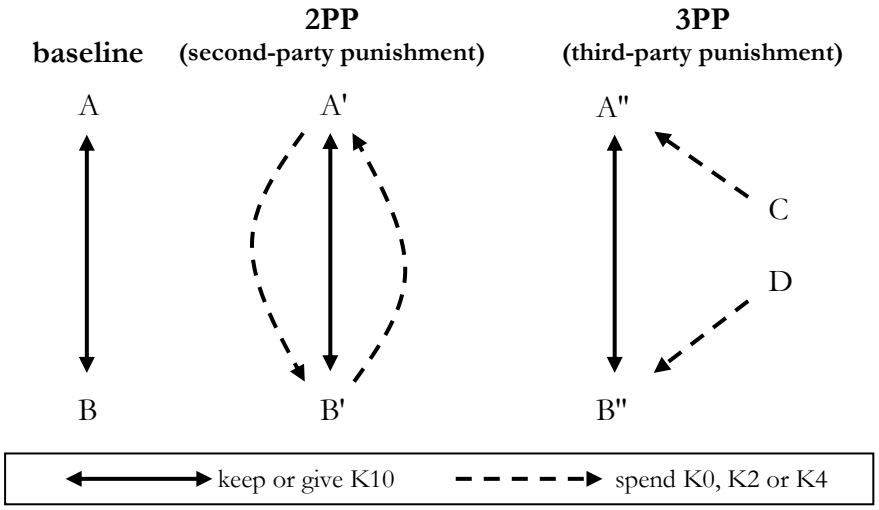
Another unique feature of Teop society is matrilineality. Women's social position in Bougainville culture has its origin in land ownership. The matrilineal kinship structure gives women considerable power over material resources and activities that are economically and ritually important. Women's prerogative over land includes defining land boundaries, giving permission to hunt or to harvest timber, and the exclusive right to veto decisions on land-related matters. While male relatives have rights to ownership, their rights are limited and conditional on female relatives' permission (Saovana-Spriggs, 2003). Moreover, unmarried, divorced, or widowed brothers and sons reside in the home of their female relative. Even married men who live with their wife's family are expected to spend much of their time in their mother's or sister's household. Still, there are some predominantly male domains. Women hardly participate in politics (neither regional nor local) and do not physically take part in tribal or civil conflicts.

3. Experimental design and procedure

3.1 Methods and experimental design

In this study, we conducted a series of anonymous, one-shot, prisoner's dilemma (PD) games involving two participants. The experimental design and methods presented in this section are comparable to those of Fehr and Fischbacher (2004). Figure 1 summarizes the design of the experiment.

Figure 1: Experimental design (baseline, 2PP and 3PP)



In the baseline condition both participants (A and B) received 10 Kina (K10) to be used in the game (Endowment I) and K4 (Endowment II) that was not used in the game but was cashed in at the end of the game.[5] Participants had to decide whether they wanted to keep K10, or give K10 to the other participant. If a participant kept the K10, this person would cash in the K10 at the end of play. If a participant gave K10, the other person would receive K20 at the end of play. Therefore, if both participants kept their K10 (mutual defection), they would both receive K10 at the end of play. If both participants gave K10 to the other person (mutual co-operation), both would receive K20. If one participant kept K10 and the other gave K10, the former would receive K30 while the latter would receive K0. Table 1 summarizes the payoff matrix of the prisoner's dilemma. This payoff structure, in its simplicity, resembles a "tragedy of the commons" (Hardin, 1968). Participants aiming to maximise their individual earnings should always keep their Endowment I. But this results in a collective loss in comparison to both players giving to the other. Participants made their decision privately and anonymously, not ever knowing who their co-player was. The only information they received is that the co-player was from their own village or other villages in the area. Unlike other research conducted in small-scale societies, experimenters left the experimental room when participants made their choice, so they ignore participants' decisions. A total of 85 participants took part in the baseline treatment.

Table 1: Payoff matrix of the prisoner's dilemma (PD)

Player A/ Player B	**Cooperation**	**Defection**
Cooperation	K20, K20	K0, K30
Defection	K30, K0	K10, K10

[5] 1 Kina ~ 0.4 US-Dollars. K10 correspond to about 50 % of the one day's wage in the area.

Second-party punishment (2PP treatment) was modelled as standard in the literature (Gächter and Fehr, 2002; Fehr and Fischbacher, 2004) by introducing a punishment stage after participants played the PD game described above. Either player could spend the K4 from Endowment II to reduce the other participant's payoff. Each participant could spend K0, K2 or K4 to reduce the counterpart's payoff by K0, K10, or K20, respectively. The strategy method was used to investigate punishment patterns. Each participant had to make two decisions under the assumption that the other participant had either kept K10 or given K10. This set up allows to examine patterns of both "altruistic" punishment and "anti-social" punishment (Hermmann et al., 2008). Such a punishment ratio of 5:1 is larger than what commonly used in the literature (Anderson and Putterman, 2006),. but ensures that defectors final payoffs - in case the other player cooperated –goes significantly below that of mutual cooperation if the defector is punished. It also enabled us to keep the explanation and the computation of payoffs in the game as simple as possible. Since the Kina currency has both K2 and K10 bills, we could visually show on the playing board that every time a K2 bill was spent by one player, the other player's money was reduced by K10. Handing out the K4 "Endowment II" in all treatments guarantees the absence of income effects across treatments (net of the punishment decision in the punishment treatments). In the 2PP treatment the punishment stage followed the PD game and decisions were, again, made privately. A total of 59 participants took part in the 2PP condition.

Third-party punishment was modelled by introducing the possibility of third party punishment into a prisoners' dilemma (PD) game, hereafter referred to as 3PP. Like above, 3PP had two decision stages. In the first stage, two participants (A and B) took part in a PD game as described above. The data from this first stage provides information about the level of cooperation when a third party is able to punish norm violations. In the second stage, two third participants (C and D) had the opportunity to reduce the payoff of one each of the two participants who had taken part in the first stage of the 3PP treatment. Third parties received an endowment of K34 at the beginning of the second stage (after not receiving any endowment in the first stage). Once in the second stage, they could spend then K4 to reduce the payoff of one of the participants in the first stage. He/she could spend K0, K2 or K4 to reduce payoffs by

K0, K10, or K20, respectively. The K30 were not used in the game and cashed out at the end. We choose such a high amount in order to avoid that punishment behavior is driven by aversion to disadvantageous inequality (the maximum payoff in PD equals K30). Again, the strategy method was used to investigate punishment patterns. The third party had to make four decisions under the assumption that the PD-player had either kept K10 or given K10, conditional on the other player either keeping K10 or giving K10. A total of 25 participants took part in the PD and 21 participnats acted as third parties.[6] To compensate this disparity in the matching-process, we used the decisions of four randomly drawn third parties, and applied their decisions to the second parties.

