Voodoo Economics

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"The place to improve the world is first in one's own heart and head and hands, and then work outward from there."

- Robert M. Pirsig

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Chapter 1. Introduction

The idea that culture matters for economic development is not new. In *The Theory of Moral Sentiments*, Adam Smith (1795) explored the cultural underpinnings of economic concepts such as markets and trade, and Max Weber (1904) tied the rise of capitalism to the protestant ethic.

In recent years interest for the relation between culture and economics has witnessed an impressive revival, resulting in the emergence of 'cultural economics' as a fully mature field of study. By bringing together knowledge and tools from a variety of other disciplines – including psychology, anthropology, and evolutionary biology – into a truly interdisciplinary approach, recent research has produced important new insights into the relation between culture and economics (Gershman, 2016; Iyer, 2016). These advances have pushed both researchers and policy makers to increasingly recognize the importance of culture for economic and human development.

Yet, in many cases this growing recognition has not yet translated into a proper understanding of the role of culture, or a proper integration of existing knowledge in policy making. For instance, in a 2013 meeting the UN General Assembly acknowledged that culture still needed a more prominent place in the post-2015 development agenda, and Secretary-General Ban Ki-moon stated that "*Too many well-intended development programmes have failed, because they did not take cultural settings into account.*" (UN, 2013).

The second chapter of this dissertation focuses on one area where attention for culture is still acutely insufficient: food security. Although it is by now widely acknowledged that culture plays a key role in food and nutrition, in many cases food security policy still fails on the grounds of a disregard for cultural aspects (Allen and Gillespie, 2001). This poor consideration of culture may be related to the fact that existing research on the topic is scattered across a variety of disciplines and research areas, making it difficult to take stock of existing knowledge and gain a thorough understanding of the nature and extent of the impact of culture.

Chapter 2 aims to address this issue by reviewing cross-disciplinary research on the role of culture in food security and assessing how this knowledge can improve policy design and implementation. We organize our review along the lines of four widely used dimensions of food security (availability, access and choice, utilization, and stability), discussing how culture affects each dimension at the individual and household level.

Although there is large heterogeneity in the size and breadth of available evidence – with research often biased toward high-income countries – we find that how and why we obtain, process, prepare, and eat food is influenced by culture in various ways. In addition, it is clear that gender, family, and decision-making power play a critical role in the impact of culture, while the dynamics

of culture and the relative importance of cultural effects are still poorly understood. In spite of these knowledge gaps, existing research suggests two important ways in which food security policy can be improved. One, there remains ample scope for policies to take culture better into account. Two, food security policy could reap major benefits from the strategic combination of cultural resources and state-of-the-art science and technology.

While Chapter 2 takes a broad perspective on culture, in the rest of the dissertation we narrow our focus to the economics of magic and the supernatural – or 'Voodoo economics'. Economists in the past decades have taken a strong interest in the economics of the world's dominant religions (e.g. Iyer, 2016), but the economics of other forms of magic and supernatural thinking, including animistic religions, remain largely unexplored.

This lack of interest within economics stands in stark contrast with a long-standing tradition of studying these topics in anthropology (e.g. Evans-Pritchard, 1937), and may be explained by an often implicit but persistent assumption rooted in the classical modernization thesis. Broadly speaking, this assumption states that processes of modernization (rising incomes, mass education, the spread of modern science and technology) bring about an inevitable shift from 'traditional' to 'modern' culture, where magic, supernatural thinking, religion, and the associated customs and practices are eroded and a culture of democracy, individual freedom and rights, and rational thinking is promoted. Thus, it follows, economic researchers and policy makers should not devote too much attention to 'traditional' culture, as it will naturally disappear with increasing modernization and economic prosperity.

A mounting body of evidence from various disciplines paints a more nuanced picture of cultural change. What drives broad cultural change is not modernization as such, but the higher level of economic and physical security that it brings about (Inglehart, 2016). This cultural change indeed takes place in a similar direction – termed individualism, post-materialism, self-expression values, or autonomy, depending on the discipline. Yet, it is also strongly path dependent. That is, environmental and historical factors create pervasive cultural differences across societies that shape the trajectory of cultural change. Hence, the general idea of broad cultural change in similar directions following modernization processes is correct, but the derived implication that cultural differences across societies inevitably become less important is not.

In addition, the broad direction of change is unrelated to the assumed shift from 'traditional' to 'modern' culture. Indeed, in spite of ongoing processes of globalization, rising incomes, and technological and scientific progress, the world continues to be religious (Johnson and Grim, 2015), in sub-Saharan Africa (SSA) witchcraft beliefs are as powerful as ever (Geschiere, 2011; Leistner, 2014), and superstition and magical thinking continue to manifest themselves in some form in all

societies – including Western countries with a strong emphasis on the rational mind (e.g. Beck and Forstmeier, 2007; Sørensen, 2005; Subbotsky, 2014). Studying and understanding Voodoo economics therefore has real-world implications that reach beyond traditional rural village societies, and that will not necessarily disappear over time.

The third and fourth chapter of this dissertation present two studies that aim to contribute to the nascent literature on Voodoo economics.

Chapter 3 focuses on the role of the animistic Voodoo religion in the management of fishery resources in Benin. Historically, Voodoo provided an institutional framework that regulated artisanal fishing activities by stipulating how, when, where, and by whom fishing was allowed (Maarleveld and Dangbégnon, 1999). A growing body of case studies argues that animistic religions in this way can play an important role in realizing sustainable community-based management of natural resources (Berkes, 2012). However, there is little micro-level quantitative evidence in support of this hypothesis.

In Chapter 3 we rely on detailed household survey data across 14 weeks in the fishing season to investigate whether traditional Voodoo-embedded fishing rules still matter today. In particular, we test whether a traditional rule against unsustainable fishing gear still discourages Voodoo followers from using it, and compare its effect with a similar rule stipulated by a more recent secular fishing institution. We find that both rules have a statistically significant but small impact on the use of unsustainable fishing gear. Although the Voodoo-embedded institution in itself is not able to realize sustainable fishery management today, our findings suggest that it could be useful to consider or integrate surviving elements of traditional institutions into contemporary fishery management.

The fourth and final chapter of this dissertation looks not at the effects of magic and superstition, but at their origins. If magic and superstition are economically relevant, it becomes important to understand how such beliefs come about and how or why they (do not) change.

We shed light on this question for the case of witchcraft beliefs in SSA by investigating the relation between present-day beliefs and the historical disease environment. Different strands of literature have proposed psychological and economic arguments for why long-run exposure to a heavy disease burden may promote the emergence and persistence of witchcraft beliefs. Yet, to date there is no large-scale empirical evidence for such a relation.

We investigate this hypothesis for the case of malaria. To estimate the relation between the long-run malaria burden and contemporary witchcraft beliefs, we combine gene-based data on historical malaria mortality with survey data on present-day witchcraft beliefs across individuals and ethnic groups within 17 countries in SSA. Consistent with our hypothesis, we find a highly

robust positive correlation between historical malaria mortality and witchcraft beliefs today. Although our finding is correlational, in combination with a large body of anthropological, psychological, economic, and evolutionary literature it bolsters the idea that the disease environment played a role in the emergence and persistence of witchcraft beliefs. Given the omnipresence and profound influence of witchcraft in SSA today, a deeper understanding of its origins and evolution could shed light on contemporary dynamics and help to explain why witchcraft beliefs have retained so much of its power until today.

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Chapter 2. Culture and Food Security

2.1. Introduction

Food is intimately connected to human culture (e.g. Feeley-Harnik, 1995; Fieldhouse, 1995; Kittler et al., 2011; Mintz and Du Bois, 2002). Improving our understanding of the cultural dimension of food security is increasingly recognized as an essential part of moving towards sustainable healthier diets for all (e.g. Helman, 2007; Keding et al., 2013). This evolution is reflected in the fact that culture is now commonly mentioned as one of the '*deep drivers*' of food security in conceptual frameworks (e.g. WFP, 2012).

Yet, in spite of this growing recognition, culture has too often remained on the fringes of discussions on the fight against malnutrition among policy-makers and researchers. Examples of well-intended food security interventions that failed because they did not take cultural settings into account are plentiful (e.g. UN, 2013) and range from rejected deliveries of culturally inappropriate food aid to disregard for dietary recommendations that conflict with the cultural meaning of certain foods. Similarly, the frameworks that identify culture as an important driver in fact rarely clarify through what specific channels it affects food security, nor how important its influence is relative to other factors. Put differently, it has been widely acknowledged that culture matters, but the questions of *in what ways* and *to what extent* it matters remain largely unaddressed.

To some extent, this lacuna may be related to difficulties in operationalizing and measuring such a comprehensive concept (Alesina and Giuliano, 2015; Guiso et al., 2006). Yet, various disciplines have made significant progress in developing theories, models, and instruments to analyze and measure culture qualitatively and quantitatively. In addition, there is a vast and growing body of literature investigating different aspects of culture in relation to several dimensions and drivers of food security. The problem is therefore not absence of research. The issue may rather be that research is scattered across a wide range of disciplines (from anthropology to biochemistry), research topics (from food processing to media and marketing), and types of research.[1] This dispersion makes it difficult to take stock of the current state of knowledge regarding the impact of culture on food security.

[1] One type of studies reviews the impact of cultural factors on one or a few specific drivers of food security across countries – although the focus is often on high-income countries (e.g. Nestle et al., 1998). Another type of research takes the form of detailed case studies on how culture affects a large number of food security drivers for a particular cultural group (e.g. Gittelsohn et al., 2003). These studies generally take a broad approach in terms of cultural factors considered, but have a limited focus in the sense that they are highly specific to the population under study.

To our knowledge, this study will be the first to provide an overview of the available evidence on the impact of culture on food security by bringing together these distinct types of research from a range of different disciplines. Since the body of relevant literature is vast, the first step in this process is to determine the scope of our review. We focus on the impact of culture on the determinants of dietary intake at the household and individual level.[2] More specifically, we concentrate on describing existing strands of research in this area, and how the current state of knowledge can inform policy making. Although we have tried to use a broad, interdisciplinary approach to account for the complex and multifaceted nature of both culture and food security, as economists, our discussion relies strongly on language and concepts common in our field.

This chapter is structured as follows. Section 2.2 elaborates on the question of how to define culture and food security. Section 2.3 reviews the different pathways through which culture affects food security. Section 2.4 discusses the role of gender, family and decision-making power . The dynamic aspects of culture and drivers of change, including the role of mass media and marketing, are explored in Section 2.5. Section 2.6 concludes and presents the implications for policy and future research.

2.2. Definitions of culture and food security

2.2.1. Culture

In the words of Alesina and Giuliano (2015: 899): "*Defining culture is an arduous task*". There is no universally accepted definition, and different disciplines have defined this complex construct in numerous ways (Alesina and Giuliano, 2015; Taras et al., 2009). While some interpretations focus on the core concepts of values, beliefs and norms, others view culture more broadly as all socially transmitted information, each approach having its strengths and weaknesses.[3] Indeed, the question of how to define culture in itself can be the subject of a review paper (e.g. Taras et al., 2009). For the sake of brevity and given the broad and interdisciplinary nature of this review, we therefore

[2] By restricting our attention to the household and individual level, we leave aside macro-level effects such as the impact of aggregate food preferences on food trade patterns.

[3] The first approach is common within economics, as is illustrated by the definition used by Gorodnichenko and Roland (2010: 1): "*the set of values and beliefs people have about how the world (both nature and society) works as well as the norms of behavior derived from that set of values*". The psychological literature tends to emphasize the role of culture in motivating human behavior. (Matsumoto and Juang, 2013: 15) for instance define culture as "*a unique meaning and information system, shared by a group and transmitted across generations, that allows the group to meet basic needs of survival, pursue happiness and well-being, and derive meaning from life*." Other strands of research, including bio-cultural evolutionary work, stress the informational content of culture. Boyd and Richerson (2004) for instance define culture as "*information that people acquire from others by teaching, imitation, and other forms of social learning*". We refer to Alesina and Giuliano (2015) and Taras et al. (2009) for a more extensive discussion on the definition and measurement of culture.

refrain from giving a strict definition of culture. Rather, we continue by discussing a number of points that we deem important for clarifying and delineating our understanding of culture.

First, we consider the social transmission of information as a crucial aspect of culture. Specific culture traits such as values, beliefs, and behavioral norms can be thought of as ways of transmitting information, both within and across generations, about how the world works and what is good and bad, right and wrong, or valuable and invaluable. Such traits and the information embedded therein aggregate into cultural models that explain a certain aspect of life (e.g. pregnancy, infant feeding, and illness) and mediate and regulate associated behavior (D'Andrade and Strauss, 1992; Fryberg and Markus, 2007). Research on culture and food security often gives importance to a particular type of culturally embedded information that is built on long periods of experimentation, observation, and learning across generations (Becker and Ghimire, 2003; Berkes, 2012; Mazzocchi, 2006). To distinguish this type of information from knowledge acquired through modern scientific methods, various terms are used, such as *traditional knowledge*, *indigenous knowledg*e and *local knowledge*, each having its own imperfections. We use the term 'traditional knowledge' throughout this chapter to emphasize the process of knowledge building and transmission along a cultural continuity (Berkes, 2012; Mazzocchi, 2006).

A second important aspect of culture is its dynamic nature. Although culture can be remarkably persistent, it is inherently evolving; it is shaped and reshaped by the social, political, economic and ecological environment and in turn (re)shapes this environment. To take a specific example, traditional knowledge is not a static or fixed body of information, but should rather be understood as a dynamic learning process that responds to changing circumstances and needs of the group (Becker and Ghimire, 2003; Berkes, 2012).

The third point is aptly described by Weisner (2000: 142): "*Cultures may have a clear central tendency and normative pattern, but they are hardly monolithic and uniform.*" In practice culture is a heterogeneous mix of different cultural models that may concur or conflict with each other. Hence, one can find substantial cultural differences within relatively small groups, and intra-group differences are generally larger than inter-group differences (Shweder, 2000). This feature of culture highlights the importance of detailed micro-level research in understanding the relation between culture and food security.

Finally, a major challenge in conceptualizing culture is identifying its boundaries. For this review, two boundary areas are of importance: the relation between culture and institutions, and between culture and religion. Religion has proven even more difficult to define than culture, and their relation remains a topic of debate. Some scholars see religion as part of culture (e.g. Geertz, 1993; Richerson and Christiansen, 2013), while others argue that there are clear conceptual

differences (e.g. Bonney, 2004). Since it is difficult to distinguish between religion and culture in much of the research relevant for this review, and the traits typically associated with religion, such as an explanation of the origin and order of existence and moral codes (Bowie, 2003; Dow, 2007; Iannaccone, 1998) fit well with our understanding of culture, we follow the first approach and treat religion as part of culture. As for institutions, we follow Alesina and Giuliano (2015) and consider informal institutions (e.g. social norms) as part of culture, whereas formal institutions are not.

2.2.2. Food security

Like culture, food security is a multi-dimensional and flexible concept that has been defined in various ways. For this review, we use one of the most widely accepted definitions, adopted by FAO in 1996 and refined in 2001; "*Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" (FAO, 2002). At the 2009 World Summit on Food Security, the four '*pillars*' of food security were defined as *availability*, *access*, *utilization* and *stability* (FAO, 2009).

Food availability focuses on the supply side and refers to the extent to which sources of nutrition are physically available through (local) food production and sales. *Food access* in turn points to the household's or individual's ability to obtain the food that is available. We pay particular attention to *food choice* within the discussion of food access because the ability to obtain food does not necessarily translate into actual acquisition (Pinstrup-Andersen, 2009). For the purpose of this review, *food utilization* concerns the preparation, processing and cooking of foods. Finally, *stability* is the temporal dimension of food security and includes both the likelihood of experiencing shocks and the ability to recover from them.

It is important to acknowledge that conceptualized in this way, individual food security is a necessary but not sufficient condition for adequate nutrition. As outlined in the UNICEF malnutrition framework (Black et al., 2008), nutrition status is the result of the interplay between food and nutrient intake and health. However, as the effects of culture on health have been discussed elsewhere (e.g. Helman, 2007; Koenig et al., 2012; Spector, 2002), we limit the scope of our review to the impact of culture on the determinants of dietary intake only. In addition, we focus on direct drivers, leaving aside indirect effects of culture through underlying deeper determinants such as political institutions or economic growth – whose relation with culture has been reviewed elsewhere (e.g. Alesina and Giuliano, 2015; Gershman, 2016; Iyer, 2016; Spolaore and Wacziarg, 2013). Given its importance as a determinant of food access, Section 2.3.2 however briefly discusses available evidence on the impact of culture on income growth.

2.3. Culture affects food security in various ways

We organize our discussion of the impact of culture on food security along the lines of the four 'pillars' discussed in Section 2.2.2. In practice there may not be a strict separation between these pillars, as there are interactions and overlaps between the different channels of impact.

2.3.1. Availability

First, *what* food is produced and traded depends on what is classified as food. Culturally transmitted classifications of available sources of nutrition as food and non-food determine what potential foods are included in the regular diet (Fieldhouse, 1995; Helman, 2007) and thereby influence the composition of local food production, sales, and trade. It is worth noting that such classifications are crucial for the effectiveness of food-based interventions. Englberger (2012) for example reports that a government program in Micronesia aimed at reducing vitamin A shortages failed because it promoted the consumption of green leafy vegetables, which were seen as fodder rather than food for human consumption.

Second, culture shapes *how* food is produced. A growing body of research has analyzed the impact of traditional food production[4] systems and the knowledge embedded therein on food availability (e.g. Altieri, 2004; Clawson, 1985). A noteworthy finding of several studies is that certain traditional crop combinations offer agricultural complementarities in the form of resource sharing or protection against environmental stresses (Kumar and Nair, 2004; Milburn, 2004) and a number of traditional crop selection and pest management systems are well adapted to local environments and risks (Abate et al., 2000**;** Altieri, 2004; Clawson, 1985; Jaenicke and Höschle-Zeledon, 2006). In addition, several traditional production practices have been documented to result in high agro-biological diversity (Altieri, 2004; Clawson, 1985), which can facilitate dietary diversity (Bélanger and Johns, 2008; Penafiel et al., 2011)**.** It is important to note however, that when food safety checks are absent or insufficient, traditional food production systems may also carry a higher risk of exposure to toxins, either organic (Benkerroum, 2013; Murphy et al., 2006; Wild and Gong, 2010) or inorganic (Isildak et al., 2004; Larsen, 2006; Muhammad et al., 2011; Nabulo et al., 2010)**.**

[4] Traditional food production refers to the production of foods in a traditional manner (not to the production of traditional foods). We see it as a system that relies on the natural resources available to the group; that has existed for a long period of time; and where production and the embedded knowledge is socially transmitted within the cultural group.

Box 1: The Native American 'three sister' food system

Based on the belief that the spirits of the 'three sisters' belonged together, the Six Nations people traditionally planted maize, beans and squash together. Agriculturally, this integrated agro-ecosystem has many advantages (e.g. Altieri, 1999; Postma and Lynch, 2012; Risch, 1981). Maize has high nitrogen requirements, and beans bring atmospheric nitrogen into the soil with the help of symbiotic bacteria. The maize stalks in turn provide structural support to the climbing bean plants. With their large round leaves, squash plants shade the soil and as such help conserve moisture and reduce weeds. Integrated plantings also reduce pest problems.

Source: Milburn (2004)

Since agricultural technology adoption takes place in a social context, culture will also influence producers' acceptance of new food technologies and their willingness to incorporate innovations in food production (Vanclay, 2004). The success of farmer field schools for Filipino rice farmers has for example been attributed to the presence of cultural norms that encourage experiential and collective learning (Palis, 2006).

The efficiency of food production systems in ensuring the availability of sufficient and nutritious foods further depends on post-harvest losses and waste of food. How food is processed and stored is strongly determined by culturally transmitted food processing and storage techniques (e.g. Cardoso et al., 2005; Chipungu et al., 2012; Kittler et al., 2011).[5] More generally, cultural models of eating may drive food waste behavior. Public discourse often refers to the emergence of a '*throwaway society*' in higher-income countries where food waste is commonplace (Evans et al., 2012; Godfray et al., 2010). Yet, the cultural drivers of food waste are strikingly understudied, and available research strongly focuses on industrialized countries (Blichfeldt et al., 2015; Evans, 2011; Evans et al., 2012).

2.3.2. Access and choice

Even when food is physically available, food and nutrient intake will depend on a household's and individual's ability to obtain that food. Two major dimensions of access to food are economic access and social access.

Economic access to food is largely determined by income. The relation between culture and (long-run) economic growth has been reviewed elsewhere (Gershman, 2016; Iyer, 2016; Spolaore and Wacziarg, 2013). These studies generally conclude that there is "*a key role for persistent traits transmitted across generations within populations in explaining development outcomes over the very long run*"

[5] The properties of traditional food processing and storage techniques are analogous to the properties of traditional food production and are discussed in more detail in Section 2.3.3 on the use of food.

(Spolaore and Wacziarg, 2013: 17). However, it remains difficult to empirically disentangle the effects of culture traits from the effects of other characteristics of human populations, locations, and societies on long-run economic development (Spolaore and Wacziarg, 2013). To our knowledge, the micro-level effects of culture on income have not been systematically reviewed. Available evidence suggests that the relation is highly heterogeneous across a wide diversity of settings, culture traits and channels of impact (e.g. Ager et al., 2014; LeMay-Boucher et al., 2013; Stifel et al., 2011. Bettendorf and Dijkgraaf (2010) for instance find that church membership and other measures of religiosity have different effects on income for high- and low-income households within countries. Hence, the current evidence base does not seem to allow us to draw any general conclusions about the impact of culture on household and individual food access through its effects on income.

By influencing social inclusion or exclusion, culture shapes social access to food as well. The social transmission of beliefs about groups and individuals (e.g. in the form of stereotypes) can lead to stigmatization and discrimination, and in severe cases result in marginalization through the structural exclusion from social and economic life (Mahajan et al., 2008; Parker and Aggleton, 2003). Some work has for example documented the exclusion of groups and individuals from food assistance programs (e.g. von Braun and Thorat, 2014). Food access can also be undermined through exclusion from regular food acquisition strategies such as food shopping or food production, but this effect has not been systematically researched.

In contrast to a large and growing literature on the implications for health (Gabrysch and Campbell, 2009; Mahajan et al., 2008; Smedley et al., 2002; Williams and Mohammed, 2009), less attention has gone to the implications of social exclusion for food security. The situation of indigenous peoples merits particular attention in this respect (King et al., 2009; Stephens et al., 2006).[6] Although data is limited, indigenous peoples appear to be worse off in terms of food security in any country (Kuhnlein et al., 2006a). In Honduras, for example a staggering 95 % of indigenous children is estimated to suffer from malnutrition. Similarly, the rate of stunting in indigenous communities in Guatemala, El Salvador and Ecuador was found to be almost twice as high as the rate among non-indigenous children (UN, 2009). The marginalized status of indigenous peoples is often named as one of the causes of this nutrition gap, but an improved understanding of the impact of social exclusion on different food security drivers is severely hampered by a lack of systematic data.

[6] The definition of indigeneity is complex and contested. We refer to the topical literature (e.g. Stephens et al., 2006) for a detailed discussion.

Culture also affects individual access to food through intra-household food distribution. Important channels of impact are culturally determined beliefs and norms about the value of different types of foods, the order in which different household members are served, and what constitutes a fair share of the meal (Gittelsohn et al., 1997; Harris-Fry et al., 2017). For instance, what is considered a fair share of the meal mainly depends on the perceived 'needs' and 'contributions' of household members, which in turn are affected by beliefs about the importance or toughness of different types of work and responsibilities within the household Engle and Nieves, 1993; Haddad et al., 1996; Harris-Fry et al., 2017). There is consensus on the fact that males are often favored over females in quantity or quality of food, which can negatively affect food access for girls and women in poor households (e.g. Gittelsohn et al., 1997; Haddad et al., 1996).

Access to food may be further affected by practices regarding how much and what kind of food to offer during feasts or to guests, in particular at large social events such as weddings or funerals (Fieldhouse, 1995). Especially when such practices oblige households to decrease food stocks or slaughter livestock, longer-run household food security could be undermined. A telling example comes from Peru, where government food aid targeted to children was served at community dinners honoring out-of-town guests (ACF, 2010). However, in other cases festivities stimulate the consumption of nutrient-rich foods (e.g. Sho, 2001), thus contributing positively to food security. Research on the effects of feasts and festivals on food access remains scarce. Some anthropological work suggests that festivals may actually be a form of institutionalized food redistribution to the poor (or to the rich) (Dietler and Hayden, 2010; Fieldhouse, 1995; Greenberg, 1981).

