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Measuring the Dynamics of Cultural Values and their Role in Human Development

Measuring the Dynamics of Cultural Values and their Role in Human Development

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ABSTRACT

Using survey data and a multi-level time-lagged linear regression, we show that cultural values are primal in the human development sequence. The spread of advantageous cultural values —like respect for individual rights —predicts future economic development and democracy.

The World and European Values Surveys (WEVS) are administered in 109 countries representing over 90% of the world's population. They are designed to quantify cultural values and facilitate comparative analysis on a global scale. We found nine underlying cultural factors in the WEVS that can be compressed into three orthogonal cultural value components: Secular-Rationality, Openness and Institutional Support. Furthermore, the 109 countries fall into one of four clusters representing different cultural-histories: African-Islamic, Catholic, Western and Communist-Confucian.

We find two independent modes of cultural value dynamics that have very different characters: generational and opinion change. Generational change is persistent and steady and shows strong links to human development. Opinion change, conversely, is rapid and transient and shows weak links to human development. Opinion change dominates short run cultural value variation, but generational change dominates in the long run.

Generational changes in cultural values *precede* those in human development. This makes it unlikely that human development causes cultural values to change. Even though analysis using the standard WEVS cross-sectional samples show that cultural values weakly predict human development, cross-sectional dynamics are dominated by transient opinion change. Human development is unaffected in the long run.

We show that cultural-history is not needed to explain human development inequalities once past cultural values have been controlled for. However, cultural-history still influences the spread of cultural values themselves. Finally, the surprising recent decline in Support for Institutions is predicted by past increases in Secular-Rationality; meaning it could be a side-effect of human development.

Dedication and acknowledgements

To Natasha, who has tolerated me talking about nothing but this thesis for the last six months.

And to Mum, who has tolerated me talking about nothing but this thesis when Natasha couldn't tolerate me talking about nothing but this thesis.

Alex and Dan: thanks for everything.

Author's declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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Chapter 1

Introduction

Cultural values are the attitudes, opinions and beliefs shared by members of a society; it is the central tendency of a group, around which we see variability in personality traits [Schwartz, 2006]. Cultural values are dynamic [Inglehart and Baker, 2000; Inglehart and Welzel, 2005; Norris, 2011] and have been linked to development outcomes such as economic development [Norris, 2011; Putnam et al., 1993] and democracy [Inglehart and Welzel, 2005; Spaiser et al., 2014].

However, past investigations into cultural values have relied on conceptual assumptions to both derive the interpretable dimensions of a cultural value space [Inglehart and Baker, 2000; Schwartz, 2008], and identify clusters of culturally similar countries [Basanez, 2016; Huntington, 1996; Inglehart and Baker, 2000]. In addition, researchers often use time series consisting of representative cross-sectional samples; but they do so without adequately considering the different modes of cultural value change and their differing effects on human development [Hofstede et al., 2010; Norris, 2011; Welzel et al., 2003].

We use data from the World and European Values Surveys (WEVS) to measure cultural values across 109 nations. In chapter three, we conduct a data driven exploratory analysis which finds that nine cultural factors underly the WEVS data. This represents a more fine-grained cultural value map than previous studies. Similarly, in chapter five we use exploratory methods to identify four clusters of countries in our nine dimension cultural factor space. These reflect cultural-historic variables such as language, religion and colonial history showing that the historic non-independence of nations is important and, therefore, must be accounted for in subsequent modeling. The findings in chapters three and five are of interest to students of cultural value dynamics because they act as a comparison with more theoretically driven perspectives.

In chapter four we characterize the different modes of cultural value change: opinion and generational. Opinion change is rapid, transient and drives change in the short term, whereas generational change is gradual, steady and drives change in the long term. In chapter six we see that generational change shows stronger links with human development variables than opinion change. Time series built from standard cross-sectional samples are often used in analyses of cultural value dynamics [Hofstede et al., 2010; Inglehart and Welzel, 2005]), but we show they are driven by opinion change, not generational change. Therefore, those interested in modeling interactions between cultural values and human development in the long-term should focus on generational changes instead.

In chapter seven we show that generational changes in secularization preceded those in economic development. This provides strong evidence against models that assume economic development causes secularization. Chapter eight shows that, in general, changes in cultural values (Secular-Rationality and Openness) precede human development (economic development and democratization). This will be of interest to development theorists who, by and large, believe that cultural value change is a consequence, rather than a cause, of human development [Hofstede et al., 2010; Norris and Inglehart, 2004].

Chapter 2

Literature Review

2.1 What are Cultural Values?

Cultural values are preferences shared by a population and an indication of the composition of social norms in a society [Gavrilets and Richerson, 2017]. They could be conceptualized as shared stories [Harari, 2014], recipes [Bentley and O'Brien, 2017], procedures Henrich [2016], shared meanings [Richerson and Boyd, 2005] or the rules of the social game [Hofstede et al., 2010]. Perhaps the best metaphor is 'the grammar of society' [Bicchieri, 2005] because cultural values are the software that dictate what we care about and how we interact with other people. This, in turn, affects the network structures from which human development emerges.

Humans have, uniquely in the animal kingdom, developed the capacity to accumulate cultural information in populations [Tomasello, 2001]. This ability means humans can more rapidly adapt to changing environments compared to species that rely on genetic adaptations or individual learning [Boyd et al., 2011]. The ability to distributively store information on social networks has led to the exponential ratcheting up of technological diversity and complexity over millenia [Arthur, 2014; Hidalgo, 2015]. Part of this are social technologies that enable the scaling-up of stable social networks to take advantage of economies of scale and increasing returns [West, 2017]. Cultural values are an important component of this social technology.

Sciences like psychology tend to focus on the individual, hence they reasonably view preferences, attitudes and beliefs as personality traits [McCrae and Terracciano, 2005]. These preferences, attitudes and beliefs become cultural values when they are shared by entire populations. Societies that have shared behavioral expectations, supported by the punishment of those who violate these expectations [Boyd and Richerson, 1992], can form large stable networks of up to a few thousand people. However, to scale up to the level of states (hundreds-of-thousands or even millions of people) socialized monitoring and punishment is not practical. Hence these early states were nearly always theocratic [North et al., 2009] because omniscient moralizing gods, with the power to punish after death, provided the threat of punishment [Norenzayan, 2013; Norenzayan and Shariff, 2008; Shariff and Norenzayan, 2007]. Religious cultural values also legitimized the stratification of political power and an economic system of tribute [Morris, 2015].

Large and stable differences in cultural values exist among the worlds nations [Inglehart and Baker, 2000; Minkov and Hofstede, 2011], but why? Social learning is the mechanism that makes cumulative culture possible and it is made more efficient by conformist bias (the tendency to copy the majority in a group), hence they likely co-evolved [Henrich and Boyd, 1998]. Also ethnic markers — such as language, religion and nationality — act to signal the reliability of a potential collaborator [McElreath et al., 2003]. Conformity and ethnic markers act to create discrete cultural groups that are robust to immigration. Hence the potential for between-group cultural value diversity is born.

Cultural values are one component of the social technology that structures society, the others are social norms and institutions. Social norms are the discrete rules of society — things that you should, or should not, do. Adherence to a complex of social norms (or a custom) are reflected in continuous cultural values. Institutions emerge only when society is politically hierarchical because they are top-down complexes of formal laws imposed by a governing elite [Hodgson, 2002].