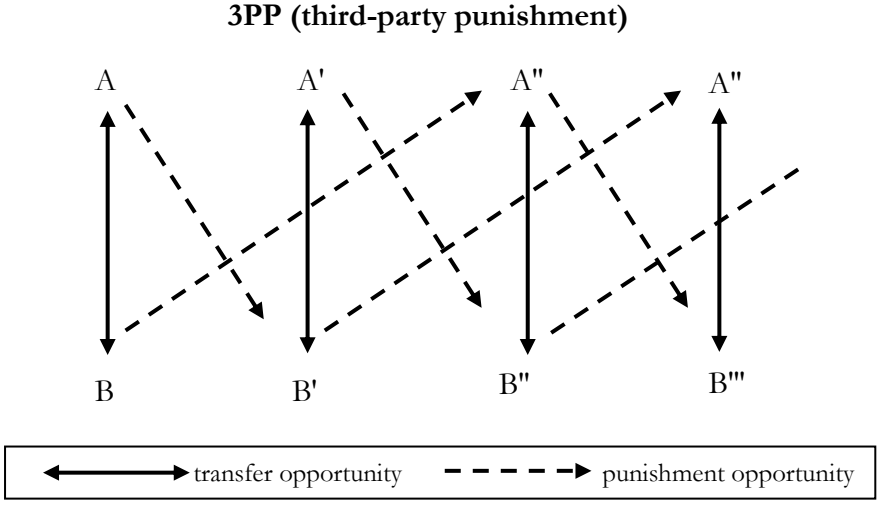
As mentioned above, the experimental design of the present study closely follows the protocol of Fehr and Fischbacher (2004), but differs from it in some imporant respects. To compare 2PP and 3PP, Fehr and Fischbacher (2004) conducted a specifically designed third-party punishment treatment, in which there is no external player C (see Figure 2). Rather, player A and player B both acted as third parties with respect to two other PD-players in another game. In other words, both players took part in a PD followed by a punishment stage where they could only sanction one of the other players (A or B) of another PD group (not the other player of their own group).[7] Fehr and Fischbacher (2004)'s implicit justification for using this form of "concatenated" punishment across pairs of PD-players is that in this way in both the 2PP and the 3PP the punisher had been involved in a PD prior to make their decisions, and as such it permits to contrast in the most rigorous possible way 2PP and 3PP. In our context, implementing a matching like the 3PP used in Fehr and Fischbacher (2004) would have likely proved too complex for our participants. Moreover, the punishment choices in Fehr and Fischbacher (2004) may possibly depend on the expectation of the outcomes from the PD played in the first stage and cause some endowment effects. Since cooperation levels are likely to be higher under 2PP than in 3PP, this may introduce a

[6] Note that the observations in baseline, 2PP and 3PP are not balanced. This was partly due to time and financial constraints. In particular, the procedures of the 3PP treamtnet are much more time-consuming compared to the baseline and 2PP.

[7] For more details, see chapter 5 and Figure 7 in Fehr and Fischbacher (2004).

confound in punishers' behavior between 2PP and 3PP. For this reason we think that it is interesting to test the robustness of Fehr and Fischbacher (2004)'s findings using a different design, where the punisher in the 3PP has *not* played a PD prior to her engagement in the game and when no uncertain endowment effects may condition her choice. Arguably, having a third party who has not been previously involved in a PD game may be seen as being closer to the original "idea" behind third-party punishment, in that the third party is a complete stranger to the interaction. A prior involvement of the third party in the PD game, as in Fehr and Fischbacher (2004), may urge individuals to act according to motivations such as indirect reciprocity (I punish A" because I expect B' to punish my counterpart A) or even wishful thinking, which are all too common in human behavior (e.g. Foddy et al., 2009). Finally we note that in our design, similarly to Fehr and Fischbacher (2004), the third-party in the 3PP is restricted to punish only one player, as is the punisher in the 2PP. We can use these data to compare it with punishment patterns of the 2PP treatment. Moreover, we think the indpendence of player C and D is necessary to reflect the true characteristics of a third-party.

Figure 2: Design of the third-party punishment treatment in Fehr and Fischbacher (2004)



3.2 Procedure

The field research took part from October to November 2014 in the east northern part of Bougainville Island (PNG). A total of 190 participants - 97 male and 93 female - voluntarily participated in 26 experimental sessions across 13 villages (Table A1 summarizes demographic and socio-economic characteristics of the participants). Recrutment was done by drawing a random sample from a residence list. In some cases these lists were already availabe, in some other cases we asked local village chiefs to prepare one. People were informed about their participation one day in advance. They were asked to show up at a given time. In order to minimize collusion we allowed only small groups of people to participate at once. Experimetnal sessions in a village did not last longer than 3 days.

Procedures followed those set out by Henrich et al. (2006)..[8] Participants were summoned in the 'waiting area', and were assigned an ID-number by our local research assistants (see Figure A2 in the appendix). Participants completed a questionnaire including socio-economic characteristics and received K5 in cash as a show-up fee.[9] Unlike Henrich et al. (2006), the game was never introduced at this stage, in order to minimise the risk of collusion or contagion. Subsequently, participants were randomly assigned to one of the two experimenters in two separated 'playing areas' (PA) (see Figure A3 in the appendix). In order to facilitate comprehension, the game was illustrated using a playing board and real money. Participants' comprehension was tested asking them to calculate payoffs corresponding to different actions. We recorded the number of mistakes in the four comprehension questions. In case of mistakes, the game was explained again and participants were asked to recalculate. Only participants who answered correctly were allowed to take part in the game (about 8 % were dismissed from the experiment). In treatments 2PP and 3PP we used a similar procedure in order to test comprehension for the punishment option.

[8] See protocols in the appendix. All sessions were conducted in Tok Pisin.

[9] We followed Henrich et al. (2006) when determining the amount of the show-up fee. K5 correspond to about 25 % of the one-day's wage in the area.

After passing the comprehension stage, participants made their decisions inserting K10 bills into one of two envelopes. One envelope was labelled 'Give' and the other 'Keep'. Both envelopes were then inserted into a large envelope to protect the anonimity of the choice. The K10 bills were tied to a stick so the experimenter could check the correctedness of the choice manipulating the large envelope from the outside. Participants in the 2PP and 3PP treatments made their punishment decision similarly. They indicated their punishmend decision by putting a stick into one of the three envelops labelled with 'spend K0', 'spend K2' and 'spend K4'. In 2PP, participants had to make two decisions. First, they were asked to decide how much of their K4 endowment to spend to reduce their counterpart's payoff assuming this person had kept K10. Subsequently they were asked to decide how much money to spend assuming that their counterpart had given K10. In 3PP, the third party had to make four decisions. First, they were asked how much they want to spend to reduce Player A's (B's) payoff assuming both players kept K10. Secondly, third parties were asked how much they want to spend to reduce Player A's (B's) payoff assuming Player A (B) kept K10 and Player B (A) gave K10. Thirdly, third parties were asked how much they want to spend to reduce Player A's (B's) payoff assuming both players gave K10 to their counterpart. Fourthly, they were asked how much they want to spend to reduce Player A's (B's) payoff assuming Player A (B) gave K10 and Player B (A) kept K10. We kept the order of punishment decisions constant throughout all sessions.
Experimenters and assistants left the room when participants made their decision in order to guarantee anonymity of decisions.

To minimize village and session effects that influence our treatments, we randomized all treatments over villages and sessions. In doing so, treatments were administered following a pre-fixed order whose sequence was randomised prior to the session.
Payment of participants was done at the end of each session or when leaving the village. We put the money into untransparent envelops labelled with the ID-number, which were handed out to the participant holding the corresponding ID-number.

4. Results

4.1 Cooperation rates

Cooperation is highest in the 2PP treatment. 58 % of participants gave their Endowment I to their counterpart in the 2PP condition, in comparison to 46 % in the baseline condition. However, this difference is statistically not distinguishable ($Z = -1.382$, $p = 0.167$).[10] The most striking result is the low level of cooperation in 3PP. Only 20 % of the participants decided to give their Endowment I to their counterpart in this treatment. Hence, cooperation rates are not only lower in 3PP than in 2PP but even fall below the level of the baseline condition. These differences are statistically significant (0.46 vs. 0.20, $Z = 2.312$, $p = 0.021$; 0.58 vs. 0.20, $Z = 3.143$, $p = 0.002$). Table 2 includes summary statistics of cooperation rates in more detail.

Table 2: Summary statistics of cooperation rates

treatment	mean	S.D.	N
baseline	0.46	0.50	85
2PP	0.58	0.50	59
3PP	0.20	0.41	25

To ensure that these findings are not confounded by different background characteristics of subjects across sex or environments, Table 3 presents results from a simple regression model. We use a logit model because cooperation is a dichotomic variable, which equals 1 if a participant co-operated and 0 otherwise. Column 1 includes a specification that controls for the environment of a village (mountain or coastal)[11], experimenter effects, gender and comprehension. The specification in Column 2 adds additional demographic controls, such as, age, education and an index of household wealth. Introducing such extra controls comes at the cost of losing many observations due to no-responses; hence we report both analyses in Table 3. However, all previous

[10] All tests in means are conducted by using a Wilcoxon rank-sum test.