Cultural models of eating also specify how, when and where one should eat and what constitutes a 'proper' meal. By shaping meal and eating patterns, such models have an important effect on what food is accessible and what food we choose to eat (Atkins and Bowler, 2001; Fieldhouse, 1995; Kittler et al., 2011). Studies of resettled refugees show that the confrontation with unfamiliar cultural models of eating can present significant barriers to food security, in the form of difficulties in navigating the new food environment and preparing unfamiliar foods (e.g. Hadley et al., 2007; Morris et al., 2009; Sheikh-Mohammed et al., 2006).

Socially transmitted food prescriptions (what should be eaten) and proscriptions (what should not be eaten) including food taboos, can affect social access to food and food choice. Such food pre- and proscriptions (collectively referred to as dietary rules) are derived from food classifications according to different criteria, including associated social status, perceived

healthiness[7], or sacredness (Helman, 2007).[8] There is large heterogeneity in the type, importance and impact of dietary rules across and within cultural groups. Even food taboos are not always absolute and can be specific to certain individuals and circumstances (Meyer-Rochow, 2009). Pregnancy, the postpartum period, and infancy are for instance commonly characterized by dietary rules for women and infants (Kim-Godwin, 2003; Piperata, 2008). Though pregnant and lactating women in various parts of the world are forced to abstain from especially nutritious and beneficial food (Barennes et al., 2009; Hartini et al., 2005; Santos-Torres and Vásquez-Garibay, 2003), some studies find that nutrition or energy intake is promoted (e.g. Kaewsarn et al., 2003; Wiley, 2002) or the effects are mixed (e.g. Piperata, 2008; Sein, 2013; Steinberg, 1996).

Overall, the impact of dietary rules seems to be highly context-specific. A case in point is the impact of religious dietary rules: certain diets and fasting rituals were found to restrict the consumption of foods that are unhealthy in obesogenic environments, while other food-related religious practices had little effect or may be harmful in case of illness, pregnancy, or when access to substitutes is limited (Trepanowski and Bloomer, 2010; Sabaté, 2004).[9]

In general, the food security impact of dietary rules will depend on the extent to which they effectively influence food intake. This in turn depends on how strictly compliance with the behavioral implications of culture traits is enforced. When dietary rules are flexibly enforced, they affect food choice, as compliance will depend on one's assessment of the costs and benefits of observance (Denney et al., 2014; Lee et al., 2009; Raven et al., 2007). These practices can however generate strictly enforced social norms that hamper access to foods that would otherwise be available and economically accessible (e.g. Meyer-Rochow, 2009; Nwajiuba and Okechukwu, 2006).

Besides strong social pressure, strict enforcement can result in a strong internalization of the culture trait as well. Fessler and Navarrete (2003) for instance describe how people's initial explanation as to why an animal is not eaten (e.g. pig among many Muslims) is a feeling of disgust, rather than an explicit taboo or symbolic value.

[7] Whether a food is classified as healthy or unhealthy can be based on beliefs about nutritional value or broader salutary or detrimental effects on the body, mind or community (Helman, 2007).

[8] The distinction between food taboos and non-food classifications is not straightforward. Many studies conflate food taboos and food proscriptions, but we prefer to make the distinction because there can be important differences in terms of the strength of underlying norms and enforcement.

[9] Ramadan fasting for instance does not seem to have any major effects on food security for healthy individuals, but may have negative consequences in case of illness (Leiper et al., 2003; Roky et al., 2004; Sabaté, 2004) or pregnancy (Almond and Mazumder, 2011; van Ewijk, 2011).

Box 2: Strictly enforced taboos for pregnant women in Ghana

In rural Ghana, pregnant women are forbidden to eat various foods including snails, rats, snakes, hot foods and animal lungs. These taboos are seen as instructions from god passed down from generation to generation to safeguard them against evil and diseases. Disobedience is considered blasphemous and believed to lead to anger of the ancestors, which can put the community and the health of mother and child at risk. Pregnant women are therefore continuously reminded about the taboos and those who break them are constantly frowned upon or even excommunicated from the family or community.

Source: Arzoaquoi et al. (2015)

Compliance and enforcement can be flexible to varying degrees. Ramadan fasting offers an example of formalized individual flexibility: pregnant, menstruating or breastfeeding women are required to defer Ramadan fasting to a later time to protect their health and that of the fetus or infant (Laway and Ashraf, 2015)[10]. In other cases, flexibility takes the form of tolerance for non-compliance as long as behavior remains in accordance with underlying cultural models. An example is the compensation of food taboo violations by performing neutralizing rituals or eating foods that counteract the negative effects of the violation (Bentley et al., 1999; Meyer-Rochow, 2009). When external enforcement in strong but internalization weak, people may resort to various strategies to circumvent external enforcement, such as secret non-compliance (e.g. Bentley et al., 1999).

There has been a rising interest in the role of traditional dietary knowledge in shaping food choice and combatting malnutrition. A substantial body of research has studied traditional diets and the embedded dietary knowledge (e.g. Kittler et al., 2011; Kuhnlein et al., 2009; Trichopoulou et al., 2007). It is now widely recognized that a large number of traditional[11] foods have high nutritional value and are important contributors to nutrition for communities worldwide (Benkerroum, 2013; Burlingame, 2000; Grivetti and Ogle, 2000; Roche et al., 2008; Trichopoulou et al., 2007). Failure to safeguard access to their traditional foods has also been identified as a major driver of poor food security outcomes of indigenous peoples (Kuhnlein et al., 2006a; King et al., 2009; UN, 2015). More generally, indigenous peoples' food security is undermined by the loss of bio-cultural resources that are the foundations of their diet.

[10] Local beliefs and norms may still override these formal rules and enforce the participation of all adults, including pregnant women (Almond and Mazumder, 2011).

[11] In analogy with the definition of traditional food production we consider traditional food as food provided by the natural resources available to the group (both wild and cultivated) that has been consumed for a long period of time and reflects cultural inheritance, i.e. the production and consumption of the food is socially transmitted within the cultural group (e.g. Guerrero et al., 2009; Roche et al., 2008; Trichopoulou et al., 2007).

Box 3: The benefits of 'little millets'

A species of millet (*Panicum sumatrense*), known as 'little millets' is one of the oldest food grains known to humans and grows well in dry zones, producing crops even on very poor soils. These grains form a traditional staple food for low-income groups in some South Asian countries (Pradeep and Guha, 2011), where they are processed into healthy snacks or nourishing flour that can be mixed with rice flour, offering longer shelf-life. The millets are rich in vitamins, phenolic acids, calcium and iron and contain more soluble fiber than rice or wheat. Moreover, the little millets also have a low glycemic index, making them attractive health foods.

Source: Jaenicke and Höschle-Zeledon (2006)

Although more research is needed to corroborate these findings in different settings, recent evidence also suggests that traditional food consumption may be associated with higher dietary diversity (e.g. Boedecker et al., 2014; Penafiel et al., 2011). In addition, cultural groups around the world continue to rely on the age-old strategy of consuming wild foods to cope with short- and long-term food shortages (Bharucha and Pretty, 2010; Burlingame, 2000; Grivetti and Ogle, 2000; Huss-Ashmore and Johnston, 1994). Despite a growing consensus on the potential value of traditional dietary knowledge and the associated consumption of traditional foods, benefits or disadvantages of a wide set of traditional foods remain largely unexplored (Johns and Sthapit, 2004).

Culture further influences food choice by determining consumers' acceptance of new food technologies and innovations. The cultural drivers of food acceptance, and the impact on food choice, have been extensively investigated for industrialized countries, primarily in the context of genetically modified (GM) foods. Finucane and Holup (2005) for instance find that conservative attitudes toward novelty in Germany, a rejection of the US fast food culture associated with GM food in France, and religious values regarding the immorality of disturbing the natural order across Europe, reduce acceptance rates of GM foods (see also Curtis et al., 2004; Ronteltap et al., 2007).

Research for non-industrialized countries and other food technologies is scarce. Some recent work has explored the cultural drivers of consumer acceptance of bio-fortified maze in low-income countries (De Groote and Kimenju, 2008; Meenakshi et al., 2012; Stevens and Winter-Nelson, 2008), but the evidence base is too limited and too heterogeneous to draw any conclusions.

Finally, culture also shapes preferences about ideal body sizes (Batnitzky, 2011; Helman, 2007; Olvera et al., 2005), which may affect eating behavior. Although globally preferences seem to be shifting to thin bodies, large bodies remain the ideal in various cultural groups (e.g. Batnitzky, 2011; Helman, 2007; Micklesfield et al., 2013). Quantitative evidence on the impact of these preferences on actual body sizes however remains limited, mixed, and likely is confounded by two-

way causality since actual body size may affect body size ideals (e.g. Flynn and Fitzgibbon, 1998; Olvera et al., 2005; Swami et al., 2007).

2.3.3. Utilization

How we prepare food is strongly determined by culture (e.g. Fieldhouse, 1995; Kittler et al., 2011; Lawrence and Barker 2009). As Lawrence and Barker (2009:191) put it: "*memories from childhood provide images that stay throughout adulthood; thus, homemade or mother's cooking are used as reference points for how food should be prepared and taste*". Food preparation involves the combination of different individual foods into meals, and the way these foods are processed. Both have important implications for nutrient intake and absorption as well as the digestibility, palatability, and safety of foods (Milburn, 2004; Ruiz-Rodriguez et al., 2008; Tapsell et al., 2006).

There has been growing interest in the properties of food combinations in traditional food preparation, with various studies finding that certain combinations offer nutritional benefits. Milburn (2004) discusses the example of the dramatically higher protein quality of grains-legumes combinations (e.g. maize and beans in the Americas) compared to the sum of the separate foods due to protein complementarity.

Traditional food processing often also continues to play an important role in present-day food preparation (e.g. Benkerroum, 2013**;** Liu et al., 2011). Certain techniques such as fermentation, soaking, or malting have been identified as cost-effective and energy-efficient ways of improving the nutritional value, safety, palatability, or digestibility of food in diverse settings (e.g. Fandohan et al., 2005; Hotz and Gibson, 2007; Hwang and Lee, 2006; Klayraung et al., 2008; Liu et al., 2011; Makokha et al., 2002). However, as one method can affect food components in different ways, trade-offs take place (Abuajah et al., 2014). Some techniques (e.g. prolonged heating, sun drying) may for instance improve food safety at the expense of nutritional value (Hotz and Gibson, 2007; Lyimo et al., 1991). In addition, there are substantial differences in the performance of different traditional processing methods of the same food across groups. Given the important effects of food processing, storage, and preparation on food security, researchers have called for heightened efforts to explore the benefits and risks of a wider set of traditional techniques (Allen and Gillespie 2001; Cardoso et al., 2005; Hotz and Gibson, 2007).

Box 4: Traditional cassava processing techniques

Cassava naturally contains cyanide in modest quantities. Consumption of large amounts of cassava and derived products may therefore cause cyanide poisoning, leading to symptoms such as vomiting, diarrhea, and possibly death. In addition, cyanide intake from cassava exacerbates goiter and cretinism in iodine deficient areas, and chronic dietary exposure to cyanide has been associated with diseases such as konzo and Tropical Ataxic Neuropathy. Processing methods to reduce the cyanide content of cassava flour were developed by trial and error hundreds of years ago by indigenous peoples in Amazonia for the preparation of *farinha* (cassava flour) which involves scraping, grating and roasting of the roots. This elaborate technique has been proven very efficient in reducing cyanogen levels, and there is no evidence of cyanide toxicity associated with cassava use among indigenous peoples in Amazonia. In contrast, heap fermentation and sun drying, commonly used in eastern and southern Africa, do not adequately remove cyanide.

Source: Cardoso et al. (2005) and Dufour (1994)

2.3.4. Stability

Culturally transmitted dietary rules have been found to affect the efficiency and sustainability of resource use. The importance of taboos – and more generally cultural or religious beliefs – as frameworks for governing natural resource extraction is gaining widespread recognition. Taboos restricting the consumption or production of certain foods in time or space can for example support species conservation and sustainable resource exploitation and thus contribute to the stability of the food supply (Cinner, 2007; Colding and Folke, 2001; Jones et al., 2008; Meyer-Rochow, 2009). In other cases the conservation value of taboos however appears to be limited – for instance because the group upholding the taboo is too small to have any significant impact (Golden and Comaroff, 2015; Fessler and Navarrete, 2003). Moreover, negative effects can occur when culturally transmitted food prescriptions result in (local) overexploitation of the targeted species – in particular when wild species become commercially traded (Chamberlain et al., 2004).

In addition, traditional food crops often demonstrate higher resilience and lower care needs compared to non-indigenous cultivated foods. A number of studies also finds that traditional crop selection and pest management systems may contribute to the stability of food production, as some have been found to be particularly well adapted to local environments and shocks, for instance through the use of crop varieties that are resistant to different types of environmental stresses, have different growing periods and durations, or have different nutritional requirements (Abate et al., 2000; Altieri, 2004; Clawson, 1985). The property of higher resilience and resistance to different

types of environmental stresses is particularly attractive in a context of increasing climatological risk and uncertainty.

Finally, as mentioned above, culture influences processing and storage of food, which can promote longer shelf life. This can in turn mitigate constraints such as seasonality and poorly functioning markets (Keding et al., 2013) and contribute to the stability of food consumption.

Box 5: The conservation value of Malagasy social norms

Among central eastern Malagasy communities, strict social norms govern the timing for harvesting and hunting certain species. The 'correct' time for hunting tailless tenrecs (a small mammal somewhat similar to a hedgehog) is for example considered to be April or May, which is after the young have become independent (Nicoll, 2003). Despite the fact that the sanction is social disapproval rather than supernatural retribution, this taboo is strictly observed. Tenrec hunting (as opposed to killing a tenrec found during other activities) only occurs during these months. As such, this taboo contributes to the sustainable exploitation of this species.

Source: Jones et al. (2008)

2.4. Gender, family and decision-making power

At the individual and household level, gender, family, and decision-making power are key cross-cutting determinants that interact with most, if not all, channels through which culture affects food security.

2.4.1. Gender

Each society is characterized by a "*set of guidelines, both implicit and explicit, that are acquired from infancy onwards, and tell the individual how to perceive, think, feel and act as either a male or female member of that society*" (Helman, 2007: 158). These cultural gender models are of paramount importance when discussing the impact of culture on food security. First, gender can determine directly what preferences, beliefs, norms, and practices one is expected to display or observe. For instance, women often face a larger number of food pre- and proscriptions due to their reproductive role (Bentley et al., 1999; Odebiyi, 1989; Meyer-Rochow, 2009). In addition, other gender-specific social norms that are not directly related to food can influence food security as well. Ravindran et al. (1986) for example describes how in Haryana, India, cultural restrictions on adolescent girls' freedom to leave their homes limit their physical access to significant sources of dietary diversity. Such gender effects call for caution in extrapolating evidence on the impact of culture from men to women and vice versa.

Second, gender will often interact with effects of culture. Gender roles within the household, notably the division of household labor, are particularly important in the context of culture and food security as they interact with many channels of impact such as dietary practices and intra-household food distribution (Moss, 2002; Piperata, 2008). For instance, the impact of food taboos on individual food access can depend on who is in charge of food purchases in the household.

Box 6: The importance of gender roles in explaining the impact of 'resguardo' in the Eastern Amazon

'*Resguardo*' derives from the Portuguese verb '*to protect'* (resguardar) and refers to a period of food and work restrictions for women after childbirth. Women throughout several parts of Brazil and other Latin American countries observe the practice. An analysis of dietary intakes during resguardo revealed that resguardo women have lower energy intakes, but not as a result of dietary restrictions. R-Instead, the combination of work restrictions and gendered household labor division explains the energy reduction. In particular, resguardo work restrictions prevent women from performing their usual staple food processing and preparation tasks, which reduces the availability of staple foods in the household (as husbands generally do not take over).

Source: Piperata (2008)

2.4.2. Family

Family structures, including the different relations and responsibilities of family members, can interact with the food security effects of culture in three important ways. First, family life plays a crucial role in the development of eating habits, among others through socialization into cultural models, parental modelling, and exposure at home (Birch and Fisher, 1998; Patrick and Nicklas, 2005; Taylor et al., 2005; WHO, 2012). There is extensive evidence for an indirect long-term impact of infant and child feeding practices on food security through the development of food preferences in later life (Birch and Fisher, 1998; Taylor et al., 2005; Wardle and Cooke, 2008). For instance, serving sugar-rich foods in positive contexts (e.g. celebrations) can strengthen children's innate preference for sweet foods, which may promote overnutrition in later life (Birch and Fisher, 1998; Birch, 1999).

Second, mothers often share home care and child feeding responsibilities with other family members – in particular grandmothers – who may have a large or even primary influence in these areas. Fouts and Brookshire (2009) for instance find that among the Aka foragers in Congo, mothers contribute less to child feeding than other family members combined (e.g. fathers, grandmothers, aunts).

Third, the preferences and beliefs of recipient family members can influence the choices of caregivers (e.g. in home care, cooking, etc.) to varying degrees (Just et al., 2007; Lawrence and Barker 2009).

2.4.3. Decision-making power

Gender models and family relations are of course closely linked to decision-making power. The main locus of power in decision-making processes varies across cultural groups, from highly individualistic models to highly collectivist models where the locus of power lies mainly with the community (Hammoud et al., 2005; McLaughlin and Braun, 1998). Individual decision-making power within groups may depend on a variety of factors, but are commonly associated with gender, age, and social status. In many cultural groups, elders are important decision makers in the family and community, and in that function play a key role in preserving, transmitting, and changing culture traits (e.g. Aubel, 2012; Bezner Kerr et al., 2008; Fouts and Brookshire, 2009; Geçkil et al., 2009; Kaewsarn et al., 2003; Raven et al., 2007).

Decision-making power is a major mediating factor in the relation between culture and food security. Who decides when and what food to buy or produce, or how to distribute it within the household, to give a few examples, can have a crucial influence on the impact of culture traits (e.g. Denney et al., 2014; Lori and Boyle, 2011; McLaughlin and Braun, 1998; Scott et al., 2014). This also implies that who provides and who receives information matters a great deal for the impact of information interventions on behavior.

2.5. Dynamic aspects of the culture-food relation and drivers of change

As mentioned before, culture is dynamic and evolving, often changing in response to a changing environment. Food and non-food classifications or food taboos, for instance, can change in times of food shortages (Fessler and Navarrete, 2003; Helman, 2007). However, culture can also be a powerful and emotionally held preserver of stability and predictability, strongly resisting change (Fieldhouse, 1995; Weisner, 2000). Even in situations of extreme starvation, for instance, groups may hold on to food taboos (Helman, 2007). Malagasy dietary rules illustrate this duality well: whereas one type of proscriptions is perceived as negotiable and people can ask their ancestors to free them in times of need, breaking other extremely strict taboos is always expected to lead to illness or misfortune (Jones et al., 2008).

The question of when, how, and why culture changes or persists is at the center of a growing body of theoretical and empirical research across disciplines.[12] Existing theories continue to be debated, and a full discussion of the topic exceeds the scope of this review. We instead highlight the question of how modernization relates to cultural change, which has received particular attention in recent years. Classic modernization theory states that traditional values, beliefs, and customs – especially religion and supernatural belief systems – will inevitably disappear with rising urbanization, education, and the spread of scientific and technological advancements (Iannaccone, 1998; Inglehart, 2016).

As many have argued that this assumption does not hold invariably, scholars have sought reformulations of the classic theory. Inglehart (2016) for instance proposes an evolutionary modernization theory, in which modernization is argued to increase economic and physical security levels, which creates important cultural changes in similar directions. Yet, because culture is highly persistent, these cultural changes are path-dependent and reflect historically determined cultural differences. A case in point is the continued and possibly growing vitality of witchcraft beliefs in sub-Saharan Africa (e.g. Gershman, 2016b; Kohnert, 2007; Leistner, 2014), or the continued importance of religion outside of Europe and its offshoots (Iannaccone, 1998). The take-away message is that one can expect important cultural change following modernization processes such as income growth, but such change does not necessarily erode cultural differences or the historically shaped core characteristics of a culture.

2.5.1. Change and persistence in the cultural drivers of FNS

In the context of food security, we indeed see both cultural change and persistence. Research has documented cases where modernization and economic development are associated with a loss of traditional knowledge (Gómez-Baggethun et al., 2010; Gómez-Baggethun et al., 2013; Reyes-García et al., 2013) and an erosion in adherence to certain food-related culture traits (e.g. Lilette, 2006; Piperata, 2008; Englberger et al., 2003). Indigenous peoples have often experienced particularly drastic dietary changes following the modernization of food systems – although the degree to which traditional food systems disappeared varies considerably (Kuhnlein et al., 2009).

Then again, an illustration of the persistence of food habits is the fact that in many regions the dominant staple crop continues to be the crop that was endemic to that ecological zone, i.e. the crop that was eaten by pre-industrial societies (Atkins and Bowler, 2001). More generally,

[12] See e.g. Alesina et al., 2013; Boyd and Richerson, 2004; Gershman, 2015; Henrich and McElreath, 2003; Lee et al., 2009; Mesoudi, 2011.

research documents various cases where in spite of broad societal changes including migration[13] and the spread of Western religion, food-related cultural models have remained relatively intact (e.g. Golden and Comaroff, 2015b; Jones et al., 2008).

While both change and persistence have been clearly observed, the question of when and how cultural models of eating and food habits change remains highly complex and poorly understood. New information appears to be a major driver of cultural change overall, as it alters the socially transmitted information set that is culture. In particular, cultural change seems to occur when new information is linked to existing cultural models, as this facilitates acceptance and integration of the new information or the reinterpretation of pre-existing knowledge (Aubel et al., 2004; Bezner Kerr et al., 2008; Kuhnlein et al., 2013; Semega-Janneh et al., 2001).

In this light, research on the impact of migration – which entails exposure to new information and different culture traits – can offer insights into the question of how and when cultural models of eating and food habits change. Chowdhury et al. (2000) for example find that Bangladeshi migrants in the UK largely maintained their traditional dietary habits. Reviewing surveys on the food habits of migrant populations in Europe, Gilbert and Khokhar (2008) find that some immigrant populations spend significantly more on preserving their food habits than others, regardless of socio-economic status. The authors suggest that the extent of dietary acculturation may depend on the value placed on one's original food habits and those in the host country, as well as the availability and accessibility of foods from the original diet. Generation and age also appear to play an important role. Younger generations of Pakistani migrants in the UK were for example more likely to change their eating habits as British foods were seen as convenient, associated with the host country, and reflective of adventure and independence (Jamal, 1998).

2.5.2. Globalization, cultural change, and shifts in diets and food habits

An important recent development in this context is the large-scale global shift in human diets and food habits in similar directions (high consumption of saturated fats and sugars, highly processed foods, and out-of-home meals), a phenomenon often referred to as the '*nutrition transition*' (Chopra et al., 2002; Kearney, 2010; Keats and Wiggins, 2014; Monteiro et al., 2013; Popkin et al., 2012). However, it remains unclear to what extent this global shift in diets reflects cultural change, and to what extent it is a consequence of the globalization of food systems.

These processes are of course not mutually exclusive, as food system changes can generate cultural change and vice versa. Recent studies on alcohol consumption patterns for example argue

[13] Migration flows (e.g. the arrival of outsiders who do not adhere to the same rules) can lead to cultural erosion (e.g. Maarleveld and Dangbégnon, 1999; Kaufmann et al., 2006).

that in combination with income growth, globalization has increased access to foreign investment and new products, as well as the spread of knowledge and information on these products, ultimately giving rise to a global convergence of alcohol consumption patterns (Colen and Swinnen, 2016; Swinnen and Briski, 2017). Other studies also suggest that the globalization of food systems along with the globalization of ICT technologies and mass media spreads cultural lifestyle and eating models (e.g. fast food) (Huynen et al., 2005; Keats and Wiggins, 2014). Yet, there is little rigorous research regarding the relative importance of cultural drivers and socio-economic or supply side factors in the nutrition transition.[14]

2.5.3. Mass media, marketing, and changing cultural models

Media and marketing are a major source of information for the public and thereby both reflect and shape culture traits (Wakefield et al., 2003). Mass media is increasingly visible and accessible through ICT developments such as mobile internet connection, and marketing has expanded far beyond simple advertising into marketing environments that include sales promotions, websites, viral marketing, music and sports sponsorship, product placement in films and television, and in-school marketing (Hawkes, 2006).[15]

It is important to note that though advertising is now a global phenomenon (Hawkes, 2006), research on the nature and impact of media and marketing in developing countries is scarce. Available evidence from developed countries shows that media and marketing have a strong effect on food choice (Cairns et al., 2013; Cohen, 2008; Harris et al., 2009; Taylor et al., 2005).