It is useful to distinguish top-down rules (formal laws) from bottom-up rules (social norms) because they can be out-of-sync [Acemoglu and Robinson, 2012]. Democratic societies have mechanisms of accountability [Fukuyama, 2012] which force institutions to align with changing cultural values. This means that, while cultural values change continuously, formal laws change in punctuated bursts. Sometimes changes in the law occur in reaction to shifts in cultural values. For example, the Civil Rights Act was passed in 1964 by the US federal government, but this is some time after most of the population had turned against racial segregation [Lieberman, 2002].

Culture values often reflect institutions. Geert Hofstede [Hofstede et al., 2010] showed that 'high power distance' cultures tend to have deleterious institutional arrangements. Corruption is rife because practices like nepotism and tribute payment are considered normal [Rose-Ackerman and Palifka, 2016]. Media consumption is lower, leading to less trust and increased nationalism [Norris and Inglehart, 2009]. Moreover, low trust societies tend to be less economically developed because economic networks are smaller [Hidalgo, 2015]. Finally, conceding unlimited power to elites tends to result in the persistence of extractive institutions (rules which only benefit elites) [Acemoglu et al., 2001] and inhibits the development of rule of law [Fukuyama, 2012].

2.2 Human Development and the Bottom-up Approach

The second half of this thesis deals with the interactions between cultural values and measures of human development. Where past investigations into cultural values have relied on conceptual assumptions to derive the interpretable dimensions of a cultural value space [Inglehart and Baker, 2000; Schwartz, 2008], we have removed as many a priori assumptions as possible to derive a new cultural space that is informed only by the global variance that exists in the entire World and European Values dataset [EVS, 2011; WVS, 2017].

We compare the time evolution of cultural values to established measures of economic development and democracy. This allows us to rule out certain classes of proposed causal models by time ordering the changes in cultural values and human development [Hofstede et al., 2010; Norris, 2011; Welzel et al., 2003].

2.2.1 Economic Development Emerges from Highly Connected Social Networks

Conceptually, economic development is the process by which the wellbeing of individuals that make up a society is improved by the cooperative actions of the whole society. Though this can be broadly defined as including human and social capital [Coleman, 1988], often it is measured more narrowly as material wealth. The material wealth of a society is usually measured using Gross Domestic Product per capita (GDP), which is the quantity of goods and services exchanged in the economy using the proxy of total income or total spending.

An important driver of sustainable economic growth is technological innovation [Arthur, 2014; Hidalgo, 2015; Romer, 1990]. Through social learning, we acquire the information required to create technology, but the body of knowledge and know-how accrued by societies is so large that no one individual could have figured it out alone [Richerson and Boyd, 2005]. The capacity of a single person to store information is limited by physical constraints in the brain. This means accumulated knowledge and knowhow must be distributed in larger and larger social networks, the computation of which creates increasingly complex products [Muthukrishna and Henrich, 2016]. However, growing economic networks requires over-coming many collective action problems [Chudek and Henrich, 2011], using social technologies like prosocial institutions [Alesina and Giuliano, 2015], civic cultural values [Newton and Norris, 2000] and enlightenment cultural values [Pinker, 2018]. Forming these large productive economic networks offers increasing returns to scale as economic development scales *super-linearly* with population size. In other words, the larger the network, the wealthier the average person is [Bettencourt et al., 2007].

There are many different reasons GDP per capita increases, and some of these are unproductive; such as capital accumulation and resource extraction. Therefore, it is preferable to isolate the proportion of productive GDP flowing from technological innovation. This can be done by estimating the proportion of GDP that is extractive [World Bank, 2018] or by calculating Total Factor Productivity [Gordon, 2016]. Nonetheless, we must use raw GDP per capita in our analysis because one of the important methodological steps we have taken is the time ordering of macro-level variables over a long time period (100 years. GDP per capita, unlike the other measures of economic development, has been estimated for all years of the 20th century and for over 100 countries [Bolt et al., 2014].

2.2.2 Democracy and Political Stability

The nation state has emerged in the last few hundred years as the preeminent unit of social organization. A state must have an administrative body that is granted a monopoly on power and violence over a fixed geographical region [Weber, 1965]. States, for the bulk of human history, have been characterized by political instability, where elite factions battle for for dominance, often through violent means [Flannery and Marcus, 2012]. Innovations — such as the hereditary inheritance of power — act to reduce violence by smoothing the power transitions between elite regimes [Wright, 2006]. In modern societies, political stability has been further facilitated by disembodying leadership roles [North et al., 2009]. For example, the role of king in medieval Europe was clearly linked to a known individual, but the role of president of the United States is an institutional role that individuals flow in and out of at preagreed intervals. An even more recent political innovation is mass-participation democracy [Huntington, 1991], which too has proven to be unstable outside of a handful of western countries [Marshall et al., 2017]. The reasons for this are complex, but I explore some of them here.

Democratic institutions thrive in populations with cultural values of openness [Inglehart and Welzel, 2005; Ruck et al., 2019]. However, democracy is highly contagious [Brinks and Coppedge, 2006] and tends to diffuse to neighboring socieites from those that have been recently democratized [Matthews et al., 2016]. This occurs whether or not their social technologies can support it [Ruck et al., 2019]. Demographic transition may also play a role in the emergence and stability of democracy. Older people are important for mediating conflicts, whereas young populations, particularly those with a disproportionate number of young men, will have a greater propensity for violent conflict [Huntington, 1996; Urdal, 2011]. This "youth bulge" effect has been linked with autocracy and democratic recession [Cincotta and Doces, 2012; Farzanegan and Witthuhn, 2017; Weber, 2013].

Democracy is a complex concept that makes it hard to measure. It helps to separate electoral democracy from liberal democracy [Inglehart and Welzel, 2005]. Electoral democracy is the institutions that ensure fair elections and reasonable checks and balances on chief executives, whereas liberal democracy also includes the cluster of rights we often associated with democratic systems; like freedom of speech, freedom of assembly and an independent media [Mounk, 2018]. In this thesis we focus on electoral democracy, measured using the tried and tested Polity Index [Jaggers and Gurr, 1995; Marshall et al., 2017; Miguel et al., 2004; Murtin and Wacziarg, 2014] because it, not only provides conceptual clarity, but also historical depth and comprehensive global coverage [Marshall et al., 2017].

2.3 Using Surveys to Measure Cultural Values

For building scientific models and testing hypotheses it is essential to make explicit what we mean by 'cultural values' using quantified data. Though cultural values may seem to have a holistic and irreducible structure, there is a rich history of using survey data to discretize culture into measurable cultural units.

2.3.1 Narrow Sampling

Between 1967 and 1973 Gert Hofstede administered surveys to 100,000 IBM employees from 40 different countries. Despite standardized training used for all IBM employees across all countries, he still noticed a strong effect of national culture [Hofstede, 2001]. By comparing only IBM employees, he ensured that the samples were comparable; this is called 'narrow sampling'. The shortcoming of narrow sampling is that we do not know if the sample is representative of the entire population (highly educated IBM employees in particular are unlikely to be representative of the national population). That said, the observed regularities have been externally validated by repeating the study within other narrow samples from different industries [Hofstede, 2001].

Using factor analysis, Hofstede derived a four dimensional cultural value space which explains the national level variation in the IBM values survey [Hofstede, 2001]. The first dimension is 'Power Distance': whether hierarchical structure is thought to be essential for the smooth running of socieity. The second dimension is 'Individualism vs Collectivism: the degree to which individuals are concerned about wider society beyond their immediate family members. The third dimension is 'Uncertainty Avoidance': how people handle uncertainty and so whether they favor rigid and well defined laws. The fourth dimension is Masculinity vs Feminism': where masculine societies have a preference for gender roles.