[11] Villages at the study site can be grouped into a mountain (3 villages) or a coastal environment (10 villages). We used this categorization to generate a 'mountain dummy' which equals 1 if the village is in the mountain and 0 otherwise. This 'mountain dummy' captures most of the between-village variability in 'behavior' observed in the experiment (cooperation and punishment). Further, including the mountain dummy instead of village fixed effects allows us to save degrees of freedom.

results hold even in the specification with fewer observations (column 2). The level of cooperation is significantly lower in 3PP than in the baseline and 2PP condition. Among the controls, age is strongly positively associated with co-operation which is in agreement with what has been found in Western societies (Bellemare and Kröger, 2002). It is worth noting, that our measure of comprehension does not drive the differences in the treatments.

Table 3: Logistic linear regression, all treatments

Dependent variable	'Cooperation'	
	(1)	(2)
2PP	0.501	0.438
	(0.346)	(0.373)
3PP	-1.312**	-1.405**
	(0.591)	(0.708)
Gender	-0.353	-0.527
	(0.332)	(0.380)
Age		0.040***
		(0.015)
Education (6 to 10 years)		0.688
		(0.885)
Education (above 10 years)		0.912
		(1.138)
Wealth		-0.072
		(0.206)
Wald test of equality of coefficients		
H_0: 2PP = 3PP	1.813***	1.843**
	(0.616)	(0.721)
N	169	155
pseudo R-sq	0.07	0.12
Log lik.	-108.250	-93.352

Note: A logistic regression model has been fitted. Huber-Whyte heteroskedasticity-robust standard errors are reported in parentheses. The dependent variable is Cooperation. It equals 1 if a participant gave the sum of K10 to the counterpart and 0 if they kept it.
Both models include the following additional controls: mountain dummy, experimenter dummy and comprehension measure.
The Wald tests reported at the bottom of the table are run on the null hypothesis that pairs of dummy coefficients identifying a treatment are equal to each other.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2 Punishment patterns

The main results of the analysis of 2PP and 3PP can be summarized as follows: both second parties and third parties strongly punish cooperators, and thus, anti-social-punishment (ASP) is widespread in the small-scale society of Teop. Defectors are significantly more punished than cooperators in the 2PP condition, while the patterns of punishment are more complex in the 3PP condition. Third parties punish defectors who were matched with another defector nearly as much as they punish cooperators who were matched with other cooperators in the PD. Moreover, the difference in the strength between second-party punishment and third-party punishment depends on the role of the punished person's PD partner and is of similar size for AP and ASP. The high patterns of punishment of cooperators even in third-party punishment sessions suggest that spitefulness played a conspicuous role in motivating punishment in our experiments.

Table 4 provides support for this claim. The table presents the average fraction of endowment II (K4) spent for altruistic punishment (punishing defectors) and anti-social punishment (punishing cooperators) in 2PP and 3PP. For the 3PP condition we include all four situations that can emerge in the PD.

Table 4: Mean fractions of Endowment II (K4) spent for punishment in 2PP and 3PP (standard deviation in brackets)

Punished person is a	2PP	3PP if the punished person's PD partner cooperates	3PP if the punished person's PD partner defects
Defector	0.66 (0.40)	0.67 (0.29)	0.42 (0.40)
Cooperator	0.51 (0.47)	0.50 (0.35)	0.19 (0.29)

In 2PP, respondents spent on average 66 % of their Endowment II to punish defectors and 51 % to punish cooperators. This difference is statistically significant by using a Mann-Whitney test (Z = -2.087, p = 0.037) and robust to potential confounders (see ordered logit regression in Table 5).[12]

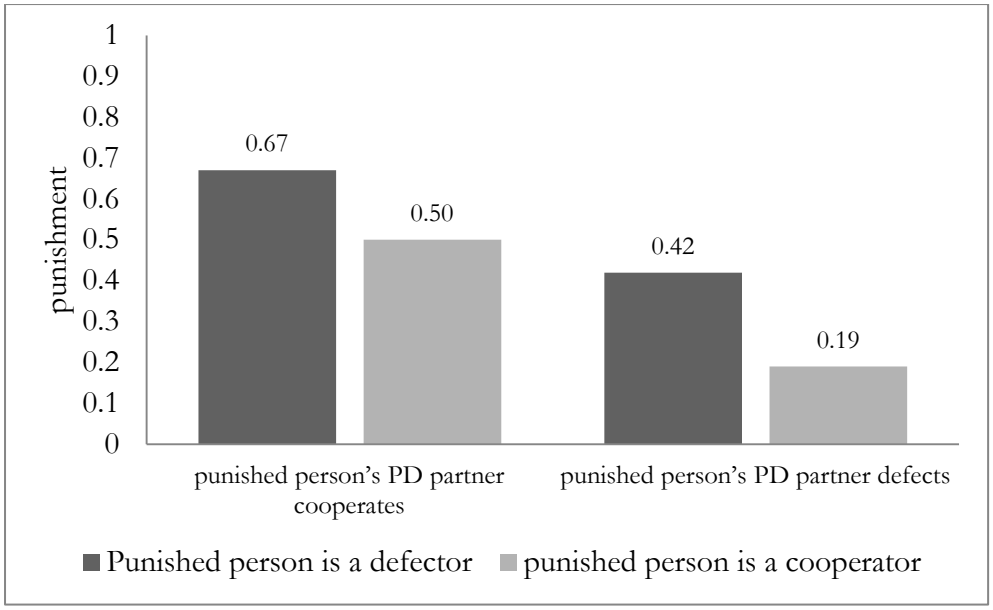
Table 5: Ordered logit regression, 2PP treatment

Dependent variable	'Punishment'	
	(1)	(2)
Anti-social punishment	-0.62**	-0.73**
	(0.29)	(0.32)
Gender	0.18	-0.32
	(0.42)	(0.50)
Age		-0.03
		(0.02)
Education (6 to 10 years)		1.30
		(0.98)
Education (above 10 years)		0.56
		(1.46)
Wealth		0.19
		(0.35)
N	118	106
pseudo R-sq	0.02	0.07
Log lik.	-119.67	-102.77

Note: An ordered logit model has been fitted. Heteroskedasticity-robust clustered standard errors are reported in parentheses. Clusters are given by individuals. The dependent variable is Punishment, which takes on the values K0, K2 and K4. The columns report results for overall punishment, that is, pooled data of punishment decisions (against both defectors and cooperators);
Both models include the following additional controls: mountain dummy, experimenter dummy and comprehension measure.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[12] We also analyzed punishment patterns of 2PP with respect to the participant's choice in the PD. Cooperators and defectors spend on average exactly the same amount for punishing defectors (66 % of Endowment II). In contrast, cooperators tend to spend more of their Endowment II than defectors for the punishment of cooperators (57 % vs. 42 %), although this difference is statistically not significant (Z = 1.24, p = 0.22). These results suggest that anti-social punishment in 2PP is not only high (on average 51 %) but also has a spiteful component.

Figure 3: Mean fraction of Endowment II (K4) spent in 3PP



The patterns of punishment in the 3PP treatment are more complex. Figure 3 illustrates these patterns separately and shows that punishment behavior follows a linear pattern. Third parties spent the largest fraction of their Endowment II for punishing a defector who was matched with a cooperator (67 %). Surprisingly, the mean of this fraction is hardly statistically distinguishable from the mean of the fraction that is spent for punishing a cooperator who was matched with another cooperator in the PD (0.67 vs. 0.50, $Z = 1.571$, $p = 0.116$). Moreover, the mean fraction of Endowment II used for punishing a defector who was matched with another defector is statistically not different from the mean fraction for punishing a cooperator who was matched with another cooperator (0.42 vs. 0.50, $Z = -0.649$, $p = 0.516$). Third parties also spend a considerable amount of their endowment for punishing a cooperator who was matched with a defector in the PD. The average of 19 % is the smallest fraction of Endowment II spent for punishment within the 3PP treatment. Mann Whitney tests indicate that these differences are significant (0.19 vs. 0.42, $Z = 2.060$, $p = 0.039$; 0.19 vs. 0.50, $Z = 2.857$, $p = 0.004$; 0.19 vs. 067, $Z = 4.176$, $p = 0.000$). To sum up, third parties punish people who behave prosocial in the PD nearly as heavily as norm violators, that is, free-riders. These findings suggest that anti-social punishment is endemic and has a spiteful

component. All the above findings are robust using the same specifications as above (see ordered logit regression in Table 6).