Three broad mechanisms are at play. First, marketing affects automated, uncontrollable responses through environmental cues, such as the placement of products in supermarkets (Cohen 2008). Second, the omnipresence of media and marketing in everyday life and popular culture shapes habits and preferences by creating powerful cultural models of food, health, and lifestyle that consumers are driven to emulate (Atkins and Bowler, 2001; Nestle et al., 1998; Wakefield et al., 2003). Exposure to mass media has for example been associated with internalization of a thin body ideal and changes in women's eating behaviors and beliefs (Grabe et al., 2008). Third, media affects perceptions of the risks and benefits of foods (Cairns et al., 2013; McCluskey and Swinnen, 2004; Taylor et al., 2005).[16]

[14] Watson (2006) offers an in-depth study of the rise of McDonald's in East Asia, and argues that the success of McDonald's in Beijing is driven by associations with freedom, democracy, and 'world citizenship', rather than the taste or convenience of the food.

[15] See also Kretchmer (2004) for a discussion of the increasing presence of advertising in the entertainment sector, resulting in so-called 'advertainment'.

[16] This media effect seems to explain a significant part of between-country differences in GM food regulations (Vigani and Olper, 2015).

As for the direction of impact, both positive and negative effects occur. On the one hand, the powerful influence of media and marketing can be detrimental to food security. Marketing generally induces overconsumption (Anderson et al., 2009; Cohen 2008; Lovato et al., 2011). Food marketing is also often heavily oriented toward low-nutrition, obesogenic foods and beverages and has been shown to increase the consumption of these foods (Cairns et al., 2013; Dixon et al., 2007; Harris et al., 2009; Monteiro, 2009).

Box 7: Focus on unhealthy foods in television advertising

Analysis of television advertisements on channels most popular with children in 13 countries across 5 continents revealed that in each country, food products were in the top 3 advertised products. For all countries, the majority of food advertisements (67%) were for foods that are relatively high in undesirable nutrients including fat and sodium. Programs specifically targeting children contained an even higher proportion of advertisements for these foods (80% of food advertisements). Fast-food restaurant meals and chocolate and confectionary in particular were the most frequently advertised food products.

Source: Kelly et al. (2010)

In addition, marketing is often aggressively targeted to children and adolescents with the aim of shaping long-term food habits, and may thereby negatively affect long-run food security already from a young age (Cairns et al., 2013; Harris et al., 2009; Wakefield et al., 2003). Finally, the information transmitted by media and marketing does not necessarily conform to the best scientific knowledge and may include misleading nutrition claims, thereby contributing to misinformation about food (Abrahams et al., 2016; Keats and Wiggins, 2014; Nestle et al., 1998; Taylor et al., 2005).

On the other hand, the power of media and marketing can also be used to promote positive behavioral change (Randolph and Viswanath, 2004; Snyder, 2007; Wakefield et al., 2010). Public mass media information campaigns appear to have small but positive effects on changing eating behaviors (e.g. Matson-Koffman et al., 2005; Pomerleau et al., 2005; Snyder et al., 2004). Experiments with the use of social media and digital technologies for promoting desirable diet and health behavior show promise, but further research is needed to draw conclusions about behavioral impact and to tackle the specific challenges of these new types of media (e.g. how to control information quality on social media) (Higgs et al., 2014; Korda and Itani, 2013; Moorhead et al., 2013).

2.6. Conclusions and implications for policy and research

This review has shown that what we eat, as well as how and why we obtain, process, store, prepare, share, and eat food, is affected by culture in various ways. Some channels of impact, such as food taboos, have been extensively researched, while for others such as the cultural drivers of food waste the literature is still in its infancy. In many cases available research is heavily oriented toward high-come countries. Overall, empirical evidence on the impact of cultural drivers of food security appears to be mixed and varies across different cultural groups and socio-economic settings for most channels of impact, making it difficult to draw general conclusions. Despite this, we try to formulate some conclusions and recommendations as to how policy can use existing knowledge on the impact of culture to improve food security, and identify areas for future research.

The growing recognition of the importance of culture for food security has already gained culture a more prominent place on the policy agenda. Yet, less progress has been made in terms of integrating and mainstreaming it into food security policies and interventions in practice. Perhaps the most obvious and widely recognized way in which culture should be taken into account is by ensuring the availability of foods that meet culturally determined preferences.[17] However, the use of culturally inappropriate foods remains a common cause of failure of supplementary feeding programs (Allen and Gillespie, 2001). A telling example comes from Kenya, where food aid in the form of maize to pastoralists, whose traditional diet is largely based on animal source foods, was not consumed but instead processed into home brewed alcohol (Barrett, 2006). Similarly, failure to safeguard the availability of and access to culturally appropriate foods has been identified as a major driver of poor food security outcomes of indigenous peoples (Kuhnlein et al., 2006a; UN, 2009).

The effectiveness of campaigns targeted at behavioral change is particularly dependent on how culture is taken into account as well (Kreuter and Haughton, 2006; Winham, 2009).

First, the impact of information on behavior will strongly depend on who provides and who receives information. The fact that information interventions are usually targeted at mothers and young reproductive women, thus bypassing existing gender, family, and power relations, may explain why many have not led to sustained behavioral change (Allen and Gillespie, 2001; Bezner Kerr et al., 2008; Cornwall, 2003). An improved understanding of cultural models of gender, family and decision-making power is therefore crucial to make sure that the most relevant decision-makers or persons of influence are involved. There is growing evidence that the inclusion of family and community members and other peers has positive effects (e.g. Kuhnlein et al., 2013; Pérez-

[17] The condition of meeting food preferences was for example added to the FAO (1996) definition of food security because of concerns related to the cultural acceptability of foods in different contexts (Pinstrup-Andersen, 2009).

Escamilla et al., 2008; Semega-Janneh et al., 2001).[18] Aubel et al. (2004) provide an illustrative example of an intervention which specifically aimed to test the impact of involvement of grandmothers in providing nutrition and health information to pregnant mothers in Senegal. The results showed sustained positive behavioral changes among grandmothers (e.g. different advice) and mothers (e.g. increased food intake during pregnancy, improved breastfeeding and complementary feeding practices) only when grandmothers were involved, affirming their key role in turning new health information into new practice.

Second, information that is culturally appropriate and builds upon certain culture traits may be more effective in capturing attention, stimulating information processing, and ultimately motivating behavioral change. Allen and Baines (2002) for example report evidence from an experiment that suggests that individuals can be persuaded to alter their diets by stressing certain values symbolized by a food product rather than focusing exclusively on nutritional arguments. Kuhnlein (2004) also argues that interventions may be more successful when they focus on stimulating the use of health-promoting traditional foods and dietary practices. The promotion and reintroduction of traditional foods may therefore also be a useful component of strategies to tackle the double burden of malnutrition in high-income settings (Johns and Sthapit, 2004). Such strategies are of particular interest in light of recent trends of reviving local traditional or artisanal food cultures, which is argued to constitute a counter-reaction to the spread of fast food and highly processed foods associated with the nutrition transition (Pieniak et al., 2009; Wilk, 2006).

Besides cultural acceptability, for certain traditional foods research has documented one or several of the following benefits: high levels of micronutrients, (natural) availability, affordability, and higher resilience and lower care needs. As such, when developing food-based strategies, it is worthwhile to explore traditional diets and gather information on the nutrition, anti-nutritional and toxic content of traditional foods, taking into account the impact of food production, processing, and preparation techniques, and (in)organic contamination, in order to identify and promote the use of traditional foods that can contribute to food security. The possible economic, social and ecological implications of these interventions should be investigated as well, since they can be highly heterogeneous across communities depending on the dietary, cultural, or economic value of the food (Kuhnlein et al., 2013; Termote et al., 2011).

Improving the integration of culture may also enhance the effectiveness of production-oriented policies and interventions as well. There is growing recognition of the potential value of

[18] See McLean et al. (2003) for interventions where the impact remains largely unclear. The impact of involving husbands in reproductive and maternal-child health interventions is more mixed (Kraft et al., 2014; Midhet and Becker, 2010; Mullany et al., 2007; Sternberg and Hubley, 2004), possibly because husbands are not always the most relevant decision-makers in this area in the study populations.

culture and the embedded knowledge for realizing sustainable, accessible, and qualitative food production systems. In some cases, traditional knowledge can offer a useful repository of alternative technologies that are particularly compatible with local food systems and cultural models, accessible, familiar, easy to use, and low-cost. Certain agro-ecological farming (Altieri, 2004; Pangaribowo et al., 2013) and climate change coping strategies (Stigter et al., 2005) were for example modelled after successful traditional agricultural systems.

Similarly, especially when other food technologies such as fridges or pasteurization are inaccessible or inappropriate for local conditions, traditional food processing and storage techniques can serve as inspiration. For instance, in eastern Africa where access to electricity remains limited, traditional pots of unbaked clay were found to act as an efficient replacement for a refrigerator to store milk, due to the cooling effect of evaporation (Roesel et al., 2015).

Based on research and experimentation, such techniques can be further transformed in collaboration with local producers and consumers to improve the productivity and resilience of food production and the safety, efficiency, and effectiveness of food processing, storage, and preparation (Abate et al., 2000; Hotz and Gibson, 2007). A successful example of this strategy is the improvement of a traditional cassava processing method into the so-called wetting method, which rapidly reduces the cyanide content of cassava flour, in addition to improving taste and storage possibilities (Bradbury, 2006; Bradbury and Denton, 2010; Cumbana et al., 2007). Being simple and based on traditional techniques, the method has shown promise in terms of acceptance rates and positive food security effects (Banea et al., 2012; 2013).

If policy is to take advantage of the potential benefits of traditional food systems, however, more efforts are needed to document and preserve these food systems and the underlying biological and cultural resources. [19]

Participatory approaches based on dialogue and information sharing rather than top-down, directive, and expert-led interventions, may be especially suitable to take culture into account in practice.[20] Such approaches are more likely to result multifaceted strategies that consider a broad range of cultural variables and the inclusion of local knowledge. This in turn facilitates the tailoring of interventions to local contexts and the acceptance and integration of new information in existing cultural models (e.g. Kuhnlein et al., 2013; Semega-Janneh et al., 2001). In the area of agricultural development, the possible advantages of these approaches are well established (e.g. Abate et al., 2000; Bezner Kerr et al., 2007). For other drivers of food security considered in this review, they

[19] In many cases these bio-cultural resources are disappearing at a fast rate (Burlingame and Dernini, 2012). Kuhnlein et al. (2006b; 2009) provide a detailed description of a protocol for documenting traditional food systems of indigenous peoples, and apply this to various indigenous peoples worldwide.

[20] See Cornwall (2003) for a critique on the current use of participatory approaches to development.

are still less common, though some existing interventions have produced encouraging results (e.g. Aubel et al., 2004; Kuhnlein et al., 2013).

One could draw useful lessons from the health sector on how to take culture better into account in the area of food security. The practice of giving cultural training to health care providers enabling them to deliver care in a way that is intelligible and acceptable (e.g. Betancourt et al., 2003; Spector, 2002), can serve as inspiration to improve the cultural competence of those involved in the delivery of various food security interventions. Another strategy employed in health care consists of adjusting logistics to ease cultural barriers in accessing health services. Delivering perinatal care at home or facilitating accompanied travel to medical facilities for example eases constraints presented by gender norms on mobility (Mumtaz and Salway, 2005). The same could hold for delivery of food assistance or nutrition information.

There has also been a rising interest for a better integration of traditional and biomedical health services in health research and policy (e.g. Homsy et al., 2004; WHO, 2013; Zhang et al., 2011). The fact that traditional and biomedical health services are founded on different (possibly conflicting) illness and health models does not necessarily pose a problem: patients and providers are found and stimulated to make different models compatible by reinterpreting biomedical information and practices through the lens of local models, or by adapting beliefs and practices so as to make them consistent with newly acquired information (Adams et al., 2005; Obermeyer, 2000; Scott et al., 2014; Wiley, 2002).

Research on the feasibility and desirability of an institutionalized integration of traditional and biomedical health services has identified the different advantages, risks, and potential obstacles (King, 2000; Mills et al., 2006). A better integration of beneficial traditional foods and traditional production, processing, and cooking methods into food systems likely faces many similar benefits, risks, and obstacles. In addition, government programs to foster health care integration that are currently being implemented in various countries (e.g. Aissan et al., 2013; Kayombo et al., 2007) may offer important insights for the design and implementation of similar interventions in the area of food security.

Finally, there are several areas for future research. A major gap in our understanding remains *how important* cultural effects are relative to other drivers, such as socio-economic (prices, income, education) or environmental factors (food availability, remoteness). A small body of qualitative and quantitative work has to tried to shed light on the relative importance of cultural drivers in the context of food security. In some cases cultural variables are argued to trump economic or environmental determinants (Atkin, 2016; Choudhury and Ahmed, 2011; Watson,

2006), while in other cases culture seems to play a secondary role (e.g. Goldman et al., 2002; Hartini et al., 2005).

One possible reason for the paucity of systematic research analyzing and comparing cultural, economic, and environmental effects on food security is the qualitative or descriptive nature of a large part of the literature, with limited information on the size of cultural effects. A first step toward an improved understanding of the relative importance of culture thus lies in the quantification of its impact on different aspects of food security. Both on the consumption side and the production side, however, major data gaps remain. For instance, in contrast to a large literature on the role of culture in health gaps for marginalized groups (e.g. Helman, 2007; Smedley et al., 2002), little is known regarding food security gaps. To understand the extent to which cultural factors contribute to poor food security of severely marginalized groups such as indigenous peoples there is an urgent need for systematic and comprehensive data collection on both cultural drivers of food security and needs and outcomes for marginalized groups (Stephens et al., 2006).

A second vital question that remains poorly understood relates to the dynamics of culture. Although notable progress has been made in various disciplines toward understanding the origins and evolution of culture, the question of when, how, and why culture changes or persists remains a highly complex one that is intertwined with environmental, social, economic, and politico-institutional change. For instance, while both change and persistence have been clearly observed, the question of when and how cultural models of eating and food habits change remains poorly understood. In this context, the rapid growth and spread of new information and communication technologies (ICT) is of particular interest. Recent research suggests that new global marketing campaigns, the rise of social media, and the rapid spread of mobile phones in developing countries can affect food preferences and dietary knowledge (e.g. Abrahams et al., 2016; Dixon et al., 2007; Rutsaert et al., 2013). Yet, overall we know little of the effects on cultural drivers of food security. Since ICT technologies can be expected to develop and spread further, more research is needed to improve our understanding of their potential effects and the implications for food security policy. For instance, future research could explore how to curb any negative food security effects and how ICT technologies can be usefully incorporated in food security strategies.

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Chapter 3. Voodoo versus fishing committees: the role of traditional and contemporary institutions in fisheries management

3.1. Introduction

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

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

We examine community-based fisheries management at Lake Nokoué in Benin. The lake fisheries provide a livelihood to artisanal fishing communities, but are severely affected by overfishing and resource degradation (FAO, 2008; Gnohossou, 2006). Fishing was historically regulated by an institution embedded in Voodoo, the traditional animistic religion of Benin (Bourgoignie, 1972; Clédjo, 2006; Dangbégnon, 2000; Pliya, 1980). After colonization, socio-economic changes undermined the influence of the Voodoo religion and Voodoo-based institutions. The erosion of traditional fisheries management in combination with failing government institutions, strong population pressure and the rising value of fishery products resulted in increasingly severe overfishing (Dangbégnon, 2000). In the 1990s the fishing communities attempted to curb this negative trend by creating committees to regulate fishing activities (Atti-Mama, 1998).

These fishing committees issued rules that differ and sometimes conflict with traditional Voodoo-based rules. For instance, both the committees and the traditional institution formulate a rule

concerning the *konou* – a highly productive fishing technique that makes use of fine mesh nets. The traditional rule bans the use of the fine meshed konou at all times (Clédjo, 2006; Pliya, 1980), while the fishing committees impose a periodical prohibition: open weeks – in which the use of the konou is allowed – alternate with closed weeks – in which the konou is banned.

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

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

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

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

explicitly identify themselves with Voodoo to fishers who follow other religions while controlling for village-level characteristics.

The next section discusses fishery management institutions and the social-ecological system of lake fisheries in southern Benin. Section 3.3 presents our data and Section 3.4 explains the methodology used to analyze the data. Section 3.5 presents our results, and in Section 3.6 we investigate a number of competing explanations for our findings. Section 3.7 concludes.

3.2. The lake fisheries of southern Benin

3.2.1. The social-ecological system

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

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

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

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

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

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

3.2.2. Fisheries management

The traditional Voodoo-based institution

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

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

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

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

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

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

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

The fishing committees

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

The fishing committees created a new rule for the konou that allows its use during four consecutive weeks (open weeks) and bans it for the following two weeks (closed weeks). These periods

[3] See online appendix C for more details.

of open and closed weeks alternate throughout the shrimp fishing season (January – August) when larvae migrate from the ocean to the lake, mature and return to the ocean (Hoestlandt, 1939). By periodically banning the use of the konou across the entire lake, the rule intends to reduce the damaging impact of the konou. Fishers are well informed about the rule: in the 2013 survey, only one out of 137 fishers said not to know it.

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

3.3. Data

3.3.1. Data sources

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

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

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

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

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

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

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

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

3.3.2. Descriptive statistics

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

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

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

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

3.4. Data analysis

3.4.1. The traditional rule

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

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

For the household survey sample we estimate the following equation:

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

Konou is an indicator variable taking value 1 if individual *i* reports to have used the konou in week *t* (and 0 otherwise)[9]; *Voodoo* is an indicator variable that equals 1 if individual *i* reports his religion to be Voodoo (and 0 otherwise); τ is a count variable that indicates the week *t* of the survey period; λ is a vector of dummy variables at the arrondissement level *a* that capture time-invariant community characteristics; *X* is a vector of control variables; and ε denotes the random error term. To deal with serial correlation of the error terms we cluster error terms at the individual level, thereby allowing error terms to be correlated within individuals (across weeks) while still imposing independence of the error terms between individuals (Wooldridge, 2010).

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

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

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

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

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

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

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

Konou is an indicator variable taking value 1 if individual *i* reports to use the konou for fishing (and 0 otherwise); *Voodoo* is as specified in equation (1); φ is a vector of village dummy variables; Φ is a vector of control variables; and ε denotes the random error term, in this case clustered at the village level to allow for within-village correlation of the error terms across individuals. The set of control variables Φ consists of the logarithm of age, a categorical variable indicating the level of education, the number of children in the household[11] and ethnicity dummy variables.[12] A significantly negative estimate of α_1' would indicate that any negative relation between Voodoo adherence and the use of the konou holds when accounting for unobserved village-level heterogeneity.

3.4.2. The fishing committee rule

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

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

Closed is an indicator variable taking value 1 if the lake is closed in week *t* (and 0 otherwise); all other variables are as specified in equation (1). A significantly negative estimate for β_1 would indicate that

[11] Dependent children.

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

the use of the konou is on average lower in closed weeks compared to open weeks, suggesting compliance to the fishing committee rule.

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

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

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

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

3.4.4. Estimation technique

We rely on logistic regression to estimate equation (1)-(4). To address concerns of unobserved individual heterogeneity confounding our results, we use an individual fixed effects model to estimate equations (3) and (4). However, this model does not allow us to estimate the impact of the time-invariant variable Voodoo adherence in equations (1) and (2). We therefore estimate these two equations using a simple logit model.[13] We report our estimation results in terms of odds ratios; marginal effects for the logit model and OLS can be found in Online appendix A.2 and A.3.2.

3.5. Results

Table 4 presents the results on compliance with the traditional Voodoo-based rule. Columns (1) and (2) show odds ratios for equation (1), without and with controls. The odds ratio for Voodoo fishers is smaller than one and statistically significant, indicating that on average Voodoo fishers are less likely

[13] The individual effects in a fixed effects model absorb all time-invariant variables such as Voodoo adherence. The Hausman-Taylor model (Hausman and Taylor, 1981) offers the possibility of estimating the impact of time-invariant regressors in a fixed effects model, but requires instruments that were not available in our data. In section 3.6.1. we use three alternative methods to address unobserved individual heterogeneity for equation (1) and equation (2).

to use the konou than other fishers (all else equal). Column (2) indicates that the odds of konou use in any given week are on average 78 % lower for Voodoo fishers compared to other fishers. In terms of marginal effects, being a Voodoo adherent reduces the probability of using the konou by on average 21 percentage points (all else equal).

Columns (3) and (4) show odds ratios for equation (2), again without and with controls. The odds ratio for Voodoo fishers remains smaller than one and statistically significant at the 10 % level when village dummy variables are included. We therefore rule out the competing explanation that unobserved village-level heterogeneity is driving the negative relation between konou use and Voodoo adherence. However, the effect of Voodoo adherence is substantially smaller when village dummies are included: the odds of using the konou are on average 33 % lower for Voodoo fishers compared to other fishers. In terms of marginal effects, the probability of konou use is 6 percentage points lower for Voodoo fishers compared to other fishers (all else equal).[14]

The estimated coefficients for the control variables (reported in Online appendix A.2) show the expected signs. The odds of konou use are significantly higher for younger and wealthier fishermen, and increase the further we are in the shrimp fishing season. Education, household size and the dependency ratio do not significantly affect konou use in either sample. For the case of education, however, we should note that there is very little variation in education levels in both samples: 86 % of fishers in the survey sample and 84 % of fishers in the census sample have not had any formal education.

Table 5 presents the results for compliance with the fishing committee rule. Columns (1) and (2) show odds ratios for equation (3), with and without controls, and column (3) shows odds ratios for equation (4). The odds ratios for closed weeks are smaller than one and statistically significant in all columns. The last column indicates that the odds of konou use are on average 38 % lower in closed weeks compared to open weeks (all else equal).[15] This finding suggests that there is some, although limited, compliance to the fishing committee rule.

[14] The difference in effect size of Voodoo adherence between the survey (equation (1)) and census (equation (2)) samples could be due to the fact that equation (2) takes village-level confounding factors into account, but other explanations are possible. The census sample includes 28 additional villages, the dependent variables are measured differently (see Online appendix B) and the identity of the interviewer may matter: fishers may have been less inclined to report konou use to census interviewers working for the government, with whom they have had many conflicts in the past about fishing activities (Dangbégnon, 2000).

[15] Since the logit fixed effects model does not estimate intercepts, we do not report marginal effects for these regressions in Online appendix A.2.

The odds ratio for the interaction term is close to one and not statistically significant. This result indicates that, among those who use the konou for fishing, Voodoo adherents are on average equally likely to use it in closed weeks as other fishers. In other words, Voodoo fishers who decide to break the traditional rule (by using the konou) display the same behavior towards the fishing committee rule as non-Voodoo fishers.

We conduct a number of tests to verify the robustness of these findings. The results for equations (1), (3) and (4) are robust to the use of a larger unbalanced sample of 121 fishers, which includes fishers who were not interviewed in all weeks (this test is not relevant for equation (2), which relies on the census sample). The results for equations (1)-(4) are robust to the use of a linear OLS model. Finally, the results for equation (1) hold when we replace the time-varying dependent variable *use of the konou in week t* by a time-invariant measure of overall compliance: *total use of the konou across 14 weeks* (dropping the time dimension from the analysis). Details on these robustness checks and full results for all regressions in this chapter can be found in Online appendix A.

What is the practical significance of our findings? From an environmental perspective one could argue that the optimal outcome is to end all fishing activities, including the use of the konou, so as to allow the lake ecosystem to recover. From this perspective, a reduction of the odds of konou use in the order of 33 % (census sample) to 78 % (survey sample) might be considered small. From an economic perspective, however, it does not seem optimal to reduce the use of the konou to zero, as this would imply a severe blow to local livelihoods. A less intensive use of the konou seems necessary, but to what extent the use of the konou needs to be limited depends on the nature of the ecosystem, the dynamics of the fishing stocks, the environmental impact of the konou and the weights placed on environmental and economic concerns.

To better grasp the economic costs of not using the konou, one could estimate how much revenue fishers forgo. An analysis of the productivity of the konou (explained in more detail in Online Appendix A.5) suggests that konou use may increase weekly shrimp fishing revenue by as much as 383 % , although this estimate needs to be interpreted with caution due to data limitations. Nevertheless, our finding that a traditional, Voodoo-based institution still holds enough power to bring fishers to give up a substantial amount of extra shrimp fishing income seems non-negligible.

We similarly find some compliance regarding the fishing committee rule. That compliance is far from perfect should not surprise given the substantial benefits of free-riding on the compliance of others. Yet, the fact that there is some compliance may indicate that there is interest in establishing a system for collective restraint and better resource management. So, even though the effects we find

are too small to speak of successful management institutions, they do indicate that these institutions contain some effective elements that are able to change fishing behavior. These elements may be valuable in devising a better resource management strategy.