In subsequent work, Hofstede and his colleagues have identified a fifth and sixth cultural dimension. The fifth, 'Long Term Orientation', was discovered when they became concerned that the contents of the survey was designed with a western bias. Using a survey created by Chinese social scientists, 'Long Term Orientation' was discovered which is the time horizon on which societies make decisions [Hofstede and Bond, 1988]. The sixth, 'Indulgence vs Self-Restraint' was discovered based on Micheal Minknov's work using the World Values Survey. It measures how comfortable the society is with short term gratification [Hofstede et al., 2010].

Hofstede takes a data driven approach, in that his cultural dimensions are statistically extracted from raw survey data. On the other hand, another prominent cultural values scholar, Shalom Schwartz, derived his cultural value space from psychological theory. He first defined a cultural value space using theory, and then subsequently designed a survey to quantify the hypothesized dimensions. Participants in the Schwartz Value Survey (SVS) were asked to place a degree of importance on 56 abstract concepts which reflect seven fundamental values: Conservatism, Hierarchy, Mastery, Affective Autonomy, Intellectual Autonomy, Egalitarianism and

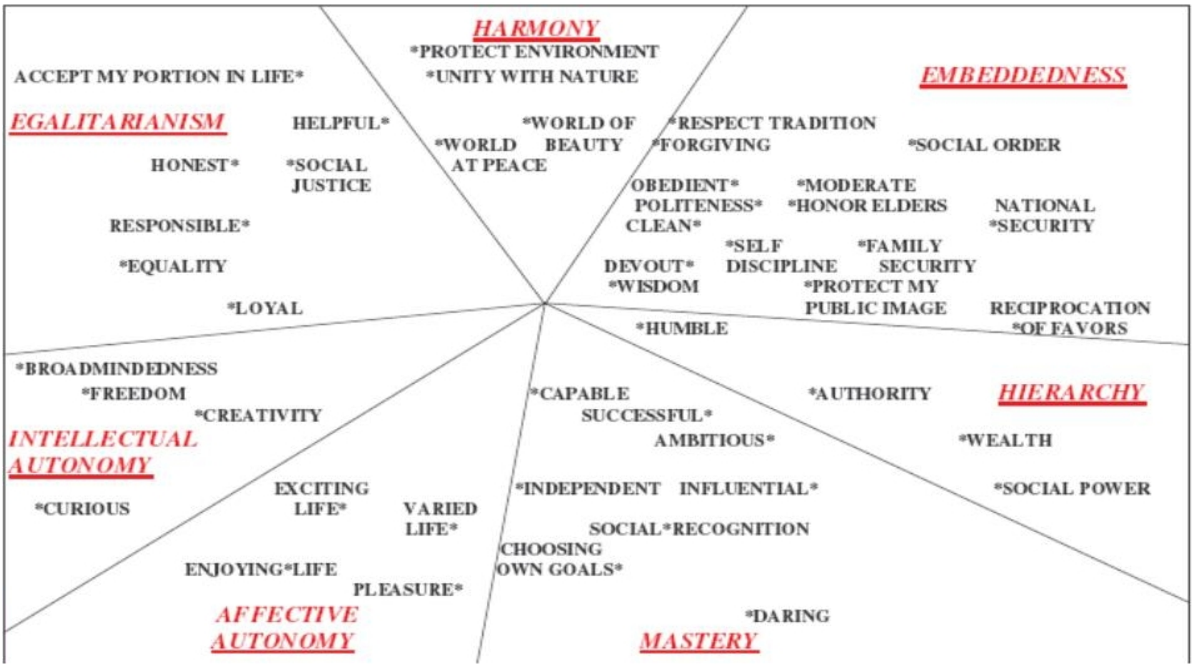


Figure 2.1: The 56 items from the Shalom Schwartz values survey are plotted onto a two dimensional space and clustered into the seven hypothesized cultural values which reduce to the three dimensions of the Schwartz cultural value space. Taken from [Schwartz, 2008]

Harmony. Guttman-Lingoes Smallest Space Analysis (SSA) confirms the 56 items cluster into the seven prescribed fundamental values (see figure 2.1). Finally, through analysis of the correlation structure, they identify three master dimensions on which nations are mapped [Schwartz, 2006].

The first of Schwartz's dimensions is 'Autonomy vs. Embeddedness' and measures the emphasis placed on individual rights and autonomy compared to collective action and the importance of rules. The second dimensions is 'Egalitarianism vs Hierarchy', where hierarchical societies place importance on power stuctures and egalitarian ones favor loyalty and equality. The third dimension is 'Harmony vs Mastery', it measures whether a society sees nature as something to be preserved or something to be mastered [Schwartz, 2006]. As the description of Hofstede and Schwatrz's cultural dimensions suggest, regression analysis shows there is correspondence between them [Hofstede, 2001].

Similar to Hofstede, Schwatrz used narrow samples to compare cultures. He collected data from school teachers—an interesting choice of occupation because they play a significant role in distributing culture to children. The results were externally validated using samples of university students [Schwartz, 2006].

2.3.2 Representative Sampling

The Eurobarometer survey has been administered to member states of the European Union since 1974 and is an early attempt at quantifying cultural values using representative samples. The state of the art sampling and administrative techniques they employed inspired subsequent global surveys like the World Values Survey and the European Values Survey.

Much of the early work using the Eurobarometer survey was by Ronald Inglehart and his colleagues. They discovered large inter-generational cultural value trends in Western Europe associated with political and economic variables [Inglehart and Welzel, 2005]. Methodologically, they expanded the temporal scope of the data by treating date of birth as a proxy for time period (generational trends). This made use of 'socialization theory', which states that cultural values are crystallized during formative years and that these generational trends persist through time [Inglehart, 2008].

The representative sample survey technique was carried forward globally by the World Value Survey [Inglehart and Welzel, 2005]. Using samples from over 100 countries, Inglehart proposed a causal framework which linked cultural value change to economic development and democratization: the 'Human Development Sequence' (HDS). It argues that economic development, through industrialization, reduces gender differences and increases collective action through urbanization. The result is a shift to post-materialist values —emphasizing principles like equality between the sexes, democracy and freedom. Then, through mass mobilization, democratization can occur. However, establishing true causation between these variables is difficult and alternative causal pathways for the HDS have been suggested [Abdollahian et al., 2012; Spaiser et al., 2014]. Using the WVS, Inglehart suggests there are two important dimensions for understanding global national variation in cultural values: 'Secular-Rational vs Traditional' (SR-T) and 'Survival vs Self-Expression' (S-SE). These two dimensions comprise the Inglehart-Welzel (I-W) map in figure 2.2.

'Secular-Rational vs Traditional' reflects differences in the importance of religion, national pride and a respect for authority and 'Survival vs Self Expression' reflects the priority given to economic and physical security over political engagement and tolerance. The cultural value migration associated with the 'Human Development Sequence' is from the bottom left of figure 2.2 to the top right. Industrialization results in a shift from traditional to secular-rational values and the material security offered in a post-industrialized society causes a shift from survival to self expression values.