Table 6: Ordered logit regression, 3PP treatment

Dependent variable	'Punishment'	
	(1)	(2)
D/D	1.55***	1.66**
	(0.53)	(0.66)
D/C	2.95***	3.22***
	(0.65)	(0.78)
C/C	1.95***	2.04**
	(0.69)	(0.81)
Gender	0.75	0.69
	(0.50)	(0.58)
Age		0.02*
		(0.01)
Education (6 to 10 years)		-1.18
		(0.93)
Education (above 10 years)		-1.27
		(1.24)
Wealth		1.01*
		(0.56)
Wald test of equality of coefficients		
$H_{0:}$ D/D = D/C	1.39**	1.56**
	(0.67)	(0.71)
$H_{0:}$ D/D = C/C	0.39	0.37
	(0.64)	(0.67)
$H_{0:}$ D/C = C/C	1.00*	1.18*
	(0.53)	(0.62)
N	84	76
pseudo R-sq	0.15	0.19
Log lik.	-75.81	-65.63

Note: An ordered logit model has been fitted. Heteroskedasticity-robust clustered standard errors are reported in parentheses. Clusters are given by individuals. The dependent variable is Punishment, which takes on the values K0, K2 and K4. The columns report results for overall punishment, that is, pooled data of punishment decisions (all four situations that can emerge in the PD).
D/D = punished person is a defector; punished person's PD partner is a defector; D/C = punished person is a defector, punished person's PD partner is a co-operator; C/C = punished person is a co-operator, punished person's PD partner is a co-operator; C/D = punished person is co-operator, punished person's PD partner is a defector (reference group);
Both models include the following additional controls: mountain dummy, experimenter dummy and comprehension measure.
The Wald tests reported at the bottom of the table are run on the null hypothesis that pairs of dummy coefficients identifying a treatment are equal to each other. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A comparison between 2PP and 3PP shows that fractions of endowment spent for altruistic and anti-social punishment are exactly the same when the punished person's PD partner cooperates (0.66 vs. 0.67, $Z = 0.305$, $p = 0.761$; 0.51 vs. 0.50, $Z = 0.093$, $p = 0.926$) but significantly different from each other when the punished person's PD partner defects (0.66 vs. 0.42, $Z = 2.279$, $p = 0.027$; 0.51 vs. 0.19, $Z = 2.678$, $p = 0.007$). These results are comparable to Marlowe et al. (2010). They find that 2PP and 3PP is of the same size in small scale societies that have an ethnic population size of less than 40000 people, while in larger societies people are more likely to engage in 3PP than in 2PP. The ethno-linguistic group of the Teop society clearly belongs to the "small end" of this spectrum (population size of Teop < 10000). In contrast to Marlow et al. (2010), we investigate violations from a cooperation norm and take into account anti-social punishment. In doing so, we find a difference in the strength of punishment between 2PP and 3PP in the small-scale society of Teop. However, this difference depends on the role of the punished person's partner in the PD.[13]

5. Discussion and concluding remarks

In this study we use the prisoner's dilemma game to compare the effectiveness of second-party and third-party punishment in a small-scale society. In contrast to Henrich et al. (2006) and Marlowe et al. (2008, 2010), we investigate cooperative behavior and associated punishment patterns in the form of a collective action problem.

We find that second-party punishment promotes cooperation more than third-party punishment. The low level of cooperation in the 3PP treatment (significantly below baseline) even proves that third-party punishment can be ruled out as an effective way of maintaining cooperation in small-scale societies. In this case, the third-party – designed as a mechanism to maintain cooperation in the PD – is counterproductive and may lead to a crowding out of social preferences such as altruism, ethical norms or intrinsic motives (see Bowles and Polania-Reyes, 2012). The establishment of centralized institutions such as courts or police – which act as third parties and solve disputes

[13] Due to the nature of the experimental design (two decisions in 2PP and four decisions in 3PP), we cannot compare and test the robustness of these results in regression models.

between parties in accordance with the rule of law – may help to explain these findings. While these institutions are quite common in modern societies (i.e., western and industrialized societies), institutions of the enforcement of legal rules of law have been established quite recently in PNG. Like many other developing countries, PNG faces challenges with the national implementation of these legal rules of law. In many tribal societies the sanctioning of norm violations (e.g., theft, murder, rape, etc.) is still regulated directly between groups without the interference of the state. For example, police intervention in local disputes is often not accepted by people and even leads to tensions among them.[14] People's lack of compliance with the law in combination with weak execution of these rules in PNG may explain the crowding out of cooperators in the 3PP treatment of our experiment.

We also extend the analysis of Henrich et al. (2006) and Marlowe et al. (2008, 2010) to the phenomenon of anti-social punishment. The high level of anti-social punishment in 2PP and 3PP is striking and requires explanation.[15] Due to the nature of the one-shot interaction in our experiment, we can rule out that any strategic behavior or revengeful acts played a role for punishing cooperators (Cinyabuguma et. al., 2006; Denant-Boemont et al., 2007; Nikiforakis, 2008). Participants had to pass through a comprehension stage in each game played. They had to calculate payoffs for themselves and the other participant(s) in the PD. Those who did not understand were dismissed from the game (about 8 % of subjects). Thus, we can also rule out that people may have

[14] This argument can be supported by anecdotal evidence from the field. During a stay in a village, two families were arguing about land properties and the harvesting of cocoa. The verbal confrontation became physical and the police showed up. Two policemen tried to interfere but recognized soon that their intervention intensified the conflict and more people become engaged. In the end, the local people regulated the conflict by themselves and the police was observing the situation from a safe distance (outside the village).

[15] Anti-social punishment was hardly observed in Fehr and Fischacher (2004) but has already emerged in several other studies (Herrmann et al., 2008; Gächter et al., 2010; Gächter and Herrmann, 2011). However, most of these studies conducted public good games with repeated interactions and none of them analyzed anti-social punishment in the context of third-party punishment. Thus, these studies are not comparable to our study. The study by Gächter and Herrmann (2011) offers the only suitable comparison to the 2PP treatment in our study since they use a one-shot public goods game followed by a punishment stage. The punishment results in the Russian sample of their study are very similar to the punishment patterns in the 2PP treatment of our study.

not understood how punishment works in our experiment.[16] Another issue which may lead people to punish cooperators is inequality aversion. Inequality aversion is understood as disutility arising from differences between one's own payoff and other's payoff (Fehr and Schmidt, 1999). A third party in our experiment received K30 which corresponds to the maximum payoff a participant can receive in the PD. This means that they are for sure better off than any cooperator in the PD. Inequality aversion then cannot explain these patterns of anti-social punishment.

Based on these findings, we can speculate that spiteful behavior might have played an important role in our experiment. Spite has been defined as the motivation to *maximize* (rather than minimize as per the Fehr and Schmidt (1999) utility function) one's advantageous inequality vis-à-vis others. A spiteful punisher is thus a person who punishes cooperators and defectors at the same time. The fact that the punisher's spent amount in the 3PP seems to vary almost linearly with the recipient's payoff, is consistent with the idea that this motivation played a relevant role for the third parties. Spiteful behavior may be a successful strategy in societies where local competitiveness is likely to provide a considerable improvement in the socio-economic condition of the individual. This is particularly true for societies where tribal warfare and conflicts between groups are continuing events. Behavior in these societies is also strongly driven by competition for status and being aggressive towards possible opponents can be the best surviving strategy within this environment. Small-scale societies may then be those where anti-social punishment evolves on a broader scale. Punishing cooperators is just one way to gain an advantage over others and may constitute to a selfish behavior that positively affects individual survival and well-being (Sylwester et al., 2013).