3.6. Competing explanations

3.6.1. Unobserved individual heterogeneity

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

As explained in section 3.4.4 (footnote 13), the individual fixed effects model or the Hausman-Taylor model, which control for unobserved individual-level heterogeneity, cannot be implemented in our case. We therefore turn to three alternative methods.

We start by addressing the specific concern that Voodoo adherents have a preference for the traditional. If this were the case, we would expect to find a negative relation between Voodoo adherence and other (relatively) recently introduced technologies as well. We test this by re-estimating equation (1) while replacing the dependent variable *use of the konou in week t* by (time-invariant) dummy variables indicating ownership of a mobile phone, an electricity generator, a radio and a TV.[16] The results, presented in Table 6, indicate that Voodoo fishers (or their households) are equally likely to own a mobile phone, electricity generator, radio or TV as other fishers.[17] This finding suggests that Voodoo adherents do not to reject recently introduced technologies more than others. It therefore seems unlikely that Voodoo fishers would reject productive fishing innovations such as the konou solely because of a preference for the traditional.

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

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

Aside from the specific concern of such unobserved preferences, there may be other unobserved characteristics related to Voodoo adherence and the use of the konou that confound our findings. Our second approach follows Oster (2013) and aims to assess the extent of the remaining omitted variable bias by looking at coefficient movements along with movements in R-squared values when control variables are included. This approach assumes that selection on unobservables is proportional to selection on observables.

Table 7 presents logit odds ratios for equation (1) when we consecutively control for the week variable, arrondissement dummies, the list of basic controls discussed in section 3.4.1 and the following additional control variables: the fisherman's relationship with the household head, his marital status, his number of wives, a dummy variable indicating whether he owns a mobile phone and three dummy variables indicating whether his household owns an electricity generator, a radio or a TV.

Table 7 shows that the odds ratio for Voodoo adherence fluctuates between 0.21 and 0.34 when controls are consecutively added. The odds ratio remains smaller than one and significant at the 10 % level (although in the last two columns the p-value increases just above 0.10). The pseudo R-squared value is 0.06 when the time trend and arrondissement dummies are included and increases to 0.15 when all controls have been added, suggesting that the included controls are informative. We conclude that controlling for a variety of informative individual characteristics has a relatively limited effect on the estimated odds ratio for Voodoo adherence, suggesting that there are no major unobservables that would entirely knock out the effect.

Our third approach follows a similar logic: we attempt to capture part of the unobserved individual effect with the use of a correlated random effects model (Wooldridge (2010), first proposed by Mundlak (1978)). To this end, we have identified a variable in our dataset that varies across time and individuals and does not give rise to reverse causation: "negative shocks to the weekly number of fishing days". Relying on this variable to implement the correlated random effects model, we find that the results for Voodoo adherence are qualitatively unchanged and quantitatively similar. Results and further details on the variable "negative shocks to the weekly number of fishing days" are provided in Online appendix A.4.1.

3.6.2. Reporting bias regarding the use of the konou

A potential caveat is that fishers may lie about konou use when the lake is closed. In this case we would overestimate compliance to the fishing committee rule. To verify whether there is reason for such

concern, we examine the fluctuations of shrimp fishing revenue across open and closed weeks.[18] As the konou is one of the most productive instruments used for shrimp fishing, any periodical variation in its use should be reflected in shrimp fishing revenue (when controlling for the use of other fishing gear). If fishers respect the fishing committee rule and abandon the konou in closed weeks, we should find that shrimp fishing revenue is lower in closed weeks compared to open weeks. Moreover, the abandonment of the konou in closed weeks may increase fishing yield when the lake is re-opened, thus giving an additional boost to fishing revenue.

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

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

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

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

The two equations can be written as follows:

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

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

F denotes shrimp fishing revenue for fisherman i in week t; $Closed^w$ ($Open^w$) are indicator variables that take value 1 if the lake is closed (open) in week t for the w-th consecutive week (and 0 otherwise); τ is a count variable as specified in equation (1); φ are individual fixed effects (i.e. individual-level dummy variables); K is a vector of control variables; ε_{it} denotes the random error term. The control variables in K reflect the fishery production function and capture the input of time, labour and capital. We include the logarithms of the number of fishing days and the number of persons fishing, and dummy variables indicating the use of the three main shrimp fishing instruments other than the konou.

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

Columns (3) and (4) in Table 8 show estimation results for equation (6). The coefficient estimates for the first and second week of opening are positive, large and statistically significant. The results indicate that shrimp fishing revenue is on average 117 % higher in the first open week and 67 % higher in the second open week, compared to the average of closed weeks. The coefficient estimates for the third and fourth open weeks are positive but not statistically significant. These findings suggest that there is a strong increase in fishing revenue in the first two open weeks, which dies out in the third and fourth weeks of opening. One possible explanation is that intensive use of the konou in the first two open weeks reduces fishing yield again, driving down fishing revenue in the two weeks after.[19]

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

These findings are a strong indication of reductions in konou use when the lake is closed However, one may still object that the fluctuations in fishing revenue are caused by a natural cycle rather the fishing committee rule. We therefore perform a falsification test, comparing the fluctuations in shrimp revenue at Nokoué with those at another southern lake in Benin (Ahémé, see Figure 1), where similar natural conditions prevail but the fishing committee rule does not apply. Finding no significant differences between the two lakes would suggest that the fluctuations observed at Nokoué are caused by a natural cycle rather than the fishing committee rule. However, we find significantly larger fluctuations of shrimp revenue at Nokoué, suggesting that the observed fluctuations do not merely result from natural cyclicality (see Online appendix A.4.2 for details).

3.7. Conclusion

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

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

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

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

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

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

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

Our empirical findings confirm qualitative evidence on the continued role of the traditional Voodoo-based institution in regulating fishing activities at the southern lakes of Benin (Amoussou, 2004; Clédjo, 2006; République du Bénin, 2008). Our findings also resonate with those of several other studies (cf. Section 3.1) and with recent research advocating an integrated resource management approach, where traditional institutions are combined with contemporary management institutions and technologies (Becker and Ghimire, 2003; Cinner and Aswani, 2007; Colding and Folke, 2001; Drew, 2005: Dudley et al., 2009).

At the same time, the above analysis is only a first step towards a quantitative assessment of the effectiveness and potential substitutability of these institutions. More research is needed to fully understand how these institutions and their interaction affect fishing behavior, and what the policy implications are. Our first analysis suggests that both institutions affect fishing behavior, but only in a limited way. In this case resource management needs to be strengthened. One integrated management strategy that is increasingly being implemented is the incorporation of sacred sites into official

protected areas. Sacred forests in Benin are already being integrated into a national system of protected areas (GEF, 2010), and the southern lakes of Benin are similarly characterized by sacred sites. Nevertheless, the official protection of sacred sites also involves risks such as a loss of spiritual value (Dudley et al., 2009). Hence, careful research is needed to evaluate the potential success of this strategy. Future research could further examine whether other elements of the traditional Voodoo-based institution (such as the prohibition to fish on days of worship) can be valuably integrated into resource management, or whether other religions can play a role in resource management.

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Figures

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

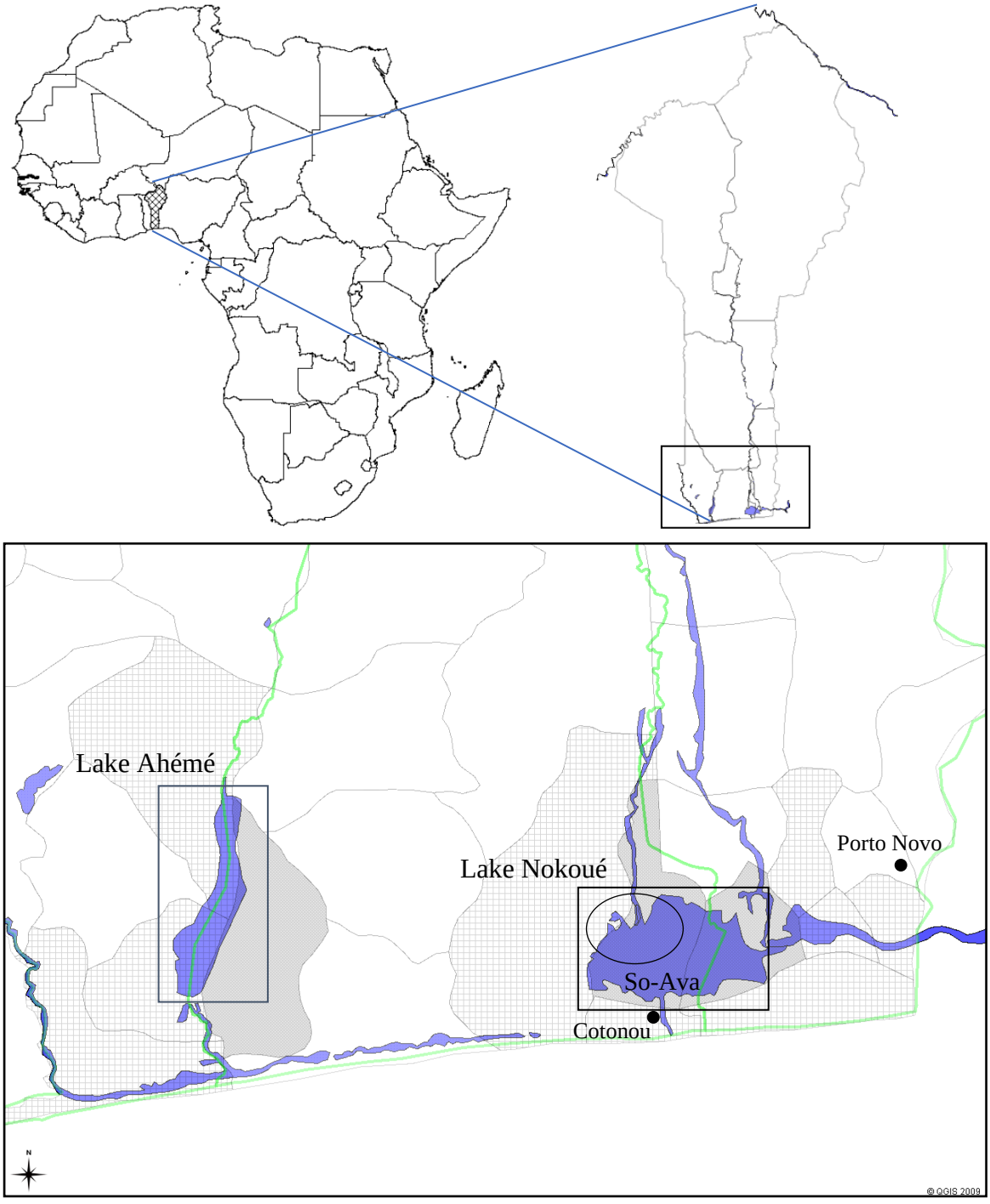
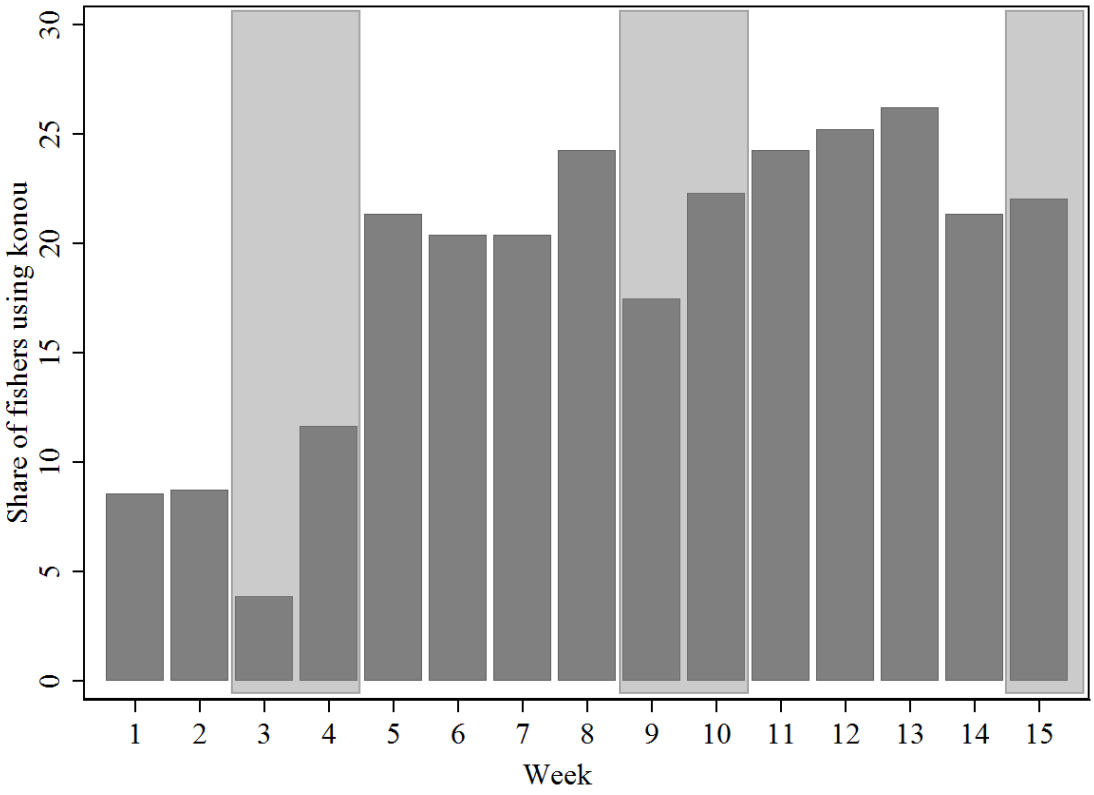
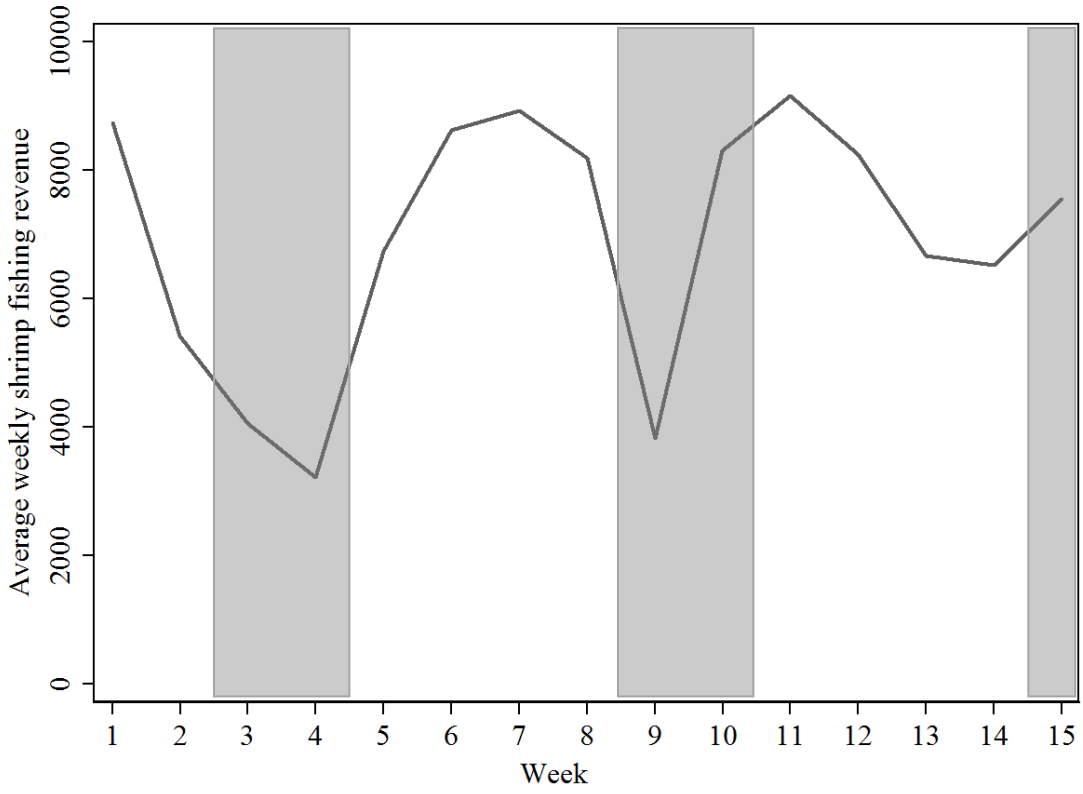


Figure 2: Share of fishers using the konou in each week, across open and closed weeks.



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

Figure 3: Average weekly shrimp fishing revenue (CFA) across open and closed weeks.



Source: Author's calculations.
Notes: Light-grey areas indicate closed weeks. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009.

Tables

Table 1: Characteristics of data samples used

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

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

Table 2: Religious affiliation of fishers in two samples

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

Source: Author's calculations.

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

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

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

Table 4: Use of the konou and Voodoo adherence in two samples: Logit odds ratios

Sample	Household survey		Fishery census	
Dependent variable	Use of the konou in week t		Use of the konou	
Variables	(1)	(2)	(3)	(4)
Voodoo	0.362**	0.219**	0.468***	0.669*
	(0.177)	(0.133)	(0.125)	(0.162)
	[0.038]	[0.012]	[0.004]	[0.097]
Week		√		
Arrondissement		√		
Controls		√		√
Village				√
Constant	√	√	√	√
Number of clusters	102	88	34	34
Observations	1,190	1,039	5,852	5,160

Notes: Odds ratios are reported with robust standard errors in parentheses and p-values in square brackets. Standard errors are clustered at the individual level for columns (1) and (2) and at the village level for columns (3) and (4). ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Week refers to a count variable that indicates the week of observation. Arrondissement and Village refer to dummy variables indicating the arrondissement or village in which the individual lives. Controls refer to the control variables discussed in section 3.4.1.

Table 5: Use of the konou and the fishing committee rule: Logit individual fixed effects odds ratios (2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week t			
Variables	(1)	(2)	(3)
Closed	0.583***	0.620***	0.621***
	(0.084)	(0.091)	(0.100)
	[0.000]	[0.001]	[0.003]
Voodoo*Closed			0.994
			(0.373)
			[0.988]
Week		√	√
Number of clusters	43	43	43
Observations	550	550	550

Notes: Odds ratios are reported with individually clustered robust standard errors in parentheses and p-values in square brackets. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Columns (1) and (2) show estimation results for equation (3). Column (3) shows estimation results for equation (4). The regression sample is limited to the subsample of konou users, i.e. fishers who report to have used the konou at least once during the survey period. The conditional logit fixed effects model does not estimate intercepts or coefficients for time-invariant regressors such as Voodoo adherence. Week refers to a count variable that indicates the week of observation.

Table 6: Ownership of recent technologies and Voodoo adherence: Logit odds ratios (2009 household survey)

Dependent variable	Individual owns mobile phone	Household owns electricity generator	Household owns radio	Household owns television
Variables	(1)	(2)	(3)	(4)
Voodoo	0.309	3.738	1.509	0.807
	(0.266)	(3.422)	(1.120)	(1.044)
	[0.173]	[0.150]	[0.580]	[0.868]
Controls	√	√	√	√
Arrondissement	√	√	√	√
Constant	√	√	√	√
Observations	79	79	79	79

Notes: Odds ratios are reported with robust standard errors in parentheses and p-values in square brackets. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For details on the explanatory variables we refer to the notes below Table 4. Controls are listed in section 3.4.1.

Table 7: Use of the konou and Voodoo adherence: inclusion of additional control variables - Logit odds ratios (2009 household survey)

Dependent variable	Use of the konou in week t										
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Voodoo	0.362**	0.344**	0.210**	0.219**	0.214**	0.214**	0.233**	0.273*	0.307*	0.331	0.331
	(0.177)	(0.173)	(0.129)	(0.133)	(0.132)	(0.133)	(0.152)	(0.189)	(0.218)	(0.231)	(0.230)
	[0.038]	[0.033]	[0.011]	[0.012]	[0.013]	[0.013]	[0.025]	[0.060]	[0.096]	[0.113]	[0.112]
Week		√	√	√	√	√	√	√	√	√	√
Arrondissement			√	√	√	√	√	√	√	√	√
Basic controls				√	√	√	√	√	√	√	√
Relationship household head					√	√	√	√	√	√	√
Marital status						√	√	√	√	√	√
Number of wives							√	√	√	√	√
Mobile phone								√	√	√	√
Electricity generator									√	√	√
Radio										√	√
TV											√
Constant	√	√	√	√	√	√	√	√	√	√	√
Observations	1,190	1,190	1,190	1,039	1,039	1,039	1,039	927	927	927	927
Number of clusters	102	102	102	88	88	88	88	79	79	79	79
Pseudo R-squared	0.026	0.041	0.058	0.113	0.124	0.125	0.127	0.146	0.150	0.154	0.154

Notes: Odds ratios are reported with individually clustered robust standard errors in parentheses and p-values in brackets. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Basic controls refer to the list of control variables discussed in section 3.4.1. For more details on the explanatory variables we refer to the notes below Table 4.

Table 8: Shrimp fishing revenue across weeks: Linear individual fixed effects estimates (2009 household survey)

Dependent variable: (log) Fishing revenue for shrimp in week t				
Variable	(1)	(2)	(3)	(4)
Closed first week	-1.186***	-0.783***		
	(0.277)	(0.253)		
	[0.000]	[0.003]		
Closed second week	-0.505**	-0.094		
	(0.233)	(0.221)		
	[0.033]	[0.671]		
Open first week			1.513***	1.169***
			(0.305)	(0.280)
			[0.000]	[0.000]
Open second week			1.179***	0.670**
			(0.346)	(0.311)
			[0.001]	[0.034]
Open third week			0.990***	0.375
			(0.347)	(0.319)
			[0.005]	[0.242]
Open fourth week			0.632**	0.228
			(0.245)	(0.243)
			[0.011]	[0.350]
Week		√		√
Controls		√		√
Constant	√	√	√	√
Observations	1,438	1,184	1,438	1,184
Number of clusters	103	102	103	102
R-squared	0.02	0.26	0.02	0.26

Notes: Coefficients are reported with individually clustered robust standard errors in parentheses and p-values in square brackets. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. For details on the explanatory variables we refer to the notes below Table 4 and section 3.6.2.

Appendix

Supplementary material is provided in the online appendix, which can be found at https://feb.kuleuven.be/drc/licos/publications/dp/dp364.

Chapter 4. Historical malaria burden and present-day witchcraft beliefs

4.1. Introduction

Culturally embedded beliefs affect economic and institutional change and explain the persistence of different development paths (e.g. Alesina and Giuliano, 2015; Gorodnichenko and Roland, 2010; Mokyr, 2014). Gaining a proper understanding of how humans form their beliefs is therefore key to understanding economic development patterns, and more generally is "*fundamental to a new social science*" (North, 2008:1005).

Some belief systems have sparked extensive interest among economists, while others remain largely unexplored and poorly understood. For instance, a growing body of research has produced important insights into the economic origins and drivers of the world's dominant religions (e.g. Iannaccone, 1998; Michalopoulos et al., 2012). In contrast, economic literature on the roots and dynamics of other globally prevalent belief systems, such as ancestral worship or witchcraft, is still in its infancy (e.g. Gershman, 2015).

We contribute to this line of research by studying the long-run drivers of present-day witchcraft beliefs in sub-Saharan Africa (SSA). 'Witchcraft' is used to denote a complex set of magical beliefs about the use of occult forces by humans (Geschiere, 2011). These beliefs appear around the world, but remain especially powerful in SSA, where they are said to have a profound influence on economic life (e.g. Comaroff and Comaroff, 1999; D'Angelo, 2014; Kohnert, 1996; Leistner, 2014; Platteau, 2014). Although witchcraft beliefs and practices take a variety of forms across cultural groups, and their specifics depend on local contexts, there are basic cross-cultural similarities within and beyond SSA (Koning, 2013; Leistner, 2014). These similarities are the key factor motivating our analysis, as they suggest the existence of cross-cultural drivers of witchcraft beliefs.

We investigate the hypothesis that the historical disease burden explains cross-cultural variation in the prevalence of witchcraft beliefs. Various disciplines have associated cultural differences and evolution with the disease environment (e.g. Fincher et al., 2008; Gelfand et al., 2011; Inglehart, 2016; McNeill, 1976; Schaller and Murray, 2008; Thornhill et al., 2009; Webb, 2006). In particular, a heavy infectious disease burden has been empirically associated with collectivistic or embedded cultures (Fincher et al., 2008; Thornhill et al., 2009). The fact that witchcraft beliefs are widely associated with collectivistic cultures (Platteau, 2014) already hints at

a possible relation with the disease environment. Several strands of research substantiate this link by identifying specific psychological and economic mechanisms through which a heavy disease burden can promote witchcraft beliefs (e.g. Foster, 1976; Keinan, 2002; Leistner, 2014; Miguel, 2005; Platteau, 2014).