In conjunction with Pippa Norris, Inglehart has used the WVS to address some more specific sociological questions. Regarding the process of secularization, they argue religiosity persists when existential security is scarce and that secularization, despite causing declining memberships for established churches, could lead to an interest in personal spirituality [Norris and Inglehart, 2004]. They also address the paradox that, despite increasing globalization, heterogeneous cultural values persist into the modern day. They argue that cultural diversity is maintained by

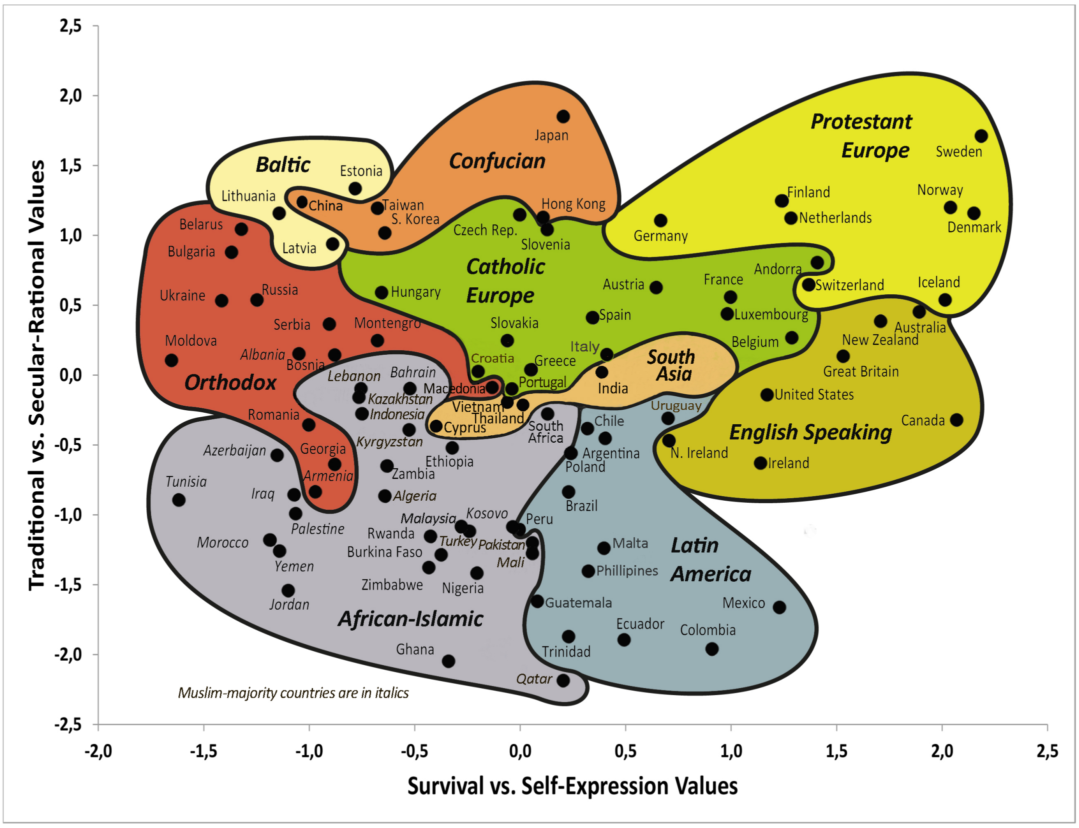


Figure 2.2: The Inglehart-Welzel cultural map: the x axis is survival vs self-expression values and the y is traditional vs secular/rational values. The axes are derived from the WEVS data using confirmatory factor analysis. This figure is taken from www.worldvaluessurvey.org

barriers to information flow, such as no press freedom, poor access to media and a lack of global trade [Norris and Inglehart, 2009].

2.3.3 Cross-Sectional Time Series and Modes of Cultural Value Change

The WEVS has been carried out multiple times resulting in repeated cross-sectional samples at the country level. These cross-sectional time series have been used to study subjective wellbeing [Easterlin et al., 2010; Inglehart et al., 2008], political engagement [Inglehart and Catterberg, 2002], institutional confidence [Van de Walle et al., 2008] and the dimensions of the Inglagert-Welzel (I-W) cultural map [Inglehart and Baker, 2000]. The Eurobarometer survey, although only administered in the European Union, offers a more detailed cross-sectional time series stretching back to 1970 [European Commission, 2017]. It has been used to quantify changes in wellbeing [Inglehart and Klingemann, 2000], support for the European Union [Anderson and Kaltenthale, 1996] and support for democracy [Van de Walle et al., 2008].

All of the mentioned analyses look at changes in representative cross-sectional samples, but we are also interested in the different modes which underlie this change: generational change, opinion change and life-cycle effects. Generational trajectories in cultural values are seen as persistent differences between birth cohorts [Inglehart, 1990]. A 'life cycle' effect is evident as peoples values change as they age, such as the possible adoption of more right-leaning political orientations [Down and Wilson, 2013].

The clear generational trends we see in cultural values [Foa et al., 2016; Inglehart, 1990, 2008] are explained by the socialization hypothesis. It states cultural values are formed during our formative years and remain relatively fixed during our life time [Inglehart, 1990] Human infants are, after all, voracious social learners enabling them to acquire the relevant social information they need to function as adults [Henrich and Henrich, 2007]. However, the cultural values of a socialized birth cohort can still change with time because of the aforementioned life-cycle and opinion change, which we will discuss in more detail later. Cultural evolution has accelerated during recent times due to technological innovation and rapid economic growth [Bentley and O'Brien, 2017; Bettencourt et al., 2007], which explains the steep generational gradient in post-materialist values seen in the last century or so [Inglehart, 2008].

Although life cycle effects do not seem to play a big role for post-materialism (figure 2.3), a given generation still exhibits cultural value change: opinion change. These are changes that, unique to a particular time, affect the entire population and are caused by exogenous events like economic downturns [Easterlin et al., 2010; Inglehart and Welzel, 2005]. Importantly though, these changes are transient and eventually return to the socialized baseline determined during formative years [Inglehart, 2008]. However, they can sometimes dominate over more persistent generational trends over the short term [De Vries, 2005]; table 2.1 provides an example of a nation's survey responses broken down by time period and birth cohort.

2.4 Primacy of Generational Change

In this thesis we make the case that generational changes are the key to understanding the global diversity in, not only cultural values, but also human development. A birth cohort is the unit of study for generational cultural values change, yet will still have internal diversity. Therefore, the cultural values within a birth cohort are best described as probability distributions. The average cultural value of a birth cohort is the culturally determined socialized part; whereas the within population variation around this average might be called personality traits [Schwartz, 2006].