From an evolutionary perspective, however, punishment in our experiment is a destructive mechanism. Looking at the average payoffs per treatment allows us to compare the relative success of different mechanisms for enforcing cooperation. We assume, as it is typical in evolutionary analyses of social behavior, that societies using

[16]In order to test our protocol in the context of a Western society, we replicated the study of the 2PP condition at the University of Kiel, following as closely as possible the original protocol. We can notice that only 7 % of Endowment II was spent for the punishment of cooperators in Germany. This is in line with other experiments conducted in Western Europe (e.g., Gächter and Hermann, 2010, 2011). Hence, we infer that nothing in our protocol induces an especially high level of anti-social punishment.

mechanisms that yield higher average payoffs could draw upon those material resources to maximize the capacity of their members to survive and reproduce. Due to the high level of altruistic punishment and anti-social punishment, average payoffs are substantially lower in 2PP (K6.01) and 3PP (K6.00) than in the baseline condition (K18.59). These findings suggest that the introduction of punishment devices is overall detrimental for this society.

Our findings may provide valuable information for policy makers. In order to solve collective action problems in small-scale societies, policy makers may focus on supporting mechanisms that promote cooperation in a more efficient way. Policy instruments based on the theory of indirect reciprocity (i.e., maintain cooperation through reputation building or social image concerns) may provide an alternative, more costless solution to maintain cooperation in small-scale societies where reputation information can be easily diffused.

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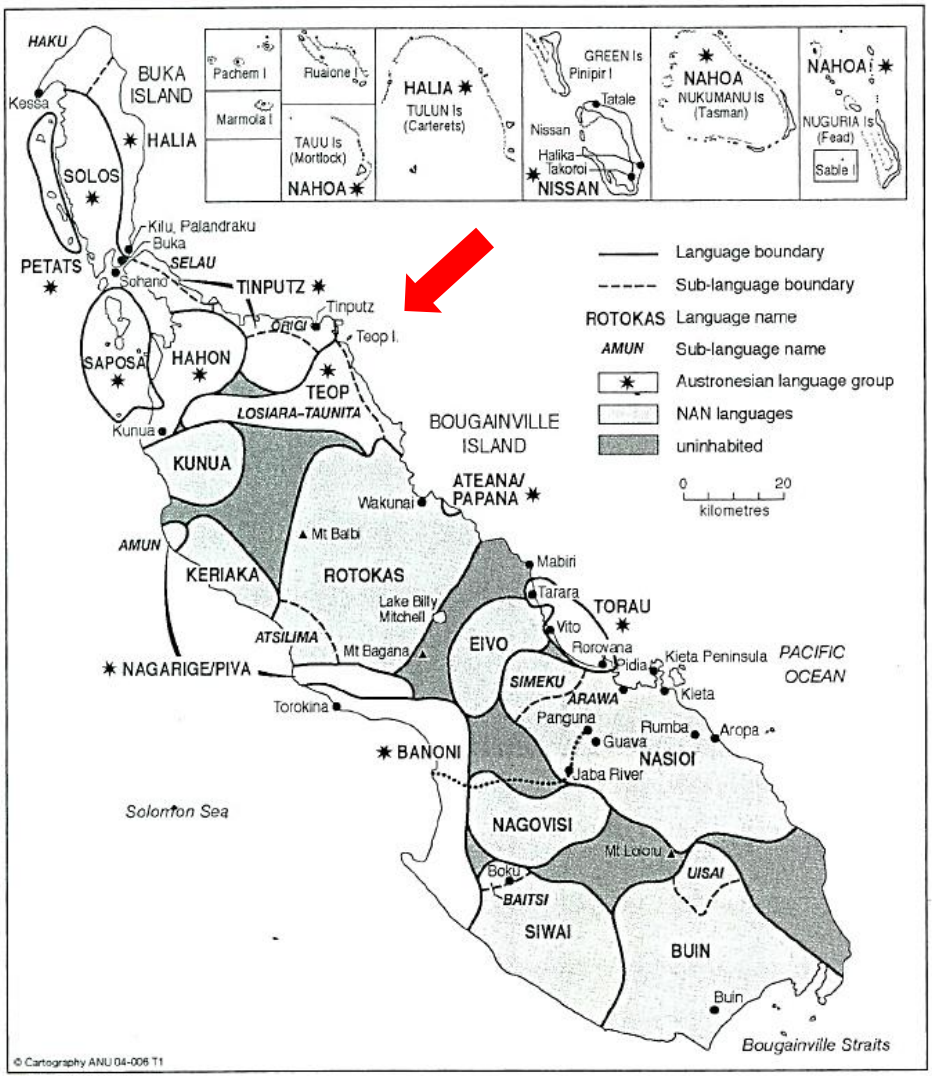
Appendix

Figure A1: Map of languages of Bougainville and location of Teop



Source: Regan and Griffin (2005)

Figure A2: Registration and pre-play interview taking place in a waiting area

Figure A3: A playing area

Table A1: Summary statistics of subject pool

Treatment	Variable	Sex (1=Female)	Age	Education[a]	Wealth[b]
ALL	Mean	0.49	37.66	0.99	0.70
	St. Dev.	0.50	14.14	0.43	0.91
	Min	0	17	0	0
	Max	1	91	2	3
	N	190	180	180	190
Baseline	Mean	0.53	36.84	1.04	0.68
	St. Dev.	0.50	14.92	0.37	0.94
	Min	0	17	0	0
	Max	1	91	2	3
	N	85	80	80	85
2PP	Mean	0.49	36.42	1.05	0.63
	St. Dev.	0.50	11.70	0.40	0.91
	Min	0	17	0	0
	Max	1	56	2	3
	N	59	55	55	59
3PP - PD	Mean	0.40	40.56	0.84	0.92
	St. Dev.	0.50	14.14	0.55	0.86
	Min	0	19	0	0
	Max	1	76	2	2
	N	25	25	25	25
3PP – Third party	Mean	0.43	40.70	0.85	0.71
	St. Dev.	0.51	16.98	0.49	0.85
	Min	0	22	0	0
	Max	1	88	2	2
	N	21	20	20	21
K-Wallis test	$\chi^2(4)$	1.235	2.403	3.363	2.393
	p-value	0.7446	0.4931	0.3389	0.4950

[a] Education is a categorical variable which takes on the values 0 (below 6 years of education), 1 (6 to 10 years of education), and 2 (above 10 years of education).

[b] Wealth is defined as the sum of livestock types owned. We consider the following livestock: pigs, chicken, and rooster. The index takes on the values 0 (holding no livestock types), 1 (holding 1 out of 3 livestock types), 2 (holding 2 out of 3 livestock types), and 3 (holding all three types of livestock).

K-Wallis tests indicate that there are no differences in the socio-economic and demographic variables between treatments

PROTOCOLS

Pre-Experimental Instructions

The following instructions were read by the local research assistant individually to subjects in the waiting area (WA=Waiting area; PA = playing area; LE1=Lead Experimenter 1; LE2=Lead Experimenter 2; RA1 = research assistant 1, presiding over WA, helped by other research assistants from our team or from the village; RA2=research assistant 2; assisting LE1; RA3 = research assistant 3, assisting LE2).

Hello! My name is *[RA1]* and I am here with *[LE1]* and *[LE2]* to conduct this study. They are researchers from the University of *[Name University where LE1 and LE2 are affiliated]*. Thank you for taking the time to come today and taking part in it. Here you have 5 Kina (K5) for your participation and for the interview. This is your money. I cannot take it back again. Take them and put it away in some safe place, they will not be needed for the decisions you will make later on.

Ok, this survey is about how people make decisions. Before we begin I want to make some general comments about what we are doing here today and explain some rules that we need to follow. By making decisions in the following game you can earn real money that you will take home. This money is yours to keep. But maybe you won't get any money. There is no right or wrong decision and you cannot lose any money. You should understand that this is not my own money and it is not *[LE1's]* or *[LE2's]* money. It is money given to them by their university to use to do a research study. The money will be paid in cash when the sessions are finished. You should come here with this card that you have just drawn and your payments will be given to you in an envelope. Please remember to take this number with you when you come to collect your payment.