However, to the best of our knowledge there is to date no large-scale empirical evidence in support of such a relationship. The aim of this chapter is to fill this gap by quantitatively investigating the relation between long-run disease burden and contemporary witchcraft beliefs across countries and ethnic groups in SSA. We focus on the long-run burden of malaria, which is one of the major diseases in historical and contemporary SSA.

To estimate the malaria-witchcraft relation, we combine recent survey data on self-reported witchcraft beliefs with ethnicity-level data on historical malaria mortality. The witchcraft data are taken from a survey conducted by the PEW Research Forum in 2008-2009 and record beliefs for 20,592 respondents across 17 countries in SSA (Pew Research Centre, 2009). Overall, 44 % of respondents reports to believe in witchcraft, with important cross-ethnic and cross-country variation. The historical malaria mortality measure is taken from Depetris-Chauvin and Weil (2016) and relies on estimates of the frequency of the sickle cell gene in a population, which results from the selective pressures exerted by malaria. These genetic data are used to calculate the historical probability of dying from malaria before reproductive age for a particular ethnic group.

We find that a one standard deviation increase in historical malaria mortality is associated with an increase of individual or ethnicity-level witchcraft beliefs by about 4 to 6 percentage points. This result is robust to the use of various estimation strategies and to the inclusion of a battery of individual- and ethnicity-level control variables.

The control vectors serve to rule out alternative channels that may drive a positive relation between malaria burden and witchcraft beliefs. For instance, malaria had important effects on historical African settlement patterns (e.g. Webb, 2006) and colonizer settlement (Flückiger and Ludwig, 2017), which could affect witchcraft beliefs today through their impact on economic development. Yet, we cannot fully exclude the possibility that the location of ethnic groups, and thus our measure of historical malaria mortality, is associated with unobserved group-level characteristics that also affect witchcraft beliefs. Our finding should therefore not be interpreted as causal evidence, but as a robust conditional correlation.

The positive disease-witchcraft correlation is nonetheless consistent with direct psychological and economic mechanisms derived from different strands of literature. The psychological channels involve the idea that witchcraft beliefs meet a psychological need to find explanations or scapegoats for misfortune in the form of disease. The economic channels state

that witchcraft beliefs strengthen resilience in the face of disease risk by instilling and enforcing strong norms of solidarity, or by relieving resource stress through the elimination of weak community members.

We attempt to distill some empirical insights into the relevance of these mechanisms by conducting a comparative analysis of other types of magical beliefs, such as the evil eye, angels and spirits, and beliefs related to protection against misfortune. Our findings indicate that the disease-beliefs relation only arises for beliefs that relate to misfortune caused by human agency. We conclude that what matters is not the need to merely explain misfortune, but rather the need to obtain visible control over the (perceived) causes of misfortune or the need to mitigate its economic impact.

The next section discusses witchcraft beliefs in SSA and how they may relate to the disease environment. Section 4.3 describes our key measures of witchcraft beliefs and historical malaria mortality. Section 4.4 presents the baseline estimation framework and results, and in Section 4.5 we address various alternative explanations for our baseline result. Section 4.6 presents a number of robustness checks, and Section 4.7 explores the relation between historical malaria mortality and other magical beliefs. Section 4.8 concludes.

4.2. Background and hypotheses

4.2.1. Witchcraft in SSA

Witchcraft is a notion riddled with definitional and conceptual controversy, as aptly described by Geschiere (2011: 233):

> *"'Witchcraft' (like 'sorcery,' 'magic,' sorcellerie, etc.) is a precarious translation – especially because of the pejorative implications of this Western notion – of African terms that often have much broader implications and might therefore be better translated by a more neutral term like 'occult force' or even 'special kind of energy.' However, these Western terms have been so generally appropriated by the African public that it has become impossible to ignore or even avoid them."*

Consequently, in this chapter we will use 'witchcraft' as an abstraction to indicate a complex series of beliefs regarding the use of occult powers by humans (for doing good or doing harm) (Leistner, 2014; Thornton, 2003).

Anthropologists have a long tradition of studying witchcraft, observing its omnipresence and importance in African societies as an integral part of religious, political, economic, and community life (e.g. Evans-Pritchard, 1935; 1937; Mbiti, 1990; Parrinder, 1956). The past decades

have seen a renewed interest in the study of witchcraft, with various scholars noting that witchcraft beliefs remain as powerful as ever in African societies and may even be growing in importance (Geschiere, 1997; Kohnert, 2007; Koning, 2013; Leistner, 2014; Platteau, 2014). Cross-country surveys corroborate this observation, finding that about 50 % of the surveyed population across various countries in SSA reports to believe in witchcraft (Gallup World Poll, 2009; Pew Research Centre, 2009).

Witchcraft is widely argued to have a profound influence on economic life in SSA through its effect on public and private decision-making (e.g. Comaroff and Comaroff, 1999; D'Angelo, 2014; Kohnert, 1996; Leistner, 2014; Platteau, 2014). Two recent studies offer quantitative support for this argument. Gershman (2016) documents a robust negative relation between witchcraft beliefs and trust – a major driver of economic growth – across SSA, and LeMay-Boucher et al. (2013) show that households in Cotonou, Benin, spend a significant income share on protection against occult forces.

Given the continued vitality of witchcraft beliefs and their proposed effects on (economic) life, it becomes important to understand why these beliefs exist and persist. A small but growing body of work on witchcraft has aimed to shed light on this question by studying its historical and contemporary drivers (e.g. Comaroff and Comaroff, 1999; Geschiere, 1997; 2011; Koning, 2013; Nunn and Sanchez de la Sierra, 2017; Oster, 2004; Shaw, 1997; Thornton, 2003; van de Grijspaarde et al., 2013).[1]

In this chapter we focus on the historical side, hypothesizing that groups exposed to a higher disease burden in the long run are more likely to hold witchcraft beliefs today. Our hypothesis is rooted in the general observation that various psychosocial behaviors among human populations are evolved mechanisms to protect against disease (Chiao and Blizinsky, 2010; Fincher et al., 2008; McNeill, 1976; Thornhill et al., 2009). For the specific case of witchcraft beliefs, several psychological and economic mechanisms can explain why they may have emerged and persisted in response to a heavy disease burden.

[1] There is an important distinction between witchcraft beliefs and witch trials or killings. The latter have been studied by economists in various works, and can be seen as (extreme) outcomes of witch beliefs following particular shocks, such as extreme rainfall (Miguel, 2005; Oster, 2004). Hence, we expect their dynamics to be different: a rise in witch killings must not necessarily imply an increase or strengthening of witch beliefs, and the absence of witch trials or killings should not be interpreted as the absence or weakness of witch beliefs. As we are interested in long-run dynamics, it is more appropriate to study the underlying beliefs rather than shock-driven outcomes such as witch killings. In addition, even actual accusations of witchcraft generally do not produce such extreme outcomes as witch killings. Studying the latter would thus entail an inevitably narrow perspective on a much broader phenomenon.

4.2.2. Psychological mechanisms

Anthropologists have long argued that witchcraft beliefs provide a framework for explaining misfortune – especially death and disease (Foster, 1976; Green, 1999; Helman, 2007; Liddell et al., 2005; Maslove et al., 2009; Muela et al., 1998; Omonzejele, 2008).[2] Foster (1976: 775) for instance categorizes most medical systems in SSA as mainly 'personalistic', where disease is explained as "*due to the active, purposeful intervention of an agent, who may be human (a witch or sorcerer), nonhuman (a ghost, an ancestor, an evil spirit), or supernatural (a deity or other very powerful being).*"

Psychological and evolutionary research has identified a cognitive underpinning for this anthropological observation. Humans have a strong psychological motivation to understand, predict, and control their environments, evidenced by the fact that undermining perceived control can have important negative effects on psychological and physical well-being (Case et al., 2004; Keinan, 2002). Evolved psychological predispositions of the human brain, such as the search for intentionality and human attributes, as well as easy recall of supernatural concepts, have resulted in a strong tendency to rely on supernatural human-like entities for explaining salient misfortune such as disease (Beck and Forstmeier, 2007; Boyer, 2003). 'Witches', as human agents that possess supernatural powers, are especially compatible with these psychological predispositions.[3]

A closely related argument stems from scapegoat theory and posits that individuals and groups have a psychological tendency to assign unmerited blame for misfortune to others, either in a process of displaced anger and frustration or as a way of diverting attention from the true underlying cause of misfortune (Jensen, 2007).

Studies of witch hunts in Europe often mention scapegoating as one of the explanations, and Oster (2004) relies on the scapegoat argument to explain a positive empirical relation between food shortages and the upsurge of witch trials in Medieval Europe. Leeson and Russ (2017) in contrast find that competition for religious market share in confessionally contested areas performs considerably better in predicting European witch hunts than temperature-induced food shortages. Scapegoating has likewise not received support in a micro-level study of the drivers of witch killings in Tanzania (Miguel, 2005).

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[2] Witchcraft tends to explain not the biological side of disease contraction ('how did I become ill?), but the ultimate reason for the occurrence or persistence of illness ('why did I become ill/do I remain ill?) (Liddell et al., 2005; O'Neill et al., 2015). In a Tanzanian case study, Muela et al. (1998) for instance describe how the community explains malaria infections by mosquito-transmitted parasites, but also believes that witches are able to make parasites invisible in the blood, so that the disease is not detected in a hospital, or to provoke the same symptoms as malaria during an attack to camouflage it and thereby gain more time to harm the victim.

[3] Leistner (2014:55-57) for instance writes: "*In its broadest sense, witchcraft is an attempt to make sense of, and deal with, the afflictions of a world dominated by unpredictable occult forces, and to secure an agreeable personal and social life. …People naturally want to understand the reasons for the hardships and disasters they have to suffer. ... where common-sense explanations fail, invisible forces are seen to be at work.*"

4.2.3. Economic mechanisms

Next to meeting psychological needs, witchcraft beliefs may contribute to the survival of a community by strengthening the group's ability to deal with the negative economic effects of disease. This economic resilience can be promoted in two ways.

First, witchcraft beliefs can relieve resource stress during negative income shocks by justifying the elimination of weak members as witches (through expulsion or murder). Miguel (2005) finds support for this hypothesis in western Tanzania, where negative income shocks induced by extreme rainfall are associated with an increase in witch killings. Although this study looks at witch killings rather than witch beliefs themselves, the results are interpreted as supportive of the underlying argument that witch beliefs create a cultural norm that makes the elimination of weak community members acceptable.

Second, witchcraft can serve as a way to instill and enforce strong in-group solidarity. Although stringent solidarity norms can be economically costly by limiting growth and dynamic efficiency, under conditions of high risk and income uncertainty they can promote the static efficiency and resilience of a community (Gorodnichenko and Roland, 2010; Platteau, 2014). Thus, in areas with high disease risk, more powerful witchcraft beliefs could have made communities better equipped to survive by boosting in-group solidarity. In his work on pre-industrial societies in West-Africa, Vansina, (2012: 318) aptly describes this mechanism:

> *"the ultimate effect of this set of [witchcraft] beliefs was to provide the very foundation of their celebrated solidarity within kingroups and/or local community groups, without which the existence of such groups could not have been sustained for very long. Indeed, both the fear of being accused and the need to stick together to guard against the attacks of witches created this solidarity and kept it alive. Consequently, belief in witchcraft actually undergirded the social basis of kinship and community."*

This aspect of witchcraft beliefs is still relevant today. In particular, community members who violate sharing norms, thereby threatening the network of solidarity relations, face the risk of being accused of witchcraft (Geschiere, 1997; Platteau, 2014). The far-reaching strategies undertaken by those who want to escape solidarity obligations – wealth concealment at significant cost, religious conversion, or even migration (Platteau, 2014) – is testimony to the strength of solidarity norms and the fear of being accused of witchcraft. Platteau (2014) thus identifies witchcraft as an external enforcement strategy that complements the ever imperfect internalization of solidarity norms and the associated values.

Yet, witchcraft beliefs may also contribute to the internalization process itself. Historians and anthropologists often emphasize the nature of witchcraft beliefs as an ethical discourse, where witches are associated with selfishness, greed, and individualism – as opposed to solidarity, other-regarding values, and collectivism (e.g. Geschiere, 1997; Leistner, 2014; Shaw, 1997; Thornton, 2003; Vansina, 2012).[4] Indeed, a salient element of present-day witchcraft beliefs across cultures is the idea that witches use their occult powers to accumulate private wealth, and that they can only garner sufficient power by taking the life force of others through human sacrifice (Geschiere, 2013; Leistner, 2014). In interviews with artisanal miners in eastern DR Congo, Stoop and Verpoorten (mimeo) quote a miner saying: "*In our activity, certain miners even sacrifice their own children or parents in order to earn more*". Other miners evoke death to demonstrate the rise of witches in their community: "*You can see it [the increase of witchcraft] with the naked eye. Lots of mourning all days*", "*The children die at any moment*".

Recent empirical research offers indirect supportive evidence for this mechanism, finding that areas with a heavy infectious disease burden are more likely to be inhabited by collectivistic cultures (Fincher et al., 2008; Thornhill et al., 2009). One of the main explanations for this finding is that human evolution positively selected for strong in-group solidarity (or 'parochial altruism') in high disease environments, because it allows communities to better manage the negative effects of morbidity and mortality (Fincher et al., 2008; Henrich, 2004; Hruschka and Henrich, 2013). The widely replicated anthropological observation that witchcraft accusations are generally targeted to members of one's intimate circle, such as neighbors and kin (e.g. Geschiere, 2013), fits well with a key role of in-group solidarity.

4.3. Data sources and description

4.3.1. Witchcraft beliefs

We take our main data on witchcraft beliefs from surveys conducted by the PEW Research Forum between December 2008 and April 2009 among 25,091 respondents across 19 countries in SSA (Pew Research Centre, 2009). The surveys interviewed between 1,000 to 1,500 persons per country in nationwide samples and collected individual-level information on a wide range of cultural and

[4] Thornton (2003:282) offers the following telling example: *"Merchants of any race or nationality were especially vulnerable to the charge of being witches because the necessarily individualistic behavior of merchants in the face of a folk ethic of sharing and community service could easily be seen as greed, the root of witchcraft."* Another illustrative element of witchcraft discourse is the fact that witchcraft represents not simply a danger to individuals, but a fundamental threat to the survival of the community (Leistner, 2014).

religious beliefs and practices. Beliefs were recorded as *yes* or *no* answers to the question '*Which, if any, of the following do you believe in?*' followed by various categories such as *witchcraft*, *the evil eye, evil spirits, heaven*, *hell*, and *angels*.

Witchcraft and the evil eye are similar beliefs in the sense that they both involve a human causing harm through occult forces. As such, one could argue that the evil eye belief is also compatible with the psychological and economic mechanisms outlined above. Yet, in contrast to the case of witchcraft, there is little documentation in anthropological work of such mechanisms relating explicitly to the evil eye belief. Moreover, belief in witchcraft preceded the evil eye belief and is widespread across a variety of societies, while the evil eye belief emerged in societies with particular socio-institutional characteristics such as class-based wealth stratification (Gershman, 2015; Koning, 2013). For these reasons, we see witchcraft as the most relevant for our empirical exercise and focus on it in our main analysis. In Section 4.7 we turn to the evil eye belief, as well as other magical beliefs.

Figure 1 shows the share of respondents reporting to believe in witchcraft for each country in the PEW survey. There is considerable variation across countries, from a low of 18 % in Ethiopia to a high of 93 % in Tanzania. Overall, 44 % of our sample reports to believe in witchcraft, and this average is the same for Christians and Muslims (43 %).

Table 1 compares selected socio-economic characteristics for individuals who report to believe in witchcraft and those who report not to. Believers in witchcraft are statistically significantly older, less educated, worse off economically and more likely to be Christian or ethnoreligionist (following an ancestral, tribal, animistic, or other traditional African religion) than Muslim.[5]

Using self-reported data raises the issue that people may not be willing to openly profess their belief in witchcraft, which could result in large underestimations of true beliefs. Although the number of people refusing to answer is low for most countries (cf. Table A.2 in Appendix A), respondents may give false negative answers for various reasons (e.g. Leistner, 2014).

By analyzing witchcraft beliefs within countries only, we account for sources of measurement error that operate at the country level, such as colonial history and anti-witchcraft policies. This leaves us with sources of measurement error operating across ethnic groups within countries, such as the social acceptability of talking openly about witchcraft. To the extent that cross-ethnic measurement error is determined by (pre)colonial European influence, patterns of

[5] Among ethnoreligionists, 84 % reports to believe in witchcraft, but this group makes up only 1.6 % of the sample (compared to an estimated 9 % of the population according to the World Religion Database (2015)). As the PEW survey targeted Christians and Muslims, ethnoreligionists are presumably underrepresented.

economic development, the embeddedness in traditional culture, or the influence of Islam and Christianity, our individual- and ethnicity-level control vectors should account for it (cf. Sections 4.4 and 4.5). As for issues of different translations of witchcraft across ethnic groups, an average 60 % of interviews per sample country were conducted in the same language, and 45 % of interviews were conducted in European languages, whose translations for witchcraft have been widely adopted by the African public (Geschiere, 2011).

4.3.2. Long-run disease burden

As the proposed links between disease burden and witchcraft beliefs run through morbidity and mortality effects, our empirical exercise would ideally rely on a measure of disease-related long-run morbidity and mortality. Since such data do not exist, we rely on a measure recently developed by Depetris-Chauvin and Weil (2016) that provides the closest approximation available: historical malaria mortality.

This measure infers the historical mortality burden of malaria from data on the prevalence of the sickle cell gene, which is the most important and widespread genetic polymorphism that protects against malaria infections in SSA (Carter and Mendis, 2002).[6] The long-run selective pressures of malaria are therefore reflected in the prevalence of the sickle cell gene in a population.

To construct their measure, Depetris-Chauvin and Weil (2016) rely on a geo-database of continuous sickle cell gene frequencies from Piel et al. (2010). These frequencies are calculated from surveys of populations that are representative of the indigenous population in a particular location. Combining the sickle cell gene data with a genetic transmission model, the authors derive the historical malaria mortality rate for over 800 ethnic groups across Africa. The resulting measure is interpreted as the estimated proportion of individuals that would have died of malaria (through malaria itself or sickle cell disease) before reproductive age, conditional on not dying of something else. This proportion is on average 6 % for ethnic homelands in SSA, but shows high cross-ethnic variation from a low of 0 % to a high of 15 %.

[6] Receiving this gene from both parents causes sickle cell disease, which results in premature death in the absence of modern medical care. Receiving the gene from just one parent instead confers a significant level of protection against malaria (see Depetris-Chauvin and Weil (2016) for an extensive discussion). Although malaria mortality rates among adults are lowered through such protective genetic polymorphisms, as well as acquired functional immunity, morbidity and mortality can still have significant psychological and economic consequences. Mortality rates among young children and pregnant women are high; most adults experience some morbidity shocks with possibly severe complications; malaria infection increases vulnerability to a host of other diseases and health problems; and severe infections can leave survivors with permanent cognitive or physical disabilities (Carter and Mendis, 2002; Snow and Omumbo, 2006). These morbidity and mortality effects create several types of economic costs, including opportunity costs of lost labor and the costs of anticipatory coping strategies such as adjusted agricultural practices (Asenso-Okyere et al., 2011; Chima et al., 2003).

Historical malaria mortality is a better approximation of the long-run malaria burden than contemporary malaria morbidity and mortality for several reasons. Most importantly, the contemporary malaria burden is strongly determined by recent socio-economic development (Asenso-Okyere et al., 2011; Gething et al., 2010; McCann, 2011) and may be influenced by changing climatic conditions since the mid-20th century (Alsan, 2015; Béguin et al., 2011). Such recent changes do not affect the historical malaria mortality measure.[7]

A disadvantage of this measure is that it may suffer from larger measurement error. Although Piel et al. (2010: 5) only consider indigenous populations, which they define as populations for which "*no information was available from the author to suspect that the population did not evolve locally in relation to the historical prevalence of malaria*", it is possible that the location of indigenous populations in the sickle cell gene database does not match their historical location. However, such measurement error should only attenuate our results as long as migration patterns are not systematically related to witchcraft beliefs. We cannot fully exclude this possibility, but have not found any indications in witchcraft literature that this is the case.

4.3.3. Historical malaria mortality and witchcraft beliefs

The historical malaria mortality measure is calculated at the level of ethnic groups as defined in Murdock's (1959a) Tribal Map of Africa, and thus proxies malaria mortality in precolonial times within the area defined as the historical ethnic homeland. We match the individual information from the PEW data to ethnicity-level malaria mortality by matching the PEW respondent's self-reported ethnicity to the ethnic groups identified by Murdock (1959a). The matching was based on ethnicity matches identified in previous empirical studies (Deconinck and Verpoorten, 2013; Gershman, 2016; Nunn and Wantchekon, 2011), and on ethnographic and linguistic sources (Olson, 1996; Simons and Fennig, 2016; Wimmer et al., 2009).

Since information on ethnicity is missing for Rwanda and South Africa in the original PEW data, these two countries are excluded from the analysis. Another 1,881 individual observations for other countries are excluded because of missing information on ethnicity. The final sample counts 20,592 observations for 334 distinct Murdock groups across 17 countries (cf. Appendix C for details).

[7] An alternative dataset offers indices of historical pathogen prevalence for several infectious diseases (Murray and Schaller, 2010), but these data are so far only available at the national level or at the level of pre-industrial societies in the Standard Cross-Cultural Sample. Combining these data with the PEW dataset would result in a sample of 17 to 28 units of observation – too few for a rigorous econometric analysis.

This sample is then combined with the malaria mortality measure, with other datasets containing ethnicity-level characteristics, and with geographical and climatic measures calculated in geo-processing software (ArcGIS 10.4). Due to the limited availability of historical ethnographic data, the baseline regression sample includes 19,115 individual observations for 314 Murdock ethnic groups. Although coverage for certain ethnic groups is limited, this regression sample represents a significant part of the population across 17 countries in SSA.

Figure 2 presents historical malaria mortality across 334 ethnic homelands alongside the share of present-day witchcraft believers in each ethnic group. Both measures vary considerably across ethnic groups, but the spatial patterns suggest a correspondence between areas with high malaria mortality and areas with a high prevalence of witchcraft beliefs.

This pattern is confirmed in Figure 3, which presents the correlation between historical malaria mortality and the prevalence of witchcraft beliefs across ethnic groups, for the raw data (0.25) and conditional on country dummies (0.16). The correlation is positive in both cases, but is substantially smaller once we partial out the influence of country-level variables – an indication that country-level factors are important predictors of witchcraft beliefs.

4.4. Estimation framework and baseline results

We estimate the relation between historical malaria mortality and present-day witchcraft beliefs at the level of the individual and the ethnic group. To capture group effects, the ethnic group is a more relevant unit of analysis than political units because we are estimating a long-run relation that has likely evolved within cultural groups. Ethnic groups in SSA tend to be better approximations of cultural groups than political units and go further back in time.

The advantage of the individual-level analysis is that we can increase the precision of our estimates by controlling for a host of individual-level factors affecting witchcraft beliefs. In addition, the number of ethnic groups in our baseline regression sample is relatively small, and the number of individual observations available to calculate the share of witchcraft believers in an ethnic group can be small. Nevertheless, we show that our findings are highly similar when we use the ethnic group as the unit of analysis.

4.4.1. Estimating equations

To assess the effect of historical malaria mortality on the individual probability of believing in witchcraft, we estimate the following equation:

$$W_{iec} = \beta M_{ec} + B' X_{iec} + \Theta' C_{ec} + \varphi_c + \varepsilon_{iec} \quad (1)$$

where the subscript *i* refers to the individual, *e* refers to the ethnic group, and *c* refers to the country. The dependent variable *W* is a dummy variable taking value 1 if the respondent reports to believe in witchcraft, and 0 otherwise. The regressor of interest *M* is the standardized historical malaria mortality measure. The vectors *X* and *C* are sets of individual-level and ethnicity-level control variables (in which continuous variables are standardized).[8] φ refers to country dummies and ε is the heteroskedastic error term.

To estimate the relation between historical malaria mortality and ethnicity-level prevalence of witchcraft beliefs, we estimate the following specification:

$$W_{ec} = \delta M_{ec} + \Phi' C_{ec} + \varphi_c + \epsilon_{ec} \quad (2)$$

where the dependent variable *W* gives the share of respondents reporting to believe in witchcraft for ethnic group *e* in country *c*. The rest of the equation is analogous to equation (1), with the exception that the vector of individual-level controls is excluded.