As [Ryder, 1965] points out, generational differentials are essential for long run change in cultural values to even occur. This is a a process where the old generations are replaced by the young called 'demographic metabolism'. Transient opinion change [Inglehart, 2008] is not sufficient to explain the sustained long-term changes in cultural values implicit in the first

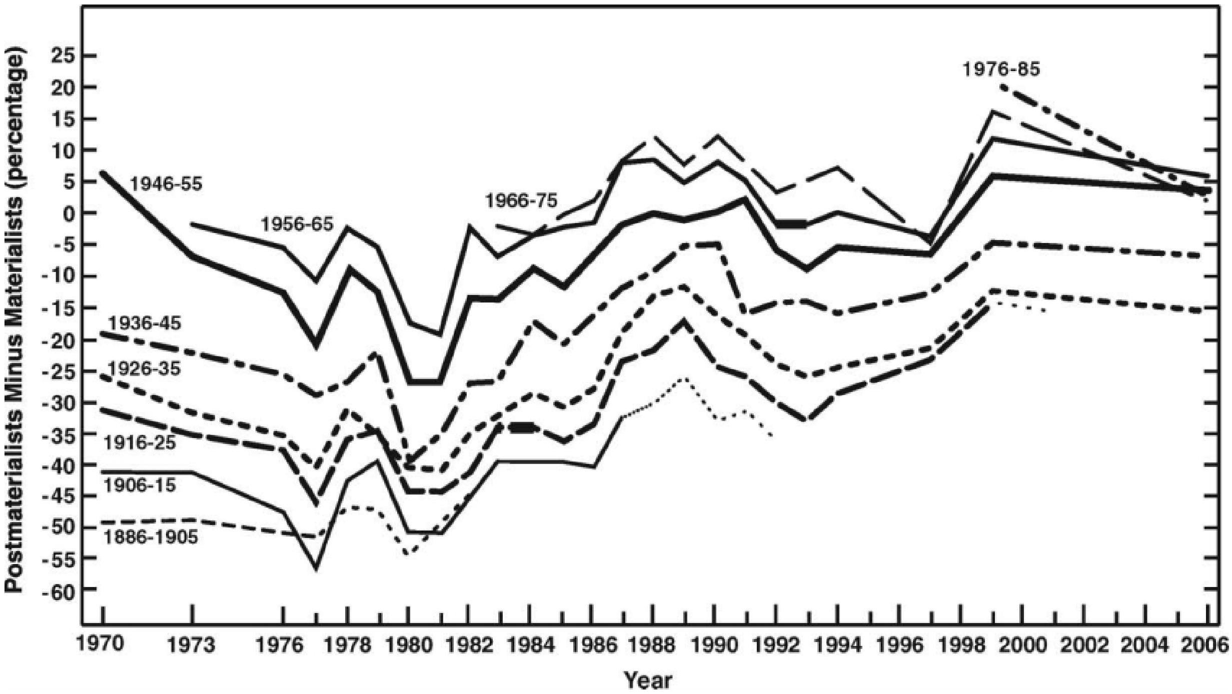


Figure 2.3: Time series of post materialist values in Western Europe since 1970, split into generations of 10 years. The trends are characterized by persistent generational changes, but rapid and transient changes occur across all generations at particular time points. This figure is taken from [Inglehart, 2008] and utilizes the Eurobarometer data.

g|p	**1990-1995**	**1995-2000**	**2000-2005**	**2005-2010**	**2010-2015**
1900					
1910	0.46 (0.063)	0.63 (0.056)			
1920	0.51 (0.04)	0.6 (0.04)			
1930	0.39 (0.049)	0.49 (0.039)		0.45 (0.07)	0.37 (0.069)
1940	0.33 (0.045)	0.43 (0.038)		0.27 (0.06)	0.2 (0.046)
1950	0.21 (0.04)	0.37 (0.031)		0.13 (0.05)	0.1 (0.042)
1960	0.21 (0.044)	0.4 (0.032)		0.11 (0.06)	-0.07 (0.047)
1970		0.14 (0.045)		0.12 (0.061)	0.02 (0.054)
1980				0.02 (0.077)	-0.18 (0.055)
1990					-0.19 (0.086)

Table 2.1: The generation-period (g-p) breakdown of Religiosity (REL) for the USA. The rows are generations and the columns are time periods. Each entry is the sample mean with the standard error in brackets. A missing time period occurs due to non-participation in a WVS wave. A missing generation occurs when it is underrepresented during a given time period (a sample of less than 100).

and second demographic transitions [Lesthaeghe, 2014]. Likewise, if the only source of cultural value change were aging effects, then persistent change can only occur when the average age of the population changes. Although it is true that western societies have been getting older [Lesthaeghe, 2014], the cultural change observed during the same period is the opposite to what a pure aging effect would predict. For example, the West has become less religious in recent times [Inglehart and Oyserman, 2004], but old people tend to be more religious. Therefore, if the population is getting older, then we should expect an increase in religiosity. The decrease in religiosity is better explained by the continuous replacement of older generations with younger ones with incrementally more secular cultural values.

Generational trends are caused by a gradually changing environment in which successive generations form their cultural valus in the early years of life. Evidence from neuroscience supports the idea that the first 3 decades of life are vital for cultural value formation. The prefrontal cortex and the striatum are the predominant brain regions used for storing, accessing and updating cultural values [Glimcher, 2016] and both of these regions mainly develop during adolescence [Sowell et al., 1999]. Though a more recent study suggests limited synaptic pruning continues into the third decade [Petanjek et al., 2011]. This leaves some ambiguity as to whether to define formative years as the first 20, or first 30, years of life.

Although baseline cultural values are developed in adolescence, significant lifetime fluctuations still do occur (opinion change). Unfortunately, statistically separating the effects of aging, time period (opinion changes) and birth cohort (generational changes) on standard cross-sectional cultural value samples is not possible with conventional linear regression. This is because these three predictors are perfectly linearly dependent (period=cohort+age), meaning linear regression is not identifiable. To obtain unique estimates, the linear dependency between age, period and cohort must be broken. We need to impose a constraint to break this linear dependency, but often no empirically justified constraint is available. There are a family of models which claim to provide valid estimates for age-period-cohort problems called Constrained Generalized Mixed Linear (CGML) models [Luo, 2013], however they tend to surreptitiously impose arbitrary constraints that are hard to validate.

One type of CGML model is the Intrinsic Estimator (IE). It provides estimates for age-period-cohort regression that have desirable statistical properties (unbiased and consistent estimators) [Yang et al., 2008]. However, IE is actually imposing a hidden constraint and simulation studies have shown that IE only provides unbiased estimators under very specific data conditions [Luo, 2013]. A second popular CGML approach is to coarse grain one or more of age, period or cohort into categories of unequal interval size, thus breaking the perfect linear dependency (period=cohort+age). This approach is often used with mixed models [Land and Yang, 2013] and has been in studies using the WEVS [Hayward and Krause, 2015]. Although, similarly to IE, the coarse-graining imposes hidden constraints that lead to biased results in simulation studies [Luo and Hodges, 2016]. Therefore, in the absence of prior information about age, period and cohort changes, linear regression is unable to estimate their separate effects.

2.4.1 Generational trends or aging effects?

Given we have no empirically justified constraint to use to separate age, period and generational effects, we must reason qualitatively about whether the persistent birth cohort differences (see chapter four) are best explained by the socialization of birth cohorts or by aging effects. In chapter five, we show that there are large global inequalities in the amount of generational cultural value change that relate to cultural-historic variables. Countries with large west European descended populations [Putterman and Weil, 2010], have transitioned to being open-access [North et al., 2009] and WEIRD (Western, Educated, Industrialized, Rich and Democratic) [Henrich et al., 2010] during the last few hundred years. This transition has not occurred in the majority of African and Islamic countries [North et al., 2009]. It is easy to see how the steady emergence of a new ecological niche could endow successive generations with steadily changing cultural values, but less obvious why the same environmental changes could lead to an exaggerated aging effect.

The aging hypothesis becomes even more improbable when we look at the magnitude of the generational changes (see chapter four). If these changes are predominately the result of aging effects, then the average twenty year old Spaniard —with religiosity comparable to someone from the Netherlands —can expect to become theologically more aligned with someone from Bahrain by the time they are 100 (see the appendix for chapter six). A more sensible explanation is that Spain experienced rapid modernization during the 20th century, and thus have the steep generational changes in religiosity to show for it.

All this is not to say that aging effects do not exist. It simply seems unlikely that they dominate over birth cohort effects in the case of cultural values.