Before we proceed any further, let me stress something that is very important. Many of you were invited here without understanding very much about what we are planning to

do today. If at any time you find that this is something that you do not wish to participate in for any reason, you are of course free to leave whether we have started the game or not. Let me tell you something about the decisions you are going to make.

Decisions are made by two individuals, you and another person. {***3PP*** : Decisions are made by two or more individuals, you and another person} This person may be from this village, or from another village from this area. Before coming here we run this research in other villages as well. None will know with whom you are matched.

We have invited many people from this area to take part in this game. At the end of the sessions, we will take your decision and match it randomly with the decision of another participant.

You will be making decisions with these envelopes here. You will receive your money in this envelope named "My Earnings". Now I write your number on this envelope and on all other envelopes. The other person also receives his money in an envelope like this one.

Now let us explain how we pair the two persons who will make a decision. At the end of the session we will draw two envelopes at a time at random from the "Decisions" box. These two people will be matched, and their decisions will determine their earnings. *[Show an example of matching. Do NOT show content of envelopes]*

For instance, here I draw envelope # X and envelope # Y. So, participant # X and participant # Y will be matched together and their decisions will determine their earnings.

You will be explained the decision later in the room over there. Please wait your turn quietly here. Everyone caught talking about the game before or after he participates will not receive any money! After you finish the game, you may not enter the WA again under any circumstances. If you do so, we may have to cancel the session and leave this village without handing out any payment. *[When a PA is free, RA1 invites the participant to go to that PA.]*

Individual instructions in the experimental session

Script of the Game: Prisoner's Dilemma (baseline, 2PP, 3PP)

Hello and thank you for you coming here. My name is LE1/LE2. I hope you can understand my Tok Pisin. If not, I will ask our assistant to translate. I am here with *[RA2/RA3]*

Now I explain the game with this board. {***2PP, 3PP:*** There are two parts in this game**.** I start explaining the first part.} It is important that you understand well, because only people who understand the game well will take part in it. Moreover, what you will earn depends on the decision you make, so you must understand well. You will receive your earnings inside this envelope "My earnings". *[Put envelope "My earnings" by participant's side. Also point to envelope "Other person's earnings".]*

Decisions are made by two individuals, you and another person. The other person is not here now but he or she will make a decision in exactly the same way as what you are going to do. Perhaps he or she has already made a decision. This person may be from this village, or from another village from this area. Before coming here we run this research in other villages as well. The other person, too, will receive his money inside an envelope similar to yours.

Ok, now I give you K14. The other person also receives K14. The K10 I give the other person in this board have a green stick. These K4 will not be used in the game, and will be paid out to you when you come to collect your payments inside your "My Earnings" envelope. Now I put this K4 aside and you can forget about it for the rest of the game. [*Put the K4 in the envelope marked ""My Earnings". Do the same for other participant.*] {***2PP:*** These K4 will be used later in the second part of this game so I put them aside. Let's now see the first part of this game}. *[Put the two K2 bills aside. Put aside K10 belonging to other person. Put K20 bills towards the middle of the board, and say that this is your (i.e. the researcher's) money.*].

Now I tell you what you can do with your K10. You can make one out of two things. You can either keep these K10 or give these K10 to the other person. If you keep the

K10, these K10 are yours. They will be put inside your "Earnings" envelope *[Show K10 going into Earnings envelope]*. If you give the K10 to the other person, I will add K10 and pass them on to the other person. So the other person receives K20 while you are left with nothing. I will put these K20 inside the "Earnings" envelope of the other person. [*Move the K10 bill across the line and add another K10*]

The other person has the same choice as you. [Rem*ove subject's own K10 from board and put green K10 onto other person's side*]. If the other person keeps the K10, these K10 are his and I will put them inside his "Earnings" envelope. If he gives the K10 to you, I will add K10 and pass them on to you so that you end up with K20 while the other person is left with nothing. I will put these K20 inside the "Earnings" envelope of the other person. [*Move the other person's K10 bill across the line and add another K10*]. So, every time a person gives K10, I add K10 and the other person receives K20. *[Show again for both giving and receiving K10.]*

After each Person makes the decision to keep or give the money {**Baseline**: the game is over.}; {**2PP, 3PP**: the first part of the game is over.}

Ok, let us check if you are clear about the game. I am going to show you some examples. You will tell me how much money you and the other person will get. You can use the board to move the money and add K10 to calculate the payoffs. *[All the examples below should be visualized on the board, placing the two envelopes "My Earnings "Other Person's Earnings" at the top end of the table. If more test questions are needed the researcher or assistant should again start from the first example]*.

Example No.1: You and the other person both keep the K10. How much money would you get inside your envelope at the end of this example? How much does the other person have? *[K10; K10]* Ok. So you both have K10 in this situation. Now the next example.

Example No. 2: You keep your K10 and the other person gives his K10 over to you. How much money would you and the other person have inside your envelope at the

end of this example? *[K30; K0]* Ok. So you have K30 and the other person has nothing in this situation. Now the next example.

Example No. 3: You give your K10 over to the other person, and the other person keeps his K10. How much money would you and the other person have inside your envelope at the end of this example? *[K0; K30]* Ok. So you have nothing and the other person has K30 in this situation. Now the next example.

Example No. 4: You and the other person both give the K10 to each other. How much money would you and the other person get inside your envelope at the end of this example? *[K20; K20]* Ok. So you both have K20 in this situation.

[Give time to answer each question and explain the correct answer if the participant gives the wrong answer. If participant does not answer correctly all questions, the game is explained again and the participant is asked to answer again. The number of mistakes in the first set of questions is recorded. In the subsequent checks, participants should answer correctly the first question and at least another question. If they still make mistakes, participants are said that they cannot take part in the game.]

{**Baseline:** Now we have finished with the explanations of the game. Do you have any questions?}

{**2PP, 3PP**: Now we have finished with the explanations of the first part of the game. Do you have any questions?}

Script of the Game: Punishment stage in 2PP

Ok, let's now come to the second part of this game. After you have made your first decision, you will make two more decisions that will affect how much money you and the other person take home. *[Show second board. Leave first board to its left, placing K20 on both players' sides on the first board.]*.

For this second part you use the K4 that we left aside from the first part. [*Place the two K2 bills in front of both players on the second board.]* Let us suppose that both you and the other person have K20 at the end of the first decision. *[Put K20 at the other person's side on*

first board]. In this second part you can spend some money to reduce the other person's earnings. If you pay K2 I will reduce by K10 the money that the other person will take home. *[Show on board]*. If you pay K4 I will reduce by K20 the money that the other person will take home. *[Show on board]*. If you pay nothing, I will not reduce the other person's money. *[Show on board]*.

So, you can do one thing out of three things: Option number 1: You can keep your K4. Option number 2: You can keep K2 and spend K2. I reduce the other person's earnings by K10; Option number 3: You can keep nothing, spend K4, and I will reduce the other person's earnings by K20. *[Show three envelopes with three options]*.

Remember that the other person has the same 3 options: Option number 1: He can keep his K4. Option number 2: He can keep K2 and spend K2. I reduce your earnings by K10; Option number 3: He can keep nothing, spend K4, and your earnings will be reduced by K20.

Remember, the money you spend and the money I take away will go outside the game; you will not receive this money nor the other person will receive your money. *[Show on board, using K2 sticks for other person and K10 belonging to subject.]*

Is this clear? Ok, I would like you to answer what is the correct answer to the following examples:

Example No. 1: Suppose that the other person has K20 after the first decision. Suppose you decide to spend K0. How much money do I take away from the other person? *[Solution: None.]*

Example No. 2: Suppose the other person has K10 after the first decision. You decide to spend K2. How much money do I take away from the other person? *[Solution: K10]*.

Example No. 3: Suppose that you have K30 after the first decision. The other person decides to spend K4. How much money do I take away from you? *[Solution: K20]*.

Example No. 4: Suppose that you have K10 at the end of the first decision. The other person decides to spend K4 to reduce your earnings. What are the final earnings for you?

Ok, this is a special situation. The other person wants to reduce your earnings by K20, but you only have K10. In all situations where one person wants to reduce the other person's earnings by an amount bigger than what that person has, I take away all the money that that person has, but nothing more. In this case I take away your K10.