In our main analysis we rely on OLS to estimate equations (1) and (2), thus treating equation (1) as a linear probability model. In Section 4.6 we show that our findings for equation (1) are robust to the use of a nonlinear logit model.

By including country dummies in the estimating equations, we only exploit within-country variation in witchcraft beliefs and historical malaria mortality. This approach allows us to account for a variety of potentially important country-level drivers of witchcraft beliefs today, such as state-sponsored religion, national policies regarding witchcraft (e.g. anti-witchcraft laws), public health policies and investments, country-level economic development and inequality, and conflict history (e.g. Geschiere, 1997; Leistner, 2014). However, it also requires us to treat individuals of the same ethnic group but living in different countries as different units of observation. We argue that this approach in any case is conceptually more appropriate, as it accounts for the possibility that ethnic groups divided by national borders experienced a different history of (de)colonization, nation-state building, and national policies, and are therefore no longer culturally homogenous today. Treating ethnic groups in different countries as different units produces 395 country-ethnicity observations.

Now that national-level confounders are accounted for, we need to address within-country factors that may interfere with our hypothesized relation. To this end, we include a number of plausibly exogenous individual- and ethnicity-level control variables in our baseline specifications.

The individual-level controls consist of age and gender. It is commonly assumed that younger generations are less likely to hold magical beliefs such as witchcraft, as these are eroded

[8] See Appendix B for a detailed description of all variables used in the analysis and their data sources.

by ongoing processes of socio-economic modernization. As for gender, anthropological and ethnographic literature suggests that witchcraft beliefs can have particular gender dimensions (e.g. Ciekawy, 1999).

The list of ethnicity-level controls is more extensive. As economic development is associated with witchcraft beliefs and disease burden, we need to separate the effect of economic development patterns from the effect of historical malaria mortality. Since individual or ethnicity-level income may be endogenous to witchcraft beliefs, we control for deep correlates of long-run economic development: absolute latitude, suitability of land for agriculture, area, mean altitude, access to a river, distance from the coast, and distance from the nearest lake (Alsan, 2015; Gershman, 2016). The presence of water bodies and mean altitude also serve as proxies for accessibility or connectivity of the area, which is related to within-country differences in the impact of national institutions and policies (cf. Michalopoulos and Papaioannou, 2014).[9]

A number of anthropological studies have argued that the slave trade in SSA played an important role in shaping witchcraft beliefs and conversely, that witchcraft played an important part in the slave trade – for instance as a justification for selling slaves (e.g. Shaw, 1997; Thornton, 2003).[10] We capture exogenous variation in slave trade intensity through distance to the coast, which Nunn and Wantchekon (2011) show to be a good predictor of slave exports. Directly controlling for the intensity of slave trade does not alter our findings (see Tables A.4 and A.5 in Appendix A).

Witchcraft is related to religion in several ways. For instance, religion can be seen as protective against witchcraft, and Catholic churches often take vocal stances against the existence of witchcraft (Geschiere, 2013; Kohnert, 1996; Leeson and Russ, 2017; Leistner, 2014). As individual religious affiliation is most likely endogenous to witchcraft beliefs, we include measures of the historical influence of the two dominant religions in SSA: Christianity and Islam. For Christianity, this measure is the historical presence of Christian missions in the ethnic homeland (Nunn, 2010; Nunn and Wantchekon, 2011). The number of missions may be associated with the local malaria burden, although a priori the direction of the effect is unclear: a high malaria burden could both increase (e.g. higher need for missionary health care) or decrease (e.g. obstacle to

[9] Michalopoulos and Papaioannou (2014) find specifically that the impact of national institutions decreases with distance to capital cities. As the PEW data do not include GPS coordinates or administrative units below regions, we cannot exploit variation in distance to the capital directly.

[10] The link between malaria mortality and slave trade is less clear. There may have been less demand for slaves from areas with a high infectious disease burden, but the data indicate that slave trade intensity is positively correlated with disease burden. If areas with a high malaria mortality were less economically or politically developed, one would also expect less slave trade (Nunn, 2008). One possible explanation is that disease burden is positively correlated with geographic factors that facilitated the slave trade, such as closeness of water bodies.

settlement) the presence of missions.[11] For Islam, we rely on the finding of Michalopoulos et al. (2012) that inequality in land endowments, measured by variability in land suitability for agriculture, was a major driver of the spread of early Islam.

Variability in land suitability for agriculture has also been identified as a deep driver of ethnolinguistic diversity (Michalopoulos, 2012), and as such captures potential effects of historical malaria mortality on the diversity and strength of ethnic identities (Chiovelli et al., 2015).

Finally, climate is an important determinant of the malaria burden and may affect witchcraft beliefs indirectly through economic development or directly as another source of misfortune (e.g. in the form of extreme rainfall). Broad climate zones are captured by absolute latitude, which is already included. We control for recent climatic conditions through the mean and standard deviation of annual rainfall and temperature during the growing season for the period 1957-2002 (Guariso and Rogall, 2016). Historical climate is proxied by mean daily humidity and temperature in 1871 (Alsan, 2015). To control for another important source of misfortune that may be correlated with the malaria burden, we include a measure recently developed by Alsan (2015) that captures climatic suitability for the Tse Tse fly, which is the disease vector for trypanosomiasis.[12]

4.4.2. Calculating standard errors

Error terms will likely be correlated between individuals of the same ethnic group because of a common cultural heritage. However, Murdock ethnic groups are not necessarily culturally independent units; many groups are likely to be culturally related because they share a common ancestry or history. Such cultural relatedness is more likely for ethnic groups that are genealogically related or geographically close. Alsan (2015) addresses this by allowing error terms to be correlated within cultural provinces, which are larger groupings devised by Murdock that should be culturally independent from each other.

[11] It is also possible that the historical presence of Christian missions was affected by the prevalence of witchcraft beliefs at that time. Again it is not clear a priori what the direction of the effect would be. In any case, including or excluding this variable does not significantly alter our findings (results not reported, but available on request), nor does controlling directly for individual religious affiliation (cf. Section 4.5.1).

[12] Aside from malaria, the second infectious disease presumed to have affected political, economic, and cultural development in SSA in major ways is trypanosomiasis (Akyeampong, 2006; Webb, 2006). We do not consider the long-run burden of trypanosomiasis in this chapter for two reasons. First, we do not have a comparable measure of long-run mortality related to trypanosomiasis. Second, an analysis of the trypanosomiasis burden would be complicated by its important effects on several precolonial political and economic characteristics (Alsan, 2015), which interacted in dynamic ways with witchcraft beliefs (Koning, 2013). Depetris-Chauvin and Weil (2016) in contrast find that historical malaria mortality is only strongly correlated with population density in precolonial SSA (Depetris-Chauvin and Weil, 2016).

Once all baseline control variables are included, our regression sample counts 37 cultural provinces with unbalanced cluster sizes. Since this data structure increases the risk of incorrect statistical inference (inflated p-values) for cluster-robust standard errors, we check whether our results hold when cluster-robust standard errors are calculated using pair-wise bootstrapping with asymptotic refinement.[13]

4.4.3. Baseline results

Table 2 presents estimation results for equation (1). In columns (1) - (6) we include a progressively richer set of control variables. The final column shows results when bootstrapped cluster-robust standard errors are used. In all columns, historical malaria mortality is positively and statistically significantly correlated with the individual probability of believing in witchcraft. All else equal, a one standard deviation increase in historical malaria mortality is associated with a 4 percentage point higher probability of believing in witchcraft on average. This estimate corresponds to an increase of 9 % of the sample average.

Table 3 shows estimation results for equation (2). The results are highly similar to our findings at the individual level: historical malaria mortality is statistically significantly and positively associated with ethnicity-level witchcraft beliefs. All else equal, a one standard deviation increase in historical malaria mortality is associated with a 4 percentage point higher share of witchcraft believers in the ethnic group, which represents a 0.12 standard deviation increase. Historical malaria mortality explains a larger part of the variation in witchcraft beliefs at the ethnicity-level (7 %) than at the individual-level (4 %), and overall the ethnicity-level specification carries considerably more explanatory power (62 %) than the individual-level specification (21 %).

4.5. Alternative explanations

A number of alternative explanations for the positive malaria-witchcraft relation remain. We account for them by enriching our specification with a large number of (potentially endogenous) additional variables that are organized into contemporary individual factors, precolonial ethnicity-level characteristics, and measures of European settlement and influence. We then discuss to what extent our finding can be explained by reverse causality.

[13] We rely on the program clustse in Stata 13.1, which bootstraps the pivotal t-statistic by sampling observations (independent and dependent variables together) with replacement by cluster groups, and uses the distribution of the t-statistic over the bootstrap samples for statistical inference. The program code was developed by Andrew Menger in 2015 and provided by the Boston College Department of Economics in its series Statistical Software Components with number S457989. As this program does not provide estimates of standard errors, all tables only show significance values for the coefficient estimates when bootstrapped cluster-robust standard errors are used. The R-squared is not reported for these estimates as post-estimation procedures cannot be run on this model.

4.5.1. Contemporary individual characteristics

4.5.1.1. Control variables

Classic modernization theory assumes that processes of modernization such as income growth, urbanization, the spread of education, and technological advancement erode religion, superstition, and magical beliefs (e.g. Iannaccone, 1998). If this is true for SSA, the positive malaria-witchcraft relation could arise when areas with a high malaria burden were the last to 'modernize' (e.g. because these areas attracted less foreign investments (Sachs and Malaney, 2002)).

To capture the possible influence of education and urbanization, we include dummies for secondary education, tertiary education, urban residence, and semi-urban residence. As the PEW data do not include measures of income that are comparable across countries, we proxy income with a dummy variable indicating self-reported money shortages in the past year and a categorical variable indicating whether the respondent rates his economic situation as (somewhat or very) bad (plus its squared term). Technology use is captured by dummies indicating use of the internet, email, or a pc, which may also partly capture income.

If classic modernization theory is incorrect, it is still possible that areas with a higher malaria burden were the places where traditional African culture and worldviews persisted for a longer time, for instance because Europeans were less likely to settle there (cf. Section 4.5.3). To address this possibility, we include an index for personal engagement in practices that are associated with traditional life and culture, and a dummy for reliance on a traditional healer in case of illness.

We further control directly for the influence of religion by including two dummies for Christian religion and ethnoreligion and an index of religiosity.[14] We also include a Herfindahl index for Christian denominations (at the regional level) to account for the possibility that different denominations compete for religious market share by offering protection against witchcraft (Leeson and Russ, 2017).

Conflict has been associated with witchcraft (Nunn and Sanchez de la Sierra, 2017; Wlodarczyk, 2009), and may be associated with the frequency of disease epidemics. We therefore control for perceived severity of crime, religious conflict, and ethnic conflict.

Finally, van de Grijspaarde et al. (2013) find that in eastern Sierra Leone witchcraft manifestations are higher in communities that experience the competing pull of traditional and

[14] We obtain the same results when we include a more refined measure of religious affiliation that distinguishes between different branches of Christianity (Protestantism, Anglicanism, African independent churches, and the Ethiopian Orthodox Church; results not reported, but available on request).

market-based institutions and norms. Potential non-linear effects of this sort may already be captured by semi-urban residence and by the quadratic function of personal economic situation. We further include a dummy variable indicating whether the respondent believes that Western popular culture has hurt morality in the country, which may capture a perceived conflict between different cultures or value systems.

4.5.1.2. Results

Table 4 presents OLS estimation results for the extended individual-level specification. Columns (1)-(6) report estimation results when we include a progressively richer set of additional controls. The coefficient estimate for historical malaria mortality remains statistically significant at the 5 % level in all columns and decreases only slightly in magnitude from 0.04 to 0.03. The R-squared values indicate that historical malaria mortality accounts for about a sixth (0.04) of the overall explanatory power (0.26) of the extended individual specification.

Table 4 also shows estimation results for the control variables, as these offer some noteworthy insights into the contemporary correlates of witchcraft beliefs. We highlight the main findings.

Most results for measures of modernization are inconsistent with the standard predictions of modernization theory, and support anthropological observations on the 'modernity' of witchcraft (Geschiere, 1997). In particular, age and education do not matter once we control for embeddedness in traditional culture and religiosity, and urban residents are more likely to hold witchcraft beliefs – suggesting that these beliefs are not a relic of rural village life.

As for income, money shortages do not matter, but assessing one's personal economic situation as bad is importantly positively correlated with witchcraft beliefs. These beliefs may thus have more to do with feelings of being worse off in society than with actual income limitations, which is in line with the strong emphasis in anthropological literature on the importance of inequality in witchcraft beliefs (e.g. Leistner, 2014).

Finally, the results point to an important role of traditional culture and religion in witchcraft beliefs, and give some support to the hypothesis that perceived tension between different value systems matters.

4.5.2. Precolonial characteristics of the ethnic group

4.5.2.1. Control variables

Historical malaria mortality could have been affected by two important group-level adaptive strategies: (semi-)nomadic settlement patterns that allowed groups to avoid high transmission

periods through seasonal migration, and low population densities that limited the risk of contagion and spread of a disease. In addition, societies with more complex institutions or centralized power may have been better able to control infectious diseases (e.g. through faster quarantine or evacuation in case of epidemics). As these three features of group organization and settlement could also be related to witchcraft beliefs and their evolution (Geschiere, 1997; Koning, 2013), they may interfere with our hypothesized relation.

To address this issue, we extend the list of controls in equations (1) and (2) to the complexity of precolonial settlement patterns (Murdock 1967), precolonial institutional centralization (Murdock 1967), and two alternative estimates for precolonial population density: colonial population density (Murdock 1967) and the presence of cities with over 20,000 inhabitants in 1800 (Chandler, 1987). Precolonial centralization of institutions also allows us to better control for within-country variation in contemporary economic development (Michalopoulos and Papaioannou, 2013) and (post-)colonial governance quality (Gennaioli and Rainer, 2005; 2007).

Finally, witchcraft beliefs have been linked to wealth inequality and social stratification, which are historically associated with pastoralism and agriculture (Gershman, 2015; Koning, 2013). As the historical malaria burden is also related to agricultural development (Carter and Mendis, 2002), we include a dummy for strong dependence of precolonial production on agriculture or husbandry.

4.5.2.2. Results

Tables 5 and 6 present OLS estimation results for equations (1) and (2). In both tables, columns (1)-(6) show that our result is robust to the gradual inclusion of the precolonial control variables discussed above. The positive coefficient estimate for historical malaria mortality remains statistically significant at the 5 % level and is relatively stable in size (within the order of 0.04 to 0.05).

4.5.3. European settlement and influence

4.5.3.1. Control variables

Disease burden affects not only the indigenous population, but also (and often more so) immigrant populations. As such, a heavy historical malaria burden could have discouraged European settlement during the colonial era. European settlement patterns in turn are found to predict contemporary patterns of urbanization and economic development within countries (Flückiger and Ludwig, 2017; Jedwab et al., 2017). Hence, it is possible that areas with a heavier historical malaria burden have less witchcraft beliefs today because they continue to be less urbanized and

economically developed. These regional effects may not be fully captured by the controls outlined above.

Alternatively, a higher presence of European settlers, who brought with them different cultural beliefs, values, and norms, in low malaria areas could have initiated processes of cultural change (Nunn, 2012) that eroded witchcraft beliefs in those areas.

To check whether our finding is driven by these alternative channels, we need to control for within-country variation in European settlement patterns. Acemoglu et al. (2002) rely on historical settler mortality data to proxy for European settlement patterns, but others have argued that settler mortality is a poor predictor of European settlement patterns within Africa (Albouy, 2012; Olsson, 2004). In any case, these data are only available at the country level.

Given that regional centers established by Europeans often persisted into urban centers today (Flückiger and Ludwig, 2017; Jedwab et al., 2017), the already included measures of colonial population density and the presence of a city in 1800 should capture part of the effect of spatial patterns in European settlement.

In addition, Jedwab et al. (2017) show that in Kenya the location of colonial railways importantly determined the location of European settlers, Asian traders, and main cities at independence. In a similar vein, Nunn and Wantchekon (2011) measure exposure to European influence in the colonial era across SSA by the pass-through of colonial railways and European explorer routes in the ethnic homeland. We add both measures as additional controls to our regression specification.

4.5.3.2. Results

Column (7) in Tables 5 and 6 presents OLS estimates when we add the railway and explorer route variables to the list of precolonial controls. Since these measures are unavailable for several countries in our dataset, we lose about a third of the regression sample, but can still rely on over 9,000 individual observations and 200 country-ethnicity groups. Our positive coefficient estimate for historical malaria mortality remains statistically significant, and again changes little in size (to 0.06). The last columns in both tables show that bootstrapped standard errors yield the same results in terms of statistical significance.

4.5.4. Reverse causality

Recent qualitative and quantitative work has argued that magical beliefs can negatively affect preventive and treatment behavior (Briones Alonso, 2015; Stoop et al., 2017). For instance, patients may not seek biomedical treatment because they see it as unable to deal with illness caused by occult forces. The question then arises whether historically the strength of witchcraft beliefs

could have affected malaria mortality.[15] We argue that this scenario is unlikely. Highly effective prevention strategies such as insecticides and bed nets were unavailable in precolonial SSA, and treatment methods sufficiently effective so as to change selective pressures were presumably not available either.[16]

A more indirect channel of reverse causality would entail historical witchcraft beliefs affecting exposure to malaria by influencing settlement location.[17] As we cannot fully exclude this possibility, we emphasize that our finding remains correlational.[18]

4.6. Robustness checks

We check the robustness of our main finding to a number of alternative estimation strategies.

Since the dependent variable in equation (1) is a binary variable, we verify whether our results hold under a logit model. Table 7 presents estimated marginal effects for various specifications of equation (1), and confirms the main results obtained using OLS estimation. The estimate for historical malaria mortality in the final specification (0.03) is slightly smaller than the analogous OLS coefficient estimate (0.04) in Table 5.

Statistical inference with cluster-robust standard errors is more reliable as the number of clusters grows larger. If error terms are correlated between individuals within the same ethnic group, but not between different ethnic groups, it is preferable to calculate cluster-robust standard

[15] Historical malaria mortality is also correlated with contemporary disease burden (Depetris-Chauvin and Weil, 2016), which raises the question whether historical malaria mortality might capture a positive effect of strong witchcraft beliefs on contemporary malaria burden. Our results do not change when we control for contemporary intensity of malaria transmission (Kiszewski et al., 2004) (results not reported, but available on request).

[16] The biomedical sciences did not understand the cause and transmission of malaria until the 19th century. This in itself does not imply the absence of knowledge on malaria prevention and treatment among precolonial societies in SSA, as many human populations independently developed biomedically consistent knowledge of and treatment for infectious diseases (Briones Alonso, 2015). However, we have found no research suggesting the existence of effective prevention or treatment (rather than symptom alleviation) for malaria, or accurate knowledge on its transmission mechanism, among precolonial societies in SSA. In addition, any such treatment or prevention method would need a high degree of effectiveness to significantly change selective pressures at the population level.

[17] An important determinant of settlement location is success in inter-group conflict. Yet, if conflict explains settlement location, we should find a negative malaria-witchcraft relation. Nunn and Sanchez de la Sierra (2017) argue that witchcraft beliefs help communities in DR Congo to win violent conflict today. In historical terms, a growing body of evolutionary literature argues that in-group solidarity or parochial altruism, which is said to be promoted by witchcraft beliefs, evolved among humans precisely because it increased the odds of surviving inter-group conflict (Bowles, 2009). Hence, one would expect stronger witchcraft beliefs to be associated with success in conflict and thus with settlement on desirable land with a lower disease burden (conditional on agricultural suitability).

[18] Following Depetris-Chauvin and Weil (2016), we attempted to instrument historical malaria burden with a temperature-dependent index reflecting the climatic suitability of an area to the malaria vector and parasite. This instrument, however, does not fully solve the issue at hand, as unobserved characteristics of human populations (such as historical witchcraft beliefs or military success) can determine where populations ultimately settle, and thus the suitability of their homeland to malaria. In any case, the malaria suitability instrument turns out to be weak in our empirical framework.

errors at the level of ethnic groups – which yields over 200 clusters in all specifications – rather than cultural provinces. Table 8 presents OLS estimation results for various specifications of equation (1), and shows that the results are virtually the same as the results presented in Table 5.[19]

For equation (2), the number of individual observations n used to calculate the ethnicity-level share of witchcraft believers varies considerably across ethnic groups, from only one for 12 % of ethnic groups to over 100 for 15 %. Since measurement error in the calculated share of witchcraft believers per ethnic group varies with n, we run a weighted regression for equation (2) where the weight w for ethnic group e is equal to $n/100$. The results are presented in Table 9, and are highly similar to the unweighted estimation results in Table 6.

Finally, for both equation (1) and equation (2) we check whether our main finding is driven by any particular country. We re-estimate the richest specifications (i.e. including all individual- and ethnicity-level control variables) for an adjusted sample that excludes one country, and repeat this exercise for all countries.

Figure 4 presents the coefficient estimates and confidence intervals for historical malaria mortality in panel (a) for equation (1) and in panel (b) for equation (2). The estimates generally remain within the same range, and the confidence intervals are above zero in all but three cases.

4.7. Other beliefs

To verify whether the observed positive correlation is particular to witchcraft beliefs, we explore the relation between historical malaria mortality and other magical beliefs. We start with the evil eye belief, which is most closely related to witchcraft beliefs.

Figure 5 documents the share of respondents reporting to believe in the evil eye across surveyed countries and Murdock ethnic groups. Overall, the geographical distribution is quite similar to that of witchcraft beliefs. Yet, the survey data indicate that witchcraft and evil eye belief do not always move together: about 30 % of respondents report to believe both in witchcraft and the evil eye and about 40 % in neither, while the remaining 30 % reports to believe in one but not the other.

Table 10 presents OLS estimation results for equation (1) (in panel A) and equation (2) (in panel B) when the dependent variable is replaced by belief in the evil eye. Similar to witchcraft beliefs, historical malaria mortality is positively correlated with evil eye beliefs. However, the relation is no longer statistically significant at the ethnicity level once we account for historical

[19] This test is not relevant for equation (2) as the unit of observation is the ethnic group itself.

population density. This finding is consistent with the hypothesis that the evil eye belief is more strongly related to particular societal characteristics than belief in witchcraft (cf. Section 4.3.1).

The PEW survey further documents four other beliefs associated with traditional African worldviews: belief in evil spirits, and the belief that you can protect yourself from 'bad things happening' through sacrifices to spirits or ancestors, through certain spiritual people, or through juju, shrines, or other sacred objects. Another set of magical beliefs documented in the PEW survey are more strongly associated with Islam or Christianity: belief in heaven, hell, angels, and miracles. If the relation between witchcraft and malaria burden is explained *solely* by the fact that it allows one to explain and protect against misfortune, we might expect a similar positive relation between malaria burden and these other magical beliefs. The absence of such a relation would be consistent with the argument that there is something particular about witchcraft beliefs that explains a positive relation with disease burden.

Table 11 shows estimation results for equations (1) and (2) when we replace the dependent variable 'belief in witchcraft' with various indices capturing other magical beliefs. None of the individual beliefs or belief indices are statistically significantly related to historical malaria mortality at the ethnicity level once we control for precolonial characteristics. At the individual level, we find a positive relation between historical malaria mortality and traditional beliefs that is statistically significant at the 10 % level. Since beliefs related to protection against harm are not related to malaria mortality in any specification, this relation is driven entirely by belief in powers that can do harm: witchcraft, the evil eye, and evil spirits. Among these three, belief in witchcraft is most strongly and most robustly related to historical malaria mortality, while the positive correlation with belief in evil spirits is the weakest and the least robust across specifications.

These findings give us two important pieces of information that may shed light on the underlying mechanisms, even though they do not allow us to unequivocally exclude one or the other. First, the fact that we find no relation whatsoever with beliefs related to protection against harm suggest that any psychological mechanism centers around the clear identification of the cause of misfortune, rather than a general need to feel protected against misfortune. Second, the two beliefs that show the strongest relation with disease burden, witchcraft and the evil eye, share in common that they involve a human agent of misfortune. As non-human agents such as evil spirits are often invoked to explain disease as well (e.g. Maslove et al., 2009), these results suggest that the underlying mechanism involves something more than a mere identification of the cause of misfortune, and that human agency plays a key role in it.

We see three possible reasons for the importance of human agency. First, the identification of a human cause of misfortune may facilitate scapegoating or give a greater sense of control over

misfortune, by allowing a clear removal of the threat (a human can be visibly removed from the community). Second, spirits are not part of the social (kinship) relations and concurrent sharing norms of the living members of a community. In other words, one cannot enforce material solidarity from non-human agents. Third, only by banning or in the extreme killing a living member of the community can resource stress be relieved in the event of negative income shocks.