2.4.2 Modeling the Influence of Generational Change

We have seen in the previous section that generational changes are the key to understanding cultural value linkages with human development. Using generational time series instead of cross sectional samples allows us to expand the time horizon of the study from the 25 years offered by the standard cross-sectional samples in the WEVS, to 100 years based on birth cohorts stretching back to the early 20th century. Although the generational change signal could be detected in a cross-sectional time seres with a broad enough time span, we would still have to control for the uncorrelated and transient opinion changes superimposed on it (see chapter four). The generational time series can be viewed as a cleaner representation of the cultural value dynamics that affect human development. Although this is not to say that opinion changes are random noise; chapters seven and eight demonstrate that this is not the case.

It is easy to imagine how levels of human development affect socialized cultural values: development leads to a more wealthy environment for successive generations of children and their socialized cultural values will reflect this affluence [Inglehart and Welzel, 2005]. It is harder to see how socialized baseline cultural values can influence human development, especially when we take into account the rapid and variable opinion changes that occur throughout life. To understand this, it is important to note that opinion changes are transient.

In this view, we see opinion change as quasi-random. Hence the longer the time series we possess, the more likely we will approximate the ‘true’ socialized baseline cultural values for a given generation. We show in chapter four that opinion changes are high frequency (on the order of 5 years or less), so the 25 year time span offered by the World Values Survey is long enough to make a reasonable approximation of the socialized baseline cultural values for a given generation.

Figure 2.4 illustrates the cultural value (Religiosity) evolution of a country. The red bars represent the socialized Religiosity level for a given generation (defined as decade of birth) which remains fixed relative to other generations. However the entire population is subject to opinion change which is why the box (which represents the entire population) translates up-and-down as time progresses. With each time step, the oldest generation dies and a new generation is added with their own socialized levels of Religiosity.

Figure 2.4 also illustrates the two possible causal pathways between cultural values and human development. If human development causes cultural value change, it does so by influencing the socialization of generations during their formative years. The yellow part of each population in figure 2.4 represents children in their formative years and levels of human development during this time will determine their level of Religiosity. According to developmental neuroscience this formative period lasts for twenty [Sowell et al., 1999] or thirty years [Petanjek et al., 2011].

On the other hand, should cultural values cause changes in human development, then we must imagine how macro-level developmental variables can emerge as a product of a country’s adult population and their cultural value configuration. It is possible that generations have different levels of influence in society (we might imagine that the young and old do not have as much influence as the middle aged for instance). But, for the sake of simplicity, we just assume that all generations have equal influence and that the population average Religiosity has a direct impact on human development. In practice, the WEVS does not provide us with whole historic populations, just the cultural values of the the youngest generation. Fortunately, this measure contains all the relevant information because the relative differences between generations are fixed (see chapter four). Therefore, any change in the average population-level cultural values must be proportional to that imparted by the new generation.

Finally, figure 2.4 shows that human development is evaluated at every time point and so we might expect transient opinion change to have an influence. However, as we see will see in chapters seven and eight, this is not the case. It appears that human development outcomes are robust to short term fluctuations in cultural values implying a more diffuse influence that averages out high frequency period changes.

High frequency and rapid opinion changes are caused by the entire population changing its values in response to environmental changes [Acerbi et al., 2013; Gelfand et al., 2011]. These represent a change in survival strategy during times of insecurity, similar to those seen in other primates [Dunbar et al., 2009; Hockings et al., 2015]. Humans tighten tried and tested norm systems that emphasize religious belief [Greeley, 1994], confidence in government [Best et al., 2006] and stricter punishment for norm-violators [Gelfand et al., 2011]. On the other hand, during times of existential security, the traditional norm system can be relaxed, which provides opportunities for innovation [Harrington and Gelfand, 2014] and economic development [Ruck et al., 2018].

Conversely, generational differences are driven by changing childhood socialization during formative years, a time when norms and values of the society are learned [House et al., 2013; Sutter and Kocher, 2007]. A generation in their formative years will learn norms and values from a number of different sources. One-to-many transmission pathways such as mass media and universal education systems have the potential to facilitate rapid intergenerational change [Mesoudi, 2011; Mesoudi et al., 2015]. These pathways have been effective in western countries for the longest time [Norris and Inglehart, 2009], which might explain the particularly large value change seen among western publics during the 20th century. However, vertical transmission from parents [Grusec and Kuczynski, 1997] ensures that new generations are exposed to traditional values too. This mediating effect explains why generational cultural value change is steady.

2.5 Culturally Similar Societies

In chapter five we use unsupervised statistics to identify four distinct clusters of countries in cultural value space. Here we review some important past efforts at doing so. Importantly though, none of these examples used unsupervised statistics to learn clusters from data. They all make prior conceptual assumptions. Samuel Huntington, in his famous 'Clash of Civilization' thesis, posited a number of world civilization clusters defined using deep rooted cultural characteristics [Huntington, 1996]. He identified nine clusters —Western, Orthodox, Islamic, Buddhist, Hindu, African, Latin American, Sinic and Japanese —which are defined using ancient and persistent cultural features like language, religion and geography. This clustering of countries has been confirmed by survey data; some using matched data samples collected from particular companies or industries [Gupta et al., 2002; Hofstede et al., 2010; Ronen and Shenkar, 1985] and, more recently, using global representative samples from the WEVS [Inglehart and Baker, 2000]. That said, a more parsimonious view is possible. These roughly nine clusters can be collated to just three: cultures of achievement (Western, Sinica and Japanese), cultures of joy (Latin America, Catholic Europe, Buddhist) and cultures of honor (Islamic, African, Orthodox) [Basanez, 2016].

Could super-national cultural values correlations exist as a result of shared history, language or religion? Phylogenetic studies can shed light on this mystery. Cultural traits, like language and religion, are key cultural identifiers with deep cultural evolutionary histories. We can use