So, the money you will take home at the end of the session is: how much money you have from the first part, minus how much money the other person takes away from you, plus the money you keep from these K4.

Example No. 1: You and the other person have K20 at the end of the first part. The other person takes K10 away from you. You spend K2 to take away K10 from the other person. How much money do you take home? *[Ask participant to answer.]* In this case you both take home K12.

Example No. 2: You have K30 at the end of the first part. The other person has 0K. The other person spends K2 and takes away K10 from you. You spend nothing. How much money do you and the other person take home? *[Ask participant to answer.]*

In this case you take home K24. The other person takes home K2.

Example No. 3: You and the other person have both K10 at the end of the first part. The other person takes no money away from you. You take no money away from the other person. *[Ask participant to answer.]* In this case you take home K14.

Ok, now I add an important thing: You will make two decisions in this second part. One decision is for when the other person keeps the K10 in the first part. The other decision is for when the other person gives you K10 in the first part. At the end of the session I will see what the other person has done. So I take away money or not take away money from his according to your decision.

Script of the Game: Punishment stage in 3PP

Ok, let's now come to the second part of this game. After you have made your first decision, a third person will make a decision that may affect how much money you and the other person take home. *[Show second board. Leave first board to its left, placing K20 on both players' sides on the first board. Second board should have "Namba 3 man o meri" clearly indicated.]*.

We will call the person who makes the decision in this second part the 'third person'. This person is NOT the person with whom you have made the previous decision. This is another person who made her decisions in the previous days. You and the other person from the first part don't have to make any decisions here. *[Place the two K4 in front of both players on the second board.]*

Let us suppose that both you and the other person have K20 at the end of the first decision. *[Put K20 at the other person's side on first board]*. Person 3 receives some money from me. He can then spend K4 to take away some money from you and the other person. The third person can make one thing out of three things: The third person can spend K2 to subtract K10 from the money you will earn at the end of the day; or the third person can spend K4 to subtract K20 from the money you will earn at the end of the day; or the third person can spend nothing, i.e., the third person keeps the money and leave your earnings unchanged. Let's see on the board how this works. Let´s suppose that you have K20 from the first part of this decision.

So, the third person can do one thing out of three things. Option number 1: The third person can keep K4. Option number 2: The third person can keep K2 and spend K2 to take K10 away from you. Option number 3: The third person can keep nothing, spend K4, and take K20 away from you.

Ok, now I add an important thing: The third person will make four decisions in this second part. One decision is for when both you and the other person keep K10 in the first part. One decision is for when both you and the other person give K10 in the first part. One decision is for when you keep K10 and the other person gives K10 in the first part. The last decision is for when you give K10 and the other person keeps K10 in the

first part. At the end of the day I will see what you do and take away money or not take away money from you according to the third person's decision.

Remember, the money that I take away will go outside the game; the third person will not receive this money, nor the other person will receive this money.

Ok, now I add another important thing. There is another fourth person in the second part. This person will receive also money from me. The fourth person can then spend money to take away some money from the person you are matched in the first part of the game. The fourth person makes the same four decisions in the second part like the third person does.

Is this clear? Ok, I would like you to answer what is the correct answer to the following examples. *[Show on board, using K2-sticks for third person and K10 belonging to subject.]*

Example No. 1: You and the other person have both given K10 and you have K20 at the end of the first part. Person 3 decides to spend K2 when both of you give K10. How much money do you take home? *[Solution: K10]. [If they answer correctly go to example 3. Otherwise go on with example 2]*

Example No. 2: Suppose you have K10 after the first decision. The third person decides to spend K2. How much money do I take away from you? *[Solution: K10].*

Example No. 3: Suppose that you have K30 after the first decision. The third person decides to spend K4. How much money do I take away from you? *[Solution: K20].*

Example No. 4: Suppose that you have K10 at the end of the first decision. The third person decides to spend K4 to reduce your earnings. What are the final earnings for you? *[Solution: K0]*

Ok, this is a special situation. The other person wants to take away K20 from you, but you only have K10. In all situations where one person wants to take away more money than another person has, we take away all the money that that person has. In this case I take away your K10.

So, the money you will take home at the end of the day is: how much money you have from the first part, minus how much money the third person takes away from you.

Script of the Game: Explanation of how to make decisions in the PD (baseline, 2PP and 3PP)

Now you will make your decision {**2PP**: in the first part of the game}. I give you two envelopes, one called "Keep" and the other called "Give". If you want to keep the K10, you will have to place the K10 into this envelope. If you want to give the K10, you will have to place the K10 into this envelope. [*Show envelopes.]*

While you make your decision, I will not be at this table so we will not watch your decision. When you are finished, please put your two envelopes "Keep" and "Give" into this big envelope. *[Show decision envelope.]* If it is all clear, you can make your decision now and I will go out. Please call us when you are finished. *[After decision has been made]* Ok, now I am going to put your decision inside the Decision box.

Script of the Game: Explanation of how to make decisions in the second part of 2PP:

Now you will make the decisions for the second part of the game. Let's first consider the situation when the other person keeps the money in the first half of the game. Here these three envelopes represent your three possible options. *[Show on first board that K10 are above "Other person's earnings" envelope.]* You have to put this stick inside the envelope that matches what you want to do. *[Put the stick inside the 3 envelopes. Illustrate 3 envelopes]*. After you have made your decision, you will put the three envelopes into this big "Decision" envelope. [RA2/RA3] and I will go out. Please call us when you are finished. [*Come back when subject has finished.]* Ok, now I am going to put your decision inside the Decision box.

[Explain and repeat for envelope "Person 2 gives". In this case put K20 by the subject's side. Say:] Let's now consider the situation when the other person gives you the money. In this case the other person gave you K10, so here are K20 going to your payment envelope. Here these three envelopes represent your three possible options. [RA2/RA3] and me will go out. Please call us when you are finished.

Script of the Game: Explanation of PD and how to make decision for the third party in 3PP:

Explanation of PD

Hello and thank you for you coming here. My name is LE1/LE2. I hope you can understand my Tok Pisin. If not, I will ask our assistant to translate. I am here with *[RA2/RA3]*.

Now I explain the game with this board. There are two parts in this game. I start explaining the first part. It is important that you understand well, because only people who understand the game well will take part in it. Moreover, what you will earn depends on the decision you make, so you must understand well. You will receive your earnings inside this envelope "My earnings". *[Put envelope "Mani bilong mi" by participant's side. Also point to envelope "Mani bilong narapela man o meri".]*

Decisions in the first part are made by two individuals, which we call Person 1 and Person 2. These two people are not here now. They will make their decisions in the next days in exactly the same way as what you are going to do. These people may be from this village, or from another village from this area.

Person 1 and Person 2 will receive K10 each. *[Put the 10 Kina onto the two sides of the board.]* Person 1 and Person 2 can make one out of two things. Each of them can either keep these K10 or give these K10to the other Person. If Person 1 keeps the K10, these K10 are hers. They will be put inside her "Earnings" envelope.*[Show 10 kina going into Earnings envelope]* If Person 1 gives the K10 to the other person, I will add K10 and pass them on to the other Person. So the other person receives K20 while Person 1 is left with nothing. *[Move the 10 Kina bill across the line and add another 10 Kina]* -

Person 2 has the same choice as Person 1. *[Remove subject's own 10 Kina from board and put green 10 kina onto other person's side.]* If Person 2 keeps the K10, these K10 are hers and I will put them inside her "Earnings" envelope. If she gives the K10 to Person 1, I will add K10 and pass them on to Person 1 so that Person 1 ends up with K20 while the

Person 2 is left with nothing. I will put these K20 inside the "Earnings" envelope of the other person. *[Move the other person's 10 Kina bill across the line and add another 10 Kina]*

So, every time a person gives K20, I add K10 and the other person receives K20. [*Show again for both giving and receiving 10 kina.]*

After each Person makes the decision to keep or give the money, the first part of the game is over.