Yet, in theory these mechanisms are compatible with other types of beliefs, including belief in non-human supernatural entities. For instance, it is possible to have spiritual leaders consult the ancestors as to which person has angered them and brought disease upon the community, or to enforce solidarity norms by instilling fear of punishment by the gods if the norms are violated. Why would witchcraft (and possibly the evil eye) in particular have emerged and persisted ?

The answer may lie in the decentralized nature of these beliefs. In principle, anyone can accuse another of witchcraft (or the evil eye); the process does not require higher-level institutions or persons of authority, even though spiritual or political leaders may be involved to arbitrate and resolve accusations. This decentralized, community-driven characteristic could have generated two important types of advantages. The first is lower transaction costs and informational advantages, for instance in identifying breaches of solidarity norms within kinship networks. The second is greater flexibility and adaptability. Systems embedded in higher-level institutions or particular power structures may be more rigid and less capable of surviving major societal transformations, such as the erosion of traditional power structures by colonial governments.[20] Recent anthropological work has indeed emphasized the dynamic nature of witchcraft and its ability to adapt to new political and economic environments (Comaroff and Comaroff, 1999; D'Angelo, 2014; Geschiere, 1997; 1998). These two types of advantages may explain why witchcraft outcompeted alternative systems and retained so much of its power until today.

4.8. Conclusion

We set out to study the link between long-run disease burden and witchcraft beliefs in SSA. Based on various psychological and economic mechanisms proposed in different strands of literature, we hypothesize that long-run exposure to a heavy disease burden promoted the emergence and persistence of witchcraft beliefs. These underlying mechanisms, if accurate, could still be actively stimulating witchcraft beliefs in contemporary African societies, but not necessarily. It is possible

[20] This flexibility of witchcraft beliefs is well illustrated by the fact that it can be seen as a desirable quality of leaders, enabling them to protect the community against attacks, or as a dangerous power that corrupts leaders into greed and selfishness. As such, witchcraft can serve both to support existing power structures, or to justify community-driven uprisings against and removal of unwanted leaders (Thornton, 2003).

that witchcraft beliefs and practices find their origins in these mechanisms, but became institutionalized into a self-sustaining and self-perpetuating belief system.

Our empirical findings are consistent with our hypothesis: historical malaria mortality is significantly and positively associated with contemporary witchcraft beliefs. This result applies to a sample of at least 9,000 individuals belonging to more than 200 ethnic groups for 17 countries in SSA. Although coverage is limited for some ethnic groups and regions in the sample countries, the dataset nevertheless spans a significant geographic area and share of the population in SSA.

We rule out a number of alternative explanations for our finding by including a battery of relevant individual- and ethnicity-level controls. Yet, as we cannot fully exclude the possibility that historical witchcraft beliefs affect settlement location, or that both witchcraft beliefs and malaria burden are determined by unobserved group characteristics, we emphasize that our finding should be interpreted as correlational rather than causal evidence.

In line with recent anthropological literature on 'the modernity of witchcraft', we further find that contemporary individual and national characteristics perform better in explaining present-day witchcraft beliefs than historical factors, including the malaria burden. Nevertheless, the fact that witchcraft beliefs today are robustly and significantly associated with the historical disease environment resonates well with recent evolutionary literature on the persistent role of the disease environment in shaping human cultures and in directing the path-dependency of cultural change (e.g. Inglehart, 2016).

Our study also captures just one aspect (mortality) of one infectious disease (malaria). As SSA suffers from the highest infectious disease burden of all continents, both historically and today, our empirical finding may underestimate the true witchcraft-disease relation. If comparable measures of the historical burden of other diseases become available, a broader replication exercise of our analysis would be useful.

Since we are not able to identify any particular mechanism(s) as the main driver of our finding, further research in this area is also needed. Survey data on collectivistic and individualistic values and behaviors, in particular in-group solidarity or parochial values, and psychological characteristics related to perceived control and scapegoating could be useful for identifying the underlying mechanisms. To establish causal effects, future research could explore the possibilities of experimental research in which the salience of disease risk, parochial values, perceived control, or witchcraft beliefs is randomly varied (see e.g. Hadnes and Schumacher, 2012).

Gaining a better understanding of how beliefs are formed and how they change is, as noted by North (2008), fundamental to a new social science. Given the omnipresence and profound influence of witchcraft in present-day SSA, a deeper understanding of its origins and evolution

could shed light on contemporary issues and dynamics. The witchcraft-disease relation in particular can provide historical context for recent upsurges of witchcraft discourse following the AIDS and Ebola epidemics (BBC, 2014; IFRC, 2014; Kalichman and Simbayi, 2004; Thomas, 2007).

A proper understanding of major culture traits such as witchcraft beliefs can also improve policy effectiveness. Some examples of possible benefits are greater cultural compatibility or a better assessment of the broader impact and implications of policies. Studying contemporary dynamics alongside historical, long-run processes may thus prove to be a fruitful research agenda for understanding how and why witchcraft beliefs affect African societies today.

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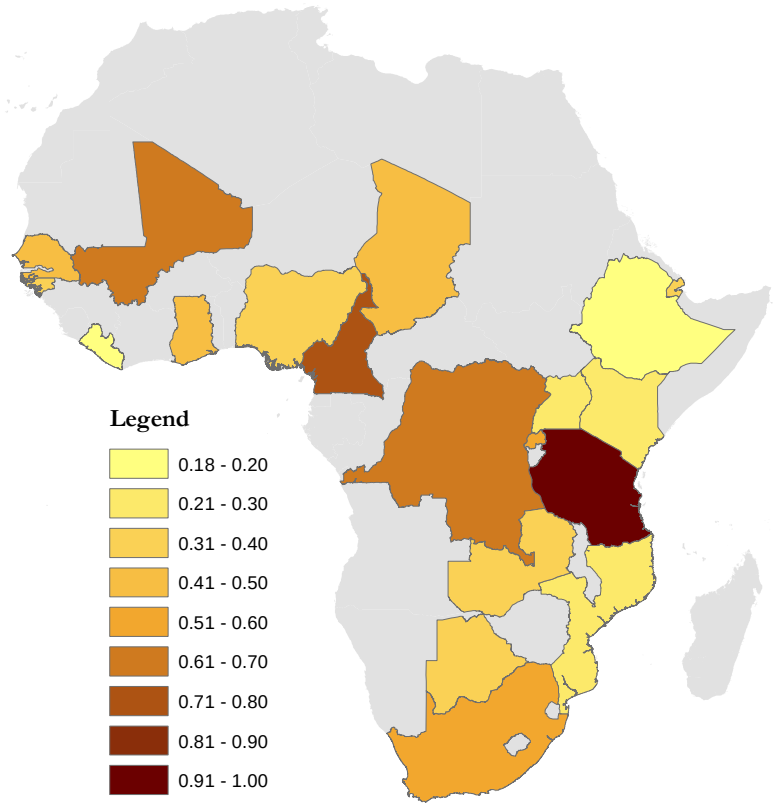
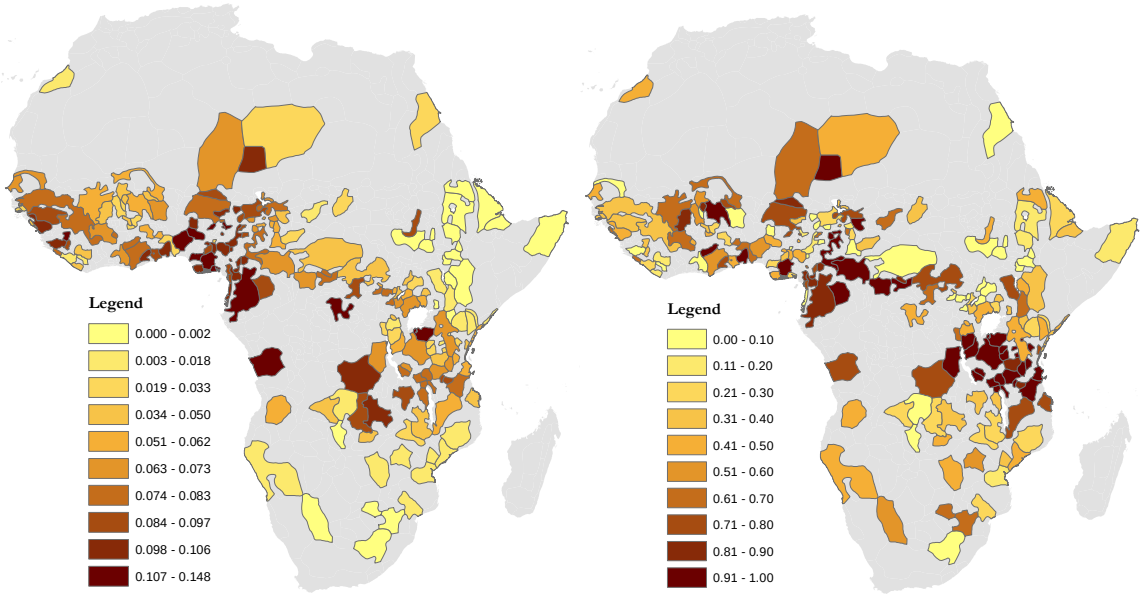
Figures

Figure 1: Share of respondents reporting to believe in witchcraft across surveyed countries.



Note: This figure shows all countries included in the original PEW survey.

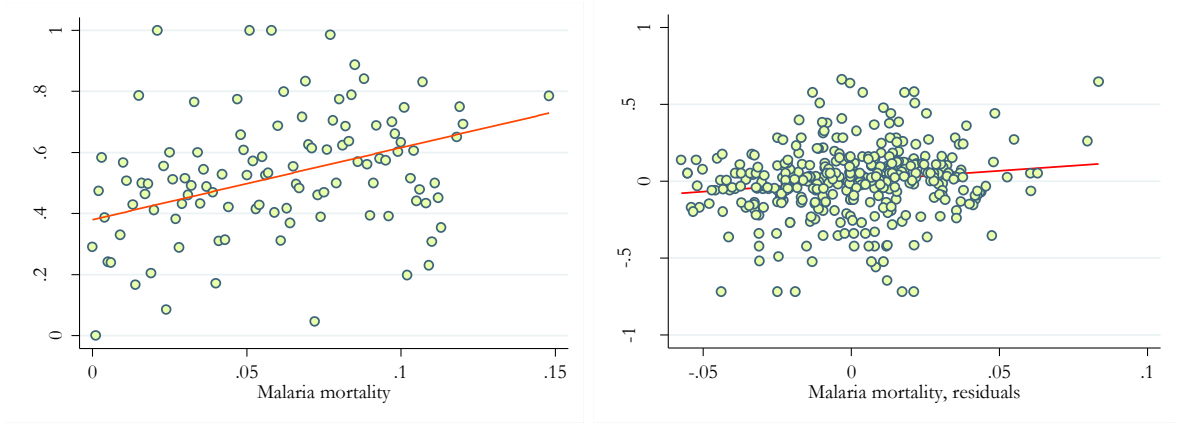
Figure 2: Historical malaria mortality and witchcraft beliefs across ethnic groups.



(a) Historical malaria mortality (b) Witchcraft beliefs

Notes: The categories for historical malaria mortality correspond to 10 quantiles (rounded up to three decimals). Ethnicity-level witchcraft beliefs are measured as the share of respondents of that ethnicity reporting to believe in witchcraft.

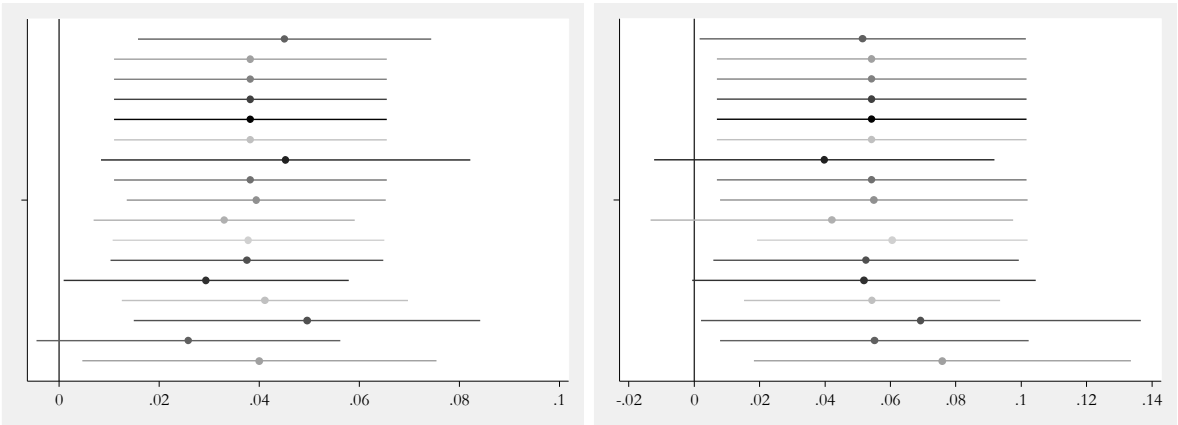
Figure 3: Correlation between historical malaria mortality and witchcraft beliefs across ethnic groups.



(a) Raw data (b) Conditional on country fixed effects

Notes: Panel (a) shows the raw data. To ease visual interpretation, data points show the averages for historical malaria mortality and witchcraft beliefs within equal-sized groups of observations (bins) based on the malaria mortality value. In Panel (b), the vertical and horizontal axes show residuals from regressions of historical malaria mortality and ethnicity-level witchcraft beliefs on country dummies. The lines show fitted values for a linear regression of ethnicity-level prevalence of witchcraft beliefs on historical malaria mortality. Ethnicity-level witchcraft beliefs are measured as the share of respondents of that ethnicity reporting to believe in witchcraft.

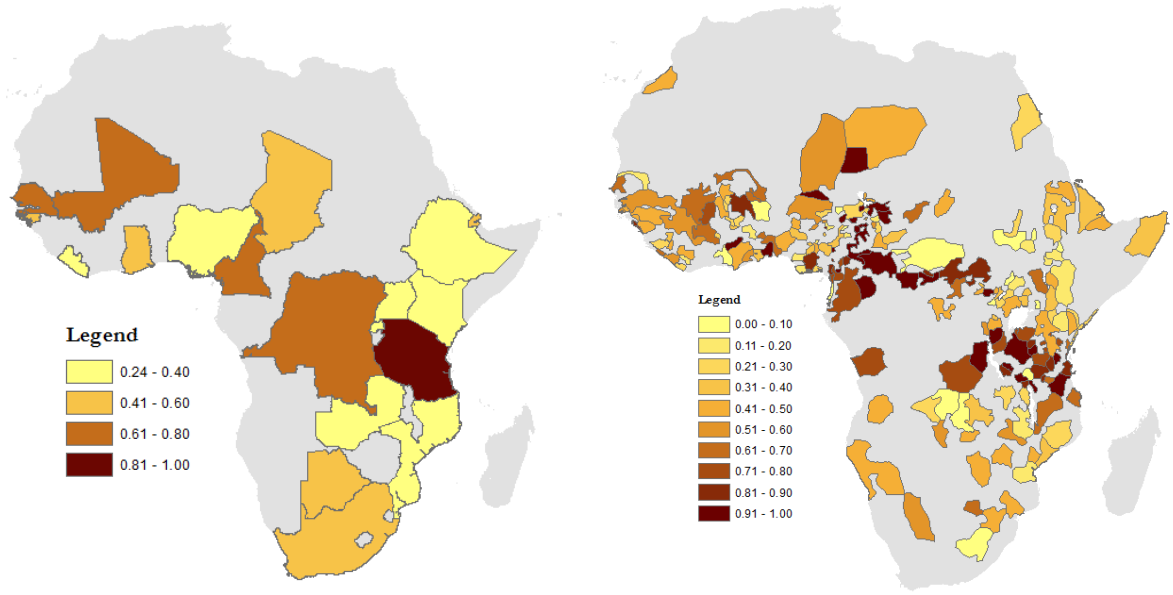
Figure 4: Estimated relation between historical malaria mortality and witchcraft beliefs, for adjusted samples excluding one country at a time.



(a) Equation (1) (b) Equation (2)

Notes: The dots indicate the magnitude of the coefficient estimate and the horizontal lines represent the corresponding 95 % confidence interval for each of the 17 adjusted samples.

Figure 5: Share of respondents reporting to believe in the evil eye across surveyed countries (a) and ethnic groups (b).



(a) (b)

Note: Panel (a) shows all countries included in the original PEW survey.

Tables

Table 1: Descriptives for selected individual characteristics, by self-reported belief in witchcraft

	Belief in witchcraft				
Variable	Yes	No	Difference	Full sample	N
Age	34.4	32.7	1.6***	33.4	20,463
Female	46.3	46.3	0.1	46.3	20,592
Rural residence	61.0	61.0	0.0	60.3	20,592
Primary education or less	45.4	34.3	11.1***	39.1	20,186
Secondary education (or part)	38.1	44.2	6.2***	41.2	20,186
Tertiary education	16.5	21.4	4.9***	19.7	20,186
Christian religion	58.3	60.8	2.5***	58.5	20,490
Muslim religion	36.6	37.5	0.9*	38.3	20,490
Ethnoreligion	3.0	0.4	2.5***	1.6	20,490
Self-reported economic situation somewhat or very bad	51.6	43.9	7.7***	46.9	20,415
Self-reported money shortages in past year	69.7	66.0	3.7***	67.6	20,238

Notes: The first two columns show the average for age and shares for dummy variables. The third column shows the absolute difference between the first two columns, along with significance values for tests of differences in proportions or differences in means (for age). The fourth column shows the means and shares for the full sample. Table A.1 in Appendix A presents summary statistics for all individual-level variables used in our empirical analysis. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 2: OLS estimates for the relation between malaria and individual witchcraft belief - Baseline specification

Dependent variable	Individual probability of believing in witchcraft						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.101***	0.041***	0.040***	0.038***	0.039***	0.035***	0.035**
	(0.023)	(0.013)	(0.013)	(0.012)	(0.011)	(0.012)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	No	No	Yes	Yes	Yes	Yes	Yes
Economic dev. controls	No	No	No	Yes	Yes	Yes	Yes
Religion controls	No	No	No	No	Yes	Yes	Yes
Climate controls	No	No	No	No	No	Yes	Yes
Observations	19,429	19,429	19,305	19,252	19,115	19,115	19,115
R-squared	0.041	0.199	0.202	0.207	0.209	0.211	
Number of clusters	37	37	37	37	37	37	37

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Section 4.4.1 provides details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 3: OLS estimates for the relation between malaria and ethnicity-level witchcraft beliefs - Baseline specification

Dependent variable	Share of individuals believing in witchcraft in the ethnic group					
	(1)	(2)	(3)	(4)	(5)	(6)
Historical malaria mortality	0.093***	0.057***	0.042***	0.041**	0.043***	0.043**
	(0.023)	(0.020)	(0.014)	(0.015)	(0.016)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes
Economic dev. controls	No	No	Yes	Yes	Yes	Yes
Religion controls	No	No	No	Yes	Yes	Yes
Climate controls	No	No	No	No	Yes	Yes
Observations	379	379	377	374	374	374
R-squared	0.067	0.581	0.603	0.613	0.620	
Number of clusters	37	37	37	37	37	37

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (5). Column (6) shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Section 4.4.1 provides details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 4: OLS estimates for the relation between malaria and individual witchcraft belief - Extended individual controls

Dependent variable	Individual probability of believing in witchcraft						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.101***	0.036***	0.030**	0.027**	0.026**	0.028**	0.028**
	(0.023)	(0.012)	(0.011)	(0.011)	(0.012)	(0.012)	
Age			0.003	-0.002	-0.001	-0.001	-0.001
			(0.005)	(0.005)	(0.005)	(0.004)	
Female			-0.001	0.002	0.004	0.003	0.003
			(0.007)	(0.008)	(0.008)	(0.009)	
Secondary education			-0.036***	-0.026**	-0.016	-0.015	-0.015
			(0.013)	(0.013)	(0.014)	(0.014)	
Tertiary education			-0.053***	-0.036*	-0.025	-0.026	-0.026
			(0.018)	(0.018)	(0.019)	(0.018)	
Urban residence			0.024	0.036**	0.037**	0.036**	0.036*
			(0.015)	(0.015)	(0.016)	(0.016)	
Semi-urban residence			-0.001	0.001	0.000	0.004	0.004
			(0.057)	(0.061)	(0.063)	(0.065)	
Bad economic situation			0.035	0.060**	0.058**	0.061**	0.061**
			(0.033)	(0.027)	(0.025)	(0.025)	
Bad economic situation (sq)			-0.003	-0.007	-0.008	-0.008	-0.008
			(0.006)	(0.005)	(0.005)	(0.005)	
Money shortages			0.019	0.007	0.009	0.006	0.006
			(0.015)	(0.015)	(0.015)	(0.015)	
Use of internet			0.045*	0.030	0.027	0.023	0.023
			(0.022)	(0.020)	(0.021)	(0.022)	
Use of a pc			-0.059***	-0.050***	-0.050***	-0.049***	-0.049***
			(0.017)	(0.017)	(0.016)	(0.016)	
Use of email			-0.008	-0.002	0.003	0.006	0.006
			(0.025)	(0.023)	(0.024)	(0.025)	
View on Western popular culture			0.030**	0.029**	0.033***	0.032***	0.032***
			(0.013)	(0.013)	(0.012)	(0.011)	
Traditional practices				0.063***	0.055***	0.056***	0.056***
				(0.008)	(0.008)	(0.008)	
Use of traditional healer				0.083***	0.079***	0.082***	0.082***
				(0.013)	(0.013)	(0.013)	
Christian religion					0.007	0.007	0.007
					(0.016)	(0.016)	
Ethnoreligion					0.201***	0.201***	0.201***
					(0.042)	(0.050)	

(Table continued on next page)

(Continuation of Table 4)

Religiosity					-0.045***	-0.045***	-0.045***
					(0.009)	(0.009)	
Religious competition					0.005	0.006	0.006
					(0.014)	(0.014)	
Perceived crime						-0.014	-0.014
						(0.009)	
Perceived religious conflict						-0.005	-0.005
						(0.008)	
Perceived ethnic conflict						0.007	0.007
						(0.006)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ethnicity controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,429	19,239	17,291	16,432	16,104	15,689	15,689
R-squared	0.041	0.208	0.219	0.250	0.258	0.258	
Number of clusters	37	37	37	37	37	37	37

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6). Column (7) shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Section 4.5.1 provides details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 5: OLS estimates for the relation between malaria and individual witchcraft belief - Extended precolonial controls

Dependent variable	Individual probability of believing in witchcraft							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Historical malaria mortality	0.101***	0.028**	0.031**	0.033***	0.039***	0.039***	0.038***	0.038**
	(0.023)	(0.012)	(0.011)	(0.010)	(0.010)	(0.010)	(0.012)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extended individual controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial settlement	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial centralization	No	No	No	Yes	Yes	Yes	Yes	Yes
Population density	No	No	No	No	Yes	Yes	Yes	Yes
Agro-pastoralism	No	No	No	No	No	Yes	Yes	Yes
European settlement controls	No	No	No	No	No	No	Yes	Yes
Observations	19,429	15,689	15,076	14,245	14,241	14,241	9,561	9,561
R-squared	0.041	0.258	0.262	0.271	0.272	0.273	0.259	
Number of clusters	37	37	36	35	35	35	26	26

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (7). Column (8) shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Sections 4.5.2 and 4.5.3 provide details on control variables. Results are shown for the population density proxy 'city in 1800'.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 6: OLS estimates for the relation between malaria and ethnicity-level witchcraft beliefs - Extended precolonial controls

Dependent variable	Share of individuals believing in witchcraft in the ethnic group							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Historical malaria mortality	0.093***	0.043***	0.062***	0.053***	0.053***	0.050***	0.057**	0.057**
	(0.023)	(0.016)	(0.016)	(0.017)	(0.016)	(0.017)	(0.024)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial settlement	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Precolonial centralization	No	No	No	Yes	Yes	Yes	Yes	Yes
Population density	No	No	No	No	Yes	Yes	Yes	Yes
Agro-pastoralism	No	No	No	No	No	Yes	Yes	Yes
European settlement controls	No	No	No	No	No	No	Yes	Yes
Observations	379	374	360	345	344	344	218	218
R-squared	0.067	0.620	0.633	0.646	0.647	0.648	0.707	
Number of clusters	37	37	36	35	35	35	26	26

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (7). Column (8) shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Sections 4.5.2 and 4.5.3 provide details on control variables. Results are shown for the population density proxy 'city in 1800'.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 7: Logit estimates for the relation between malaria and individual witchcraft belief