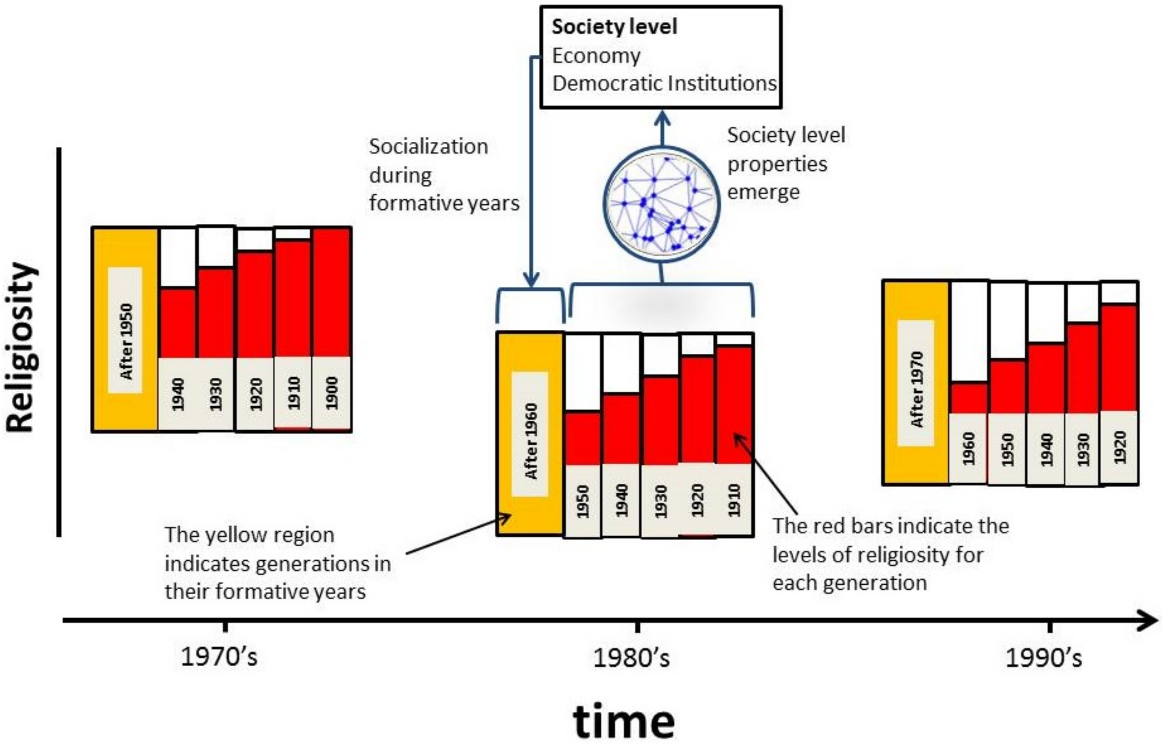


Figure 2.4: An illustration of cultural value change (using Religiosity as an example) and the possible causal pathways with human development. Each box represents a population at a given time, where the red bars are the socialized baseline Religiosity levels of each generation and the yellow section consists of generations still in their formative years and not part of the active adult population (each generation is labeled by their decade of birth). As time progresses the box (population) moves to the right. With each time step the oldest generation dies and a new one enters with their own level of socialized Religiosity. The entire population can collectively increase or decrease in Religiosity (opinion change) by moving up or down. Human development can change cultural values by acting on the part of the population still in their formative years (the yellow box). Cultural values can change human development if we view the later as an emergent property of the adult population and their socialized cultural values.

phylogenetic trees of language [Pagel et al., 2007] or religion [Matthews, 2012] as a proxy for historical relationships between societies. Therefore, through the processes of socialization,it is possible for two societies to have the same set of cultural values inherited from a shared ancestral society.

Unfortunately, this simple view of cultural value transmission does not fit with our findings (see chapter four), where we see large cultural value divergences in just the last 100 years. However, cultural-history can still influence the distribution of cultural values over this shorter time period. The preexisting differentials in stable cultural features like language and religion can act like barriers to the diffusion of other information: such as cultural values. For example, [Spolaore and Wacziarg, 2016] showed the economic benefits of the industrial revolution, caused by the technological innovations originating in England, were next observed in countries that were culturally similar to England. A similar pattern was noted for the spread of economic and political shocks [Matthews et al., 2016]. It follows from this work that, if Ronald Inglehart is correct and economic development leads to cultural value change [Inglehart and Welzel, 2005], then this same effect of cultural barriers might also explain cultural-historic divides we observe in cultural values. In fact, such a pattern can emerge even without reference to economic development, if the cultural values themselves are diffusive.

The Inglehart-Welzel cultural value map (I-W) uses the WEVS data to define its two dimensions (Survival vs Self-Expression and Tradition vs Secular-Rational) and has been used to develop clusters of countries called 'cultural zones' [Inglehart and Klingemann, 2000]. However, the cultural zones were not arrived at using a clustering algorithm or other objective method. The countries were simply plotted and rough lines were drawn around historically similar groups. Another problem is that, although these culturally similar countries are qualitatively convincing in the two dimensions of the I-W map, they are not detectable in other cultural dimensions like Prosociality [Minkov et al., 2013].

2.6 Does Economic Development Cause Secularization?

In chapters seven and eight we use our generational time trends, developed in the first half of the thesis, and compare them statistically to equivalent time series for measures of economic development and democracy.

In chapter six, we reveal a strong negative correlation between religiosity and economic development. We are not the first to notice this [Crabtree, 2010; Norris and Inglehart, 2004]; in fact, debate about the link between economic development and religiosity has been raging for a long time. Emile Durkheim proposed that the functions of religion become obsolete in the face of economic and institutional modernization, so will fade in the wake of modernization [Durkheim, 1912]; a perspective endorsed in more recent times [Norenzayan, 2013; Norris and Inglehart, 2004]. In another view, Max Weber wrote that the productive capacity unleashed by the 'Protestant work ethic' explains why Protestant societies tend to be more economically advanced [Weber, 1930]. These two classic hypotheses diverge on an important empirical prediction: for Durkheim to be correct economic development must precede religious change, but if Weber is correct then religious change must precede economic development.

Previous studies addressing this issue prove inconclusive. Some show development preceding secularization [Hungerman, 2014], some show secularization preceding development [Becker and Woessmann, 2013] and still others show a co-evolutionary process [Herzer and Strulik, 2017]. Our analysis not only employs a unique perspective on the data by using generational trends as representative of historical time periods, but it is also more comprehensive in other important ways.

One shortcoming in the secularization literature is the limited geographical scope of cross-national samples. Often the studies are limited to only western countries [Bettendorf and Dijkgraaf, 2010; Franck and Iannaccone, 2014] or sometimes just a single country [Becker et al., 2017; Becker and Woessmann, 2013]. One study we know of includes some non-western countries [Ruiter and van Tubergen, 2009], but this is one of many which prefers instrumental variable analysis to time series analysis [Becker et al., 2017; Franck and Iannaccone, 2014; Paldam and Gundlach, 2013; Ruiter and van Tubergen, 2009]. One study spans 167 countries, but only looks at behavioral change during the limited time span of Ramadan and focuses only on Muslims [Campante and Yanagizawa-Drott, 2013]. Therefore, our use of a truly global sample (109 countries drawn from the complete socioeconomic spectrum) is unique.

A second shortcoming in the literature is the narrow definition of religiosity. Religiosity is usually defined simply as 'church attendance' because this data is prevalent [Becker et al., 2017; Becker and Woessmann, 2013; Franck and Iannaccone, 2014; Glaeser and Sacerdote, 2008; Herzer and Strulik, 2017; Ruiter and van Tubergen, 2009]. Our Religiosity cultural factor (derived in chapter three) is a more holistic and multidimensional metric. In fact, our metric is similar to that used in [Paldam and Gundlach, 2013], but they also focused on instrumental variable analysis instead of time series analysis.

The economics literature on secularization has spawned a new theory called the 'supply-side hypothesis'. This is where the reduction of choice in the religious market place —possibly due an established state church or some other governmental intervention —results in the demand for religion not being met. It has been used to explain the unusually religious nature of the United States [Crabtree, 2010], but it does not generalize well to other countries [Norris and Inglehart, 2004]. Other studies have found that institutional innovations and socialization environments do affect secularization: such as government intervention in the educational system [Franck and Iannaccone, 2014] and the religious views of parents [Finke and Iannaccone, 1993]. These examples suggest possible causes for secularization that are not economic.

In chapter six, we show that many of our cultural values correlate with economic development. One of these, "Importance of Personal Prohibitions" is correlated with individualism [Ruck et al., 2018] and [Gorodnichenko and Roland, 2011] showed that individualism predicts long run economic growth, possibly due to its effect on innovation. This effect is robust to the inclusion of institutional variables and colonial history (both thought to be important for economic development [Acemoglu and Robinson, 2012]). Individualism is also associated with low corruption [Hofstede et al., 2010] and corruption is known to retard economic growth [Treisman, 2000].