Ok, let us check if you are clear about the game. I am going to show you some examples. You will tell me how much money Person 1 and Person 2 will get. You can use the board to move the money and add K10 to calculate the payoffs. *[All the examples below should be visualized on the board, placing the two envelopes "Mani bilong mi" "Mani bilong narapela man" at the top end of the table]. If more test questions are needed the researcher or assistant should again start from the first example.]*

Example No. 1: Person 1 and Person 2 both keep the K10. How much money would they get inside their envelopes at the end of this example? *[K10; K10]*

Ok. So they both have K10 in this situation. Now let's see the next example.

Example No. 2: Person 1 keeps her K10 and Person 2 gives her K10 over to Person 1. How much money would they have inside their envelopes at the end of this example? *[K30; K0]*

Ok. So Person 1 has K30 and Person 2 has nothing in this situation. Now let's see the next example.

Example No 3: Person 1 gives her K10 over to the other person, and the other person keeps her K10. How much money will they have inside their envelopes at the end of this example? *[0 Kina; 30 kina]*.

Ok. So Person 1 has nothing and Person 2 has K30 in this situation. Now let's see the next example.

Example No 4: Person 1 and Person 2 both give the K10 to each other. How much money would you and the other person get inside their envelopes at the end of this example? *[K20; K20]* Ok. So they both have K20 in this situation.

[Give time to answer this question. If payoffs are unclear, go through the examples again and check. If payoffs still unclear, turn the subject away without paying the extra kina. They should answer correctly the first question with no help, and at least another questions even with one cue. If they don't get one question right with at least one giving go through 4 examples again.]

Now we have finished with the explanations of the first part of the game. Do you have any questions?

Explanation of punishment stage

Ok, let's now come to the second part of this game. Now you will make a decision that may affect how much money Person 1 and Person 2 take home. *[Show second board. Leave first board to its left, placing 20 kina on both players' sides on the first board. Second board should have "Mi" clearly indicated.]*

Now I give you K34. These K34 are yours.

Let us suppose that both Person 1 and Person 2 have K20 at the end of the first decision. You can spend some of your money to take away some money from Person 1. You can spend K2 to subtract K10 from Person 1's money; or you can spend K4 to subtract K20 from Person 1's money. Or you pay nothing and don't take away money from Person 1. *[Show on board]*

So, you can do one thing out of three things: Option number 1: You don't spend any money and keep all of your K34. I don't take away money from Person 1. Option number 2: You can spend K2. I take away K10 from Person 1; Option number 3: You can spend K4, and I take K20 away from the other person. [*Show three envelopes with three options]*.

Remember, the money that I take away will go outside the game; you will not receive this money, nor the other person will receive this money.

Another important thing: there will be another person who, like you, receives K34. This person can spend money to take away money from Person 2, like you did for Person 1.

Is this clear? Ok, I would like you to answer what is the correct answer to the following examples. [*Show on board, using 2-kina sticks for third person and 10-kina belonging to subject]*

Example No. 1: Suppose that both Person 1 and Person 2 have given. They have K20 after the first part. Suppose you decide to spend K0. How much money does Person 1 take home? *[Solution: 20 kina] [They should answer correctly this example, leading answer is OK. If they do, just show second example without requiring answers. Otherwise require answer (again, leading answer by experimenter is OK). -*

Example No. 2: Both Person 1 and Person 2 have kept their K10 in the first part. They both have K10 at the end of the first part. You spend K2. How much money does Person 1 take home? *[Solution: K0]*

Example No. 3: Person 1 has kept her K10 while Person 2 has given her K10 to Person 1. Person 1 has K30 at the end of the first part and Person 2 has nothing. You spend K4. How much money does person 1 take home? *[Solution: K10] [Require answer from Example 3.]*

Example 4: Person 1 and Person 2 have held beck her K10. Both Person 1 and Person 2 have K10 at the end of the first part. You spend K4. How much money does Person 1 take home? *[Solution: K0]*

Ok, this is a special situation. You want to take away K20 from Person 1, but Person 1 has nothing. In all situations where one person wants to take away more money than another person has, I take away all the money that that person has, but nothing more. In this case I take away your K10.

Ok, now I add an important thing: You will make four decisions in this second part, for each possible choices that Person 1 and Person 2 can make. The first decision is for when Person 1 and Person 2 both keep the K10 in the first part. The second decision is for when Person 1 gave K10 and Person 2 kept K10. The third decision is for when Person 1 and Person 2 gave K10. The fourth decision is for when Person 1 kept K10 and Person 2 gave K10.

Now I don't know what the other players have done. So I am asking you to tell me what to do for each possible case. When I know their decisions, I will take away money or not take away money from Person 1 according to your decision.

Decision

Now you will make the decisions for the second part of the game. Let's first consider the situation when Person 1 and Person 2 both kept K10 in the first half of the game. Both have K10 after the first part of the game. Here these three envelopes represent your three possible options. How much do you want to spend, K0, K2 or K4? You have to put this stick inside the envelope that matches what you want to do. *[Put the stick inside the 3 envelopes. Illustrate 3 envelopes].* After you have made your decision, you will put the three envelopes into this big "Decision" envelope. [RA2/RA3] and I will go out. Please call us when you are finished. [*Come back when subject has finished.]* Ok, now I am going to put your decision inside the Decision box.

Let's now consider the second situation when Person 1 gave K10 and Person 2 kept K10. Person 1 has K0 and Person 2 has K30 after the first part of the game. Here these three envelopes represent your three possible options. How much do you want to spend, K0, K2 or K4? You have to put this stick inside the envelope that matches what you want to do. *[Put the stick inside the 3 envelopes. Illustrate 3 envelopes].* After you have made your decision, you will put the three envelopes into this big "Decision" envelope. [RA2/RA3] and I will go out. Please call us when you are finished. [*Come back when subject has finished.]* Ok, now I am going to put your decision inside the Decision box.

Let's now consider the third situation when Person 1 gave K10 and Person 2 gave K10. Person 1 has K20 and Person 2 has K20 after the first part of the game. Here these three envelopes represent your three possible options. How much do you want to spend, K0, K2 or K4? You have to put this stick inside the envelope that matches what you want to do. *[Put the stick inside the 3 envelopes. Illustrate 3 envelopes].* After you have made your decision, you will put the three envelopes into this big "Decision" envelope. [RA2/RA3] and I will go out. Please call us when you are finished. [*Come back when subject has finished.]* Ok, now I am going to put your decision inside the Decision box.

Let's now consider the fourth situation when Person 1 kept K10 and Person 2 gave K10. Person 1 has K30 and Person 2 has K0 after the first part of the game. Here these three envelopes represent your three possible options. How much do you want to spend, K0, K2 or K4? You have to put this stick inside the envelope that matches what you want to do. *[Put the stick inside the 3 envelopes. Illustrate 3 envelopes]*. After you have made your decision, you will put the three envelopes into this big "Decision" envelope. [RA2/RA3] and I will go out. Please call us when you are finished. [*Come back when subject has finished.]* Ok, now I am going to put your decision inside the Decision box. You have made all decision now and the session is over.

Ethical aspects of the study

The surveys and experiments used in this paper do not involve deception and the anonymity of the subjects was guaranteed. There was no danger of physical or psychological damages to be expected from participants. All people voluntary participated in the studies and were told to leave at any point of time if they feel uncomfortable with the situation. Moreover, prior the field research was conducted, the research teams were requested to give a presentation of the research methods and goals to the local communities and regional authorities. In all cases the request was granted approval. Our research project was also supported by the regional government of Bougainville and by the Teop Council of Elderly.

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Eidesstattliche Erklärung

Ich erkläre hiermit an Eides statt, dass ich meine Doktorarbeit „Essays on Climate Change and Adaptation in Developing Countries“selbstständig und ohne fremde Hilfe angefertigt habe und dass ich als Koautor maßgeblich zu den weiteren Fachartikeln beigetragen habe. Alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehnenden Ausführungen der aufgeführten Beiträge wurden besonders gekennzeichnet und die Quellen nach den mir angegebenen Richtlinien zitiert.

Kiel, Dezember 2015

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Curriculum Vitae

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