Dependent variable	Individual probability of believing in witchcraft					
	(1)	(2)	(3)	(4)	(5)	(6)
Historical malaria mortality	0.099***	0.041***	0.034***	0.023**	0.033***	0.033**
	(0.022)	(0.013)	(0.012)	(0.012)	(0.010)	(0.016)
Country dummies	No	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes	Yes
Extended individual controls	No	No	No	Yes	Yes	Yes
Precolonial controls	No	No	No	No	Yes	Yes
European settlement controls	No	No	No	No	No	Yes
Observations	19,429	19,429	19,115	15,689	14,241	9,561
Number of clusters	37	37	37	37	35	26

Notes: Standardized continuous regressors. Marginal effects are reported at means. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses. Sections 4.4 and 4.5 provide details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 8: OLS estimates for the relation between malaria and individual witchcraft belief - Ethnic group clusters

Dependent variable	Individual probability of believing in witchcraft					
	(1)	(2)	(3)	(4)	(5)	(6)
Historical malaria mortality	0.101***	0.040***	0.035**	0.028**	0.039***	0.038**
	(0.018)	(0.012)	(0.014)	(0.014)	(0.013)	(0.019)
Country dummies	No	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes	Yes
Extended individual controls	No	No	No	Yes	Yes	Yes
Precolonial controls	No	No	No	No	Yes	Yes
European settlement controls	No	No	No	No	No	Yes
Observations	19,540	19,540	19,115	15,689	14,241	9,561
R-squared	0.041	0.201	0.211	0.258	0.273	0.259
Number of clusters	394	394	373	369	340	216

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of the country-ethnicity unit are shown in parentheses. Sections 4.4 and 4.5 provide details on control variables. Results are shown for the population density proxy 'city in 1800'.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 9: OLS estimates for the relation between malaria and ethnicity-level witchcraft beliefs - Weighted regression

Dependent variable	Share of individuals believing in witchcraft in the ethnic group				
	(1)	(2)	(3)	(4)	(5)
Historical malaria mortality	0.094***	0.037***	0.034***	0.042***	0.057***
	(0.022)	(0.013)	(0.011)	(0.011)	(0.014)
Country dummies	No	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes
Precolonial controls	No	No	No	Yes	Yes
European settlement controls	No	No	No	No	Yes
Observations	379	379	374	344	219
R-squared	0.118	0.817	0.847	0.855	0.861
Number of clusters	37	37	37	35	26

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses. Sections 4.4 and 4.5 provide details on control variables. Results are shown for the population density proxy 'city in 1800'.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 10: OLS estimates for the relation between malaria and belief in the evil eye

Panel A: Individual probability of believing in evil eye							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.065**	0.047***	0.032**	0.026**	0.034**	0.042**	0.042
	(0.027)	(0.011)	(0.012)	(0.011)	(0.014)	(0.016)	
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes	Yes	Yes
Extended individual controls	No	No	No	Yes	Yes	Yes	Yes
Precolonial controls	No	No	No	No	Yes	Yes	Yes
European settlement controls	No	No	No	No	No	Yes	Yes
Observations	19,432	19,432	19,117	15,699	12,019	7,908	7,908
R-squared	0.017	0.145	0.155	0.225	0.246	0.234	
Number of clusters	38	38	38	38	32	23	23
Panel B: Share of individuals believing in evil eye in the ethnic group							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Historical malaria mortality	0.075***	0.039***	0.035**	0.045***	0.030*	0.029	0.028
	(0.024)	(0.013)	(0.014)	(0.015)	(0.015)	(0.018)	(0.018)
Country dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	No	No	Yes	Yes	Yes	Yes	Yes
Precolonial settlement	No	No	No	Yes	Yes	Yes	Yes
Precolonial centralization	No	No	No	No	Yes	Yes	Yes
Population density	No	No	No	No	No	Yes	Yes
Agro-pastoralism	No	No	No	No	No	No	Yes
Observations	380	380	375	361	346	279	279
R-squared	0.050	0.483	0.516	0.509	0.525	0.555	0.555
Number of clusters	38	38	38	37	36	32	32

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (6) in Panel A and columns (1) - (7) in Panel B. Column (7) in Panel A shows significance levels for cluster-robust standard errors calculated using pair-wise bootstrapping with asymptotic refinement (standard errors are not reported). Sections 4.4 and 4.5 provide details on control variables. *** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table 11: OLS estimates for the relation between malaria and other magical beliefs at the individual and ethnicity level

Dependent variable	All 'traditional' beliefs		Protection against misfortune		Evil spirits		Abrahamic beliefs	
	Individual	Ethnicity	Individual	Ethnicity	Individual	Ethnicity	Individual	Ethnicity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Historical malaria mortality	0.084*	0.174	0.002	0.059	0.019*	0.023	-0.035	-0.048
	(0.048)	(0.113)	(0.026)	(0.067)	(0.011)	(0.016)	(0.021)	(0.038)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extended individual controls	Yes	No	Yes	No	Yes	No	Yes	No
Precolonial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,218	342	14,706	343	15,194	344	14,913	343
R-squared	0.386	0.623	0.357	0.544	0.206	0.603	0.118	0.240
Number of clusters	37	35	37	35	37	35	38	36

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses. The first two columns show results for an index that captures all surveyed beliefs associated with a traditional African worldview (witchcraft, the evil eye, evil spirits, protection from sacrifices to ancestors, protection from certain spiritual people, protection from sacred objects). The third and fourth column show results for an index that only captures traditional beliefs related to protection against misfortune. Columns (5) and (6) show results for belief in evil spirits, and columns (7) and (8) present results for an index of beliefs typically related to Christianity and Islam (heaven, hell, angels, and miracles). Sections 4.4 and 4.5 provide details on control variables.

*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Appendix A. Additional tables

Table A.1 gives summary statistics for the full list of individual controls used in the empirical analysis, for the full sample.

Table A.2 shows the distribution of answers given to the survey question about belief in witchcraft across countries.

Table A.3 presents the distribution of individual observations across countries for the original PEW dataset and our baseline regression sample, as well as the number of Murdock ethnic groups per country in the baseline regression sample.

Table A.4 shows OLS estimation results for the relation between historical malaria mortality and individual belief in witchcraft when we directly control for the intensity of slave exports instead of distance to the coast. Column (2) includes the full set of baseline ethnicity-level controls, while column (3) drops distance from the coast as a control variable and replaces it with the logarithm of the number of slaves exported by area of the ethnic homeland. Column (4) adds the list of extended individual control variables to the specification in column (3). The results show that replacing distance to the coast with the intensity of slave exports does not affect the results for our regressor of interest.

Table A.5 shows analogous results when the dependent variable is ethnicity-level prevalence of witchcraft beliefs. Our main finding is again robust to the inclusion of the intensity of slave exports directly.

Table A.1: Summary statistics for individual characteristics in the full sample

Variable	Mean/Share	St. dev.	N
Belief in witchcraft	0.44	0.50	19,540
Age	33.44	12.88	20,463
Male	0.54	0.50	20,592
Rural residence	0.60	0.49	20,592
Completed primary education or less	0.39	0.49	20,186
Completed secondary education (or part)	0.41	0.49	20,186
Post-secondary education	0.20	0.40	20,186
Reports own economic situation as bad	0.47	0.50	20,415
Reports money shortages in past year	0.68	0.47	20,238
Use of internet (at least occasionally)	0.20	0.40	20,341
Use of computer (at least occasionally)	0.22	0.41	20,334
Use of e-mail (at least occasionally)	0.19	0.40	20,310
Reports crime as big problem	0.89	0.32	20,452
Reports religious conflict as big problem	0.57	0.50	20,168
Reports ethnic conflict as big problem	0.59	0.49	20,160
Thinks Western culture is hurting morality	0.73	0.45	19,441
Christian religion	0.59	0.49	20,490
Ethnoreligion	0.02	0.13	20,490
Index value for traditional practices (0 to 3)	0.70	1.00	19,703
Uses traditional religious healer when sick	0.43	0.50	19,678
Index value of religiosity (7 (lowest) to 1 (highest))	2.05	0.85	20,573
Belief in evil eye	0.45	0.50	19,544
Belief in evil spirits	0.49	0.50	19,616
Belief in protective power of sacrifices to ancestors	0.32	0.47	19,566
Belief in protective power of sacred objects	0.29	0.45	19,304
Belief in protective power of spiritual people	0.41	0.49	19,582
Belief in heaven	0.95	0.22	20,114
Belief in hell	0.84	0.36	19,966
Belief in angels	0.82	0.39	19,719
Belief in miracles	0.76	0.43	19,697

Notes: The first column shows the mean for continuous and index variables, and shows the share of observations for which the variable takes value 1 for dummy variables.

Table A.2: Responses to the survey question regarding witchcraft beliefs, by country

Country	Yes (%)	No (%)	Don't know (%)	Refused (%)	N
Botswana	35.5	54.1	7.6	2.9	980
Cameroon	78.5	20.9	0.6	0.1	1,410
Chad	42.2	57.0	0.8	0.0	1,181
DR Congo	61.7	27.9	7.8	2.6	806
Djibouti	23.7	57.0	11.3	8.0	1,339
Ethiopia	17.6	80.8	1.5	0.1	1,465
Ghana	46.9	49.3	3.5	0.3	1,490
Guinea-Bissau	30.3	55.5	12.5	1.6	893
Kenya	26.8	71.9	1.2	0.1	1,481
Liberia	19.2	77.8	2.7	0.3	1,486
Mali	61.3	26.8	10.2	1.7	937
Mozambique	29.8	68.8	1.3	0.2	1,136
Nigeria	37.0	60.7	2.1	0.1	1,493
Senegal	42.5	46.4	10.1	1.0	990
Tanzania	93.1	5.8	1.1	0.0	1,482
Uganda	28.3	70.0	1.6	0.1	1,040
Zambia	33.4	65.3	1.2	0.1	983
Total	41.6	53.3	4.1	1.0	20,592

Notes: Data are shown for the full sample. The average share of respondents reporting to believe in witchcraft across countries (0.41) differs from the sample average in Table A.1 (0.44) because this table takes into account 'don't know' or 'refused' responses, which are otherwise set to missing.

Table A.3: Distribution of individual observations and Murdock ethnic groups across countries in the original PEW dataset and the baseline regression sample.

Country	PEW dataset		Regression sample		Share of PEW observations in regression sample	Murdock ethnic groups (regression sample)
	Obs.	%	Obs.	%	%	Number
Botswana	1,002	4.0	817	4.5	82	21
Cameroon	1,503	6.0	1,395	6.8	93	55
Chad	1,503	6.0	1,040	4.5	69	17
DR Congo	1,519	6.1	722	2.9	48	16
Djibouti	1,500	6.0	1,081	5.9	72	2
Ethiopia	1,500	6.0	1,441	7.9	96	13
Ghana	1,500	6.0	1,429	7.8	95	25
Guinea Bissau	1,000	4.0	767	4.2	77	12
Kenya	1,500	6.0	1,433	7.7	96	25
Liberia	1,500	6.0	1,403	7.7	94	20
Mali	1,000	4.0	820	4.5	82	17
Mozambique	1,500	6.0	1,080	4.9	72	15
Nigeria	1,516	6.0	1,429	7.8	94	32
Rwanda	1,000	4.0	NA	NA	NA	NA
Senegal	1,000	4.0	880	4.8	97	17
South Africa	1,504	6.0	NA	NA	NA	NA
Tanzania	1,504	6.0	1,386	7.5	92	65
Uganda	1,040	4.1	1,022	5.6	98	16
Zambia	1,000	4.0	970	5.3	97	27
Total	25,091		19,115			

Notes: The first four columns show the number of individual observations per country and their share in the total dataset, for the original PEW dataset and for our baseline regression sample. The third column shows the share of individual observations from the original PEW dataset that was retained in our baseline regression sample. The final column shows the number of Murdock ethnic groups per country in our baseline regression sample after we have matched the individual PEW observations to ethnic groups identified by Murdock (1967).

Table A.4: OLS estimates for the relation between malaria and individual witchcraft belief - Accounting directly for slave trade intensity

Dependent variable	Individual probability of believing in witchcraft			
	(1)	(2)	(3)	(4)
Historical malaria mortality	0.041***	0.036***	0.037***	0.031**
	(0.013)	(0.012)	(0.012)	(0.012)
(log) Slave exports by area			0.020***	0.019**
			(0.007)	(0.009)
Country dummies	Yes	Yes	Yes	Yes
Baseline ethnicity controls	No	Yes	Yes	Yes
Extended individual controls	No	No	No	Yes
Observations	19,429	19,239	18,900	14,655
R-squared	0.199	0.208	0.207	0.259
Number of clusters	37	37	36	36

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (4). In columns (3) and (4) distance to the coast is replaced by the intensity of slave trade. Sections 4.4 and 4.5 provide details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table A.5: OLS estimates for the relation between malaria and ethnicity-level witchcraft beliefs - Accounting directly for slave trade intensity

Dependent variable	Share of individuals believing in witchcraft in the ethnic group			
	(1)	(2)	(3)	(4)
Historical malaria mortality	0.057***	0.043***	0.045**	0.054***
	(0.020)	(0.016)	(0.017)	(0.018)
(log) Slave exports by area			0.022	0.023
			(0.022)	(0.023)
Country dummies	Yes	Yes	Yes	Yes
Baseline ethnicity controls	No	Yes	Yes	Yes
Observations	379	374	364	337
R-squared	0.581	0.620	0.605	0.637
Number of clusters	37	37	36	35

Notes: Standardized continuous regressors. Cluster-robust standard errors at the level of cultural provinces are shown in parentheses for columns (1) - (4). In columns (3) and (4) distance to the coast is replaced by the intensity of slave trade. Sections 4.4 and 4.5 provide details on control variables.
*** Significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Appendix B. Data sources and description

B.1. PEW survey data

Raw data and documentation for the PEW survey "Tolerance and Tension: Islam and Christianity in Sub-Saharan Africa" are available at http://www.pewforum.org/datasets.

Individual belief in witchcraft. Dummy variable equal to 1 if the respondent reports to believe in witchcraft, and 0 otherwise.

Ethnicity-level prevalence of witchcraft beliefs. Proportion of people from Murdock group y in country x reporting to believe in witchcraft. Calculated based on matching of self-reported ethnicity in the PEW data to ethnic groups devised by (Murdock, 1967).

Age. Self-reported age.

Female. Dummy variable equal to 1 if the respondent is female, and 0 otherwise.

Secondary education. Dummy variable equal to 1 if the respondent reports to have attained some secondary education or completed secondary education, and 0 otherwise.

Tertiary education. Dummy variable equal to 1 if the respondent reports to have attained post-secondary education or higher, and 0 otherwise.

Urban residence. Dummy variable equal to 1 if respondent lives in an urban area, and 0 otherwise.

Semi-urban residence. Dummy variable equal to 1 if respondent lives in a semi-urban area, and 0 otherwise.

Personal economic situation. Categorical variable indicating how the respondent assesses his personal economic situation. On the ordinal scale: very good, somewhat good, somewhat bad, very bad.

Shortage of money in past year. Dummy variable equal to 1 if respondent reports that there have been times during the last year when he/she did not have enough money to buy food that the family needed, to pay for medical and health care that the family needed, or to buy clothing that the family needed. Equals zero when the respondent answers 'no' to all three questions.

Use of internet. Dummy variable equal to 1 if the respondent reports to "use the internet, at least occasionally", and 0 otherwise.

Use of a pc. Dummy variable equal to 1 if the respondent reports to use a computer at the workplace, at school, at home, or anywhere else on at least an occasional basis, and 0 otherwise.

Use of email. Dummy variable equal to 1 if the respondent reports to send or receive e-mail, at least occasionally, and 0 otherwise.

Perception of crime as a problem. Categorical variable indicating to what extent the respondent thinks that crime is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.

Perception of religious conflict as a problem. Categorical variable indicating to what extent the respondent thinks that conflict between religious groups is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.

Perception of ethnic conflict as a problem. Categorical variable indicating to what extent the respondent thinks that conflict between ethnic groups is a problem in the country. On the ordinal scale: not a problem at all, small problem, moderately big problem, very big problem.

View on Western popular culture. Dummy variable equal to 1 if the respondent thinks that Western music, movies and television have hurt morality in the country.

Christian religion. Dummy variable equal to 1 if the respondent reports to be a Christian, and 0 otherwise.

Ethnoreligion. Dummy variable equal to 1 if the respondent reports to have an ancestral, tribal, animist, or other traditional religion, and 0 otherwise.

Traditional practices. Index variable capturing the respondent's engagement in practices associated with traditional religion or culture. Equals the number of questions to which the respondent answers yes, for the following questions: (i) do you have traditional African sacred objects in your home, such as shrines to ancestors, feathers, skins, skulls, skeletons, powder, carved figures or branches, spears, cutlasses or animal horns? (ii) do you ever participate in traditional African ceremonies or perform special acts to honor or celebrate your ancestors? And (iii) do you ever participate in traditional African puberty rituals or manhood/womanhood initiation rituals for friends, relatives or neighbors in your area, such as endurance or challenge tests, or initiation to a traditional dance?

Use of traditional healer. Dummy variable equal to 1 if the respondent says that he/she or their family ever use traditional religious healers when someone is sick, and 0 otherwise.

Religiosity. Index variable indicating the frequency with which the respondent engages in religious activities and the importance of religion in his/her life. The index is based on the following categorical variables with ordinal scales: Frequency of attending religious services (never, seldom, a few times a year, once or twice a month, once a week, more than once a week); frequency of praying (never, seldom, a few times a month, once a week, a few times a week, once a day, several times a day); frequency of

reading religious scripture (never, seldom, several times a year, once or twice a month, at least once a week); frequency of sharing religious views (never, seldom, several times a year, once or twice a month, at least once a week); importance of religion in one's life (not at all important, not too important, somewhat important, very important).

B.2. Regional controls

Competition among Christian denominations. Herfindahl index capturing the religious market share of the different Christian denominations in a region. Religious market share is calculated as the share of Christian respondents in a region reporting to follow denomination *d*.

B.3. Ethnicity-level controls

For all own calculations, the geo-processing software ArcMap 10.4 was used to spatially match geographical information to ethnic homelands on the Murdock (1959a) Tribal Map of Africa and to perform the necessary analyses.

Geographic controls

Historical malaria mortality. Estimated proportion of children in the Murdock ethnic group that would have died of malaria (through malaria itself or sickle cell disease) before reproductive age, conditional on not dying of something else. Source: (Depetris-Chauvin and Weil, 2016).

Absolute latitude. Absolute latitude of the centroid of the Murdock ethnic homeland. Source: (Alsan, 2015), (Depetris-Chauvin and Weil, 2016), and Murdock (1959a).

Mean land suitability. Based on the index of suitability of land for rain-fed agriculture (maximizing technology mix) provided by the FAO GAEZ dataset (plate 46). Coded on a scale from 1 (very high suitability) to 8 (not suitable) for cells at 5 arc-minute resolution. The variable used in the analysis is the average value of the suitability index across cells in each Murdock ethnic homeland. Source: FAO GAEZ dataset (plate 46) downloaded at http://webarchive.iiasa.ac.at/Research/LUC/GAEZ/index.htm, and own calculations.

Variation in land suitability. Based on the same data as mean land suitability. Calculated as the standard deviation of index values across cells in each Murdock ethnic homeland.

Area. Area of the Murdock ethnic homeland measured in 1000 sq. km. Source: own calculations based on the sinusoidal projection for Africa and Murdock (1959a).

Mean altitude. Average elevation in km. Source: (Alsan, 2015).

Access to river. Dummy variable taking value 1 if the historical ethnic homeland has access to a river, and 0 otherwise. Source: (Alsan, 2015).

Distance to coast. Geodesic distance from the centroid of the Murdock ethnic homeland to the nearest point on the coast in meters. Source: own calculations using the coastline shapefile downloaded at http://www.naturalearthdata.com.

Distance to lake. Geodesic distance from the centroid of the Murdock ethnic homeland to the nearest water body in meters. Source: own calculations using the shapefile for water bodies in Africa downloaded at http://geoportal.rcmrd.org.

Climate data

Mean annual rainfall (1957-2002). Weighted average of mean annual rainfall (m) during the growing season for the period 1957-2002 across cells for the Murdock ethnic homeland. Weights based on relative area of the cell compared to total area of the Murdock ethnic homeland. Source: own calculations based on data obtained from (Guariso and Rogall, 2016). See Guariso and Rogall (2016) for more information on the underlying data (ERA-40).

Mean annual temperature (1957-2002). Weighted average of mean annual temperature (C°) during the growing season for the period 1957-2002 across cells for the Murdock ethnic homeland. Weights based on relative area of the cell compared to total area of the Murdock ethnic homeland. Based on the same data as mean annual rainfall for this period.

Mean daily humidity (1871). Relative humidity (%) in the earliest year of available data (20th Century Reanalysis version 2.0). Source: (Alsan, 2015).

Mean daily temperature (1871). Temperature (C°) in the earliest year of available data (20th Century Reanalysis version 2.0). Source: (Alsan, 2015).

Tse Tse Suitability. Tse Tse suitability index capturing the normalized steady state population of the Tse Tse fly for the Murdock ethnic homeland depending on historical temperature and humidity. Source: (Alsan, 2015).

Precolonial political and economic outcomes

Complexity of settlement pattern. A measure of the complexity of the precolonial settlement pattern of the ethnic group constructed by (Murdock, 1967), on the ordinal scale: nomadic or fully migratory; semi-nomadic; semi-sedentary; compact but impermanent settlements; neighborhoods of dispersed

family homesteads; separated hamlets, forming a single community; compact and relatively permanent settlements; complex settlements. Source: (Nunn and Wantchekon, 2011) and (Gershman, 2016).

Centralization of institutions. Dummy variable equal to 1 if the precolonial jurisdictional hierarchy (constructed by (Murdock, 1967)) is at least 2 levels above the local authority, and 0 otherwise. Source: (Alsan, 2015).

Historical population density. Proxied by population data estimated by (Murdock, 1959b) for African ethnic groups for approximately the 20th century. Population density is defined as the logarithm of inhabitants per square kilometer. Source: (Nunn and Wantchekon, 2011) and (Alsan, 2015).

Presence of city in 1800. Dummy variable equal to 1 if a city with over 20,000 inhabitants was located on the Murdock ethnic homeland in 1800, and 0 otherwise. Source: (Alsan, 2015), based on (Chandler, 1987).

High dependence on agro-pastoralism. A dummy variable equal to 1 if the ethnic group depended on agriculture or husbandry for at least 66 % of subsistence production, and 0 otherwise. Source: (Alsan, 2015) and (Gershman, 2016).

Other ethnicity-level controls

Christian missions by area. Number of Christian mission stations on the Murdock ethnic homeland per 1000 sq. km. Source: own calculations using data from (Nunn, 2010), provided in shapefile available at https://scholar.harvard.edu/nunn/pages/data-0.

Connection to railway network. Dummy variable equal to 1 if any part of the railway network was built on land historically inhabited by the ethnic group. Source: (Nunn and Wantchekon, 2011).

European explorer route. Dummy variable equal to 1 if a European explorer traveled through land historically occupied by the ethnic group. Source: (Nunn and Wantchekon, 2011).

Appendix C. Additional details on data construction.

In the original PEW dataset, ethnicities are not recorded for Rwanda and South Africa. Hence, these two countries were dropped. The resulting sample included 17 countries, 22,587 individuals, and 697 self-reported ethnicity categories – of which a large number are synonyms, languages, or particular clans within an ethnic group.

For 370 individual observations (or 13 self-reported ethnicities) matching was not possible because the PEW ethnicity is reported as nationality or religion. The large majority of these cases (345) is due to respondents from Mozambique describing their ethnicity as Portuguese, which does not figure in the Murdock list of ethnic groups. An additional 268 respondents refused to answer or said not to know. For 1,243 individual observations, corresponding to 91 self-reported ethnicity categories, we could not find any information that allowed a match with a Murdock group. The 593 remaining self-reported ethnicities were then matched to 334 Murdock groups, resulting in a sample of 20,592 observations.

For 10 countries this final sample includes over 90 % of the observations from the original PEW dataset, and for 6 others we keep (roughly) between 70 % and 90 %. For the Democratic Republic of the Congo, the self-reported PEW ethnicity Bantu/other could not be matched to any Murdock group, resulting in the loss of 52 % of the original observations. Table A.3 in Appendix A shows the correspondence between the original PEW dataset and our baseline regression sample in terms of individual observations, and lists the number of Murdock ethnic groups for each country in the baseline regression sample. The same Murdock group may appear in several countries due to overlaps with national borders.

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