The rise of individualism is also correlated with self-expression cultural values [Inglehart and Oyserman, 2004] —one the two dimensions of the Inglehart-Welzel cultural map. Self Expression has been strongly associated with modernization and human development [Inglehart and Welzel, 2005]. It is part of a recent pattern of cultural value change which also involves the emergence autonomy.

2.7 Human Development Sequence Revisited

A prominent model linking cultural values to the emergence of democracy and economic development is the 'Human Development Sequence' (HDS) [Inglehart and Welzel, 2005], which is posited as an updated version of modernization theory. It claims that the improved material circumstances provided by economic development led to the rise of 'self-expression' cultural values because having material security means people can take survival for granted. Self-expression cultural values are associated with a rise in individualism and autonomy, which creates a popular drive to institutionalize choice; i.e. have democratic institutions [Welzel et al., 2003]. However, there is controversy surrounding this causal explanation. Others have claimed that democratic institutions must emerge first, otherwise self-expression values cannot be adopted [Spaiser et al., 2014].

The HDS states that the rise of self-expression values is associated with the later stages of economic development, namely when the economy is transitioning from industrial to post-industrial. However, the initial stage of economic development, the transition from agrarian to industrial society, is also also associated with cultural value change: moving from traditional to secular-rational cultural values. In chapter seven we show that changes in secular values precede those in economic development, contrary to the standard model of the HDS which assumes the opposite [Inglehart and Welzel, 2005]. We should mention that our measure of Secularization is a narrow representation of the Human Development Sequence's secular-rational value dimension, as it is also composed of questions related to respect for authority and autonomy [Inglehart and Baker, 2000].

Using data from the WEVS, [Foa et al., 2016] showed that 'support for democracy' in western countries has suffered an inter-generational decline. In chapter four, we detected a synchronous global generational decline in institutional confidence and interest in politics. Taken together, this confluence of cultural factors might be conceptualized as a decline in support for national institutions. This finding is surprising because it runs contrary to democratic capital theory [Fuchs-Schündeln and Schündeln, 2015] which predicts that familiarity with democratic institutions strengthens support for them. Western countries, with the longest unbroken record of democratic experience, have actually seen the biggest decline.

Chapter 3

Nine Cultural Factors

In this chapter we used unsupervised methods to find a reduced set of cultural factors from the World Values Survey and European Values Survey data (WEVS). Having reviewed prominent efforts at using survey data to measure cultural values in the literature review, we see how our cultural factors analysis compares. We discuss the technical challenges associated with unsupervised learning of cultural value factors, such as missing data mitigation, matrix decomposition, factor interpretation and national aggregation. Our reduced set of cultural factors are the descriptive cultural value units we utilize in the remaining chapters, where we look at cultural value dynamics and their interaction with human development variables.

3.1 WEVS Data

We derive our cultural factors using the open-source World Value Survey (WVS) and European Values Survey (EVS) datasets. They quantify the cultural values of representative samples from over 100 countries located on every inhabited continent. The EVS was first posited in the late 1970's by Jan Kerkhofs and Ruud de Moor for capturing European opinion on politics, family, religion and society. Since then, four completed waves have covered 47 European countries — as well as the USA and Canada [EVS, 2011]. The WVS — headquartered in Stockholm, Sweden — was instigated by political scientist Ronald Inglehart and uses similar sampling and administrative techniques as the EVS. During its six waves since 1981, the WVS has gradually increased its global scope from just 12 countries (who were largely western), to almost 100 from the full socioeconomic and political spectrum. Such is the international character of the WVS, it is cited in thousands of scientific publications in 20 different languages [WVS, 2017].

To achieve this broad coverage, the WVS planners have taken a decentralized approach to data collection. A team of social scientists in each country are responsible for their own data collection, but must adhere to strict centrally planned rules. Samples must contain at least 1000 people to minimize sampling error [Norris and Inglehart, 2004]. Full probability sampling is recommended, but stratified sampling is permissible to ensure a demographically representative sample. Should the researchers choose a stratified sampling approach, they must use many demographic categories so as each nested category contains around 10 individuals. Face to face interviews must be used, this mitigates non-response bias and allows illiterate people to be surveyed; although phone interviews are permitted for remote locations [WVS, 2017].

The WVS is centrally translated into English, Spanish, Arabic and Russian. If none of these languages are spoken by 15% or more of the population, then the national surveyor is responsible for translation into the local languages. Should this additional translation be required, the process must involve two translators and a mediator to avoid the pitfalls of old techniques like 'back translation'. If the meaning of a particular question gets lost in translation, then it can be removed from the survey but no more than 12 questions can be omitted for any reason. Any violations of these guidelines must be reported to WVS association and they reserve the right to exclude the results from the country in question. [WVS, 2017].

Systematic behavioural validation for WEVS questions has not been carried out because the WEVS is seeking to measure cultural values rather than individual values or actual behavior Welzel and Inglehart [2016]. At the group level, it is possible that collective attitudes will not match behavior in obvious ways. For instance, politically engaged people actually vote less [Inglehart, 1977; Norris, 2011] and the most tolerant countries are among the least diverse [Alesina et al., 2003]. For these reasons, validation of the World Value Survey comes from clear linkages to group-level external variables such as economic development [Norris and Inglehart, 2004], democracy [Inglehart and Welzel, 2005] and civic attitudes [Norris, 2011]. In one exception, Deborah Kistler and her colleagues showed that Germans with higher emancipative and secular values exhibited greater prosociality in experimental games [Kistler et al., 2015].

In fact, using survey data to separate individual-level personality traits from group-level cultural values is not trivial. Firstly, if people from different cultures do not respond to a question using the same standard, then cross-cultural comparisons will be affected by the 'reference group effect', which necessitates objective behavioural measures [Heine et al., 2002]. The World Values Survey ensures standardized question interpretation through careful question design and translation [WVS, 2017], hence they detect stable cross-cultural differences [Inglehart and Baker, 2000; WVS, 2017] that are linked with external variables [Inglehart and Welzel, 2005; Norris, 2011; Norris and Inglehart, 2004]. Secondly, the responses of individuals to surveys will be necessarily filtered through the culture in which they are socialized [Inglehart and Welzel, 2005; Schwartz, 2006]. Therefore to detect the 'true' opinion of an individual, you must correct for what that person thinks other people think [Goffin and Christiansen, 2003; Prelec, 2004] — effectively correcting for culture.

Wave	Years	# countries	# participants	# questions
WVS-1	1981-1984	12	19378	320
EVS-1	1981-1984	16	10307	108
WVS-2	1990-1994	18	24588	342
EVS-2	1990-1994	29	38213	384
WVS-3	1995-1999	56	76075	363
EVS-3	1999-2001	33	41125	241
WVS-4	2000-2004	41	60045	337
WVS-5	2005-2009	58	83975	304
EVS-4	2008-2010	47	66281	311
WVS-6	2010-2014	60	85070	298

Table 3.1: Important summary attributes of the six WVS and four EVS waves completed since 1981

Period	Years	# Countries	# Participants
1	1990-1994	44	63551
2	1995-1999	66	116710
3	2000-2004	42	61748
4	2005-2009	81	148302
5	2010-2014	60	86272

Table 3.2: Important summary attributes when the WEVS participants are binned into five time periods since 1990 at five year intervals (data from the 1980s are excluded)

3.2 Time Resolution and Scope

There are six waves of the WVS and four of the EVS. Given they contain many of the same questions, we consider both surveys together as the composite WEVS (table 3.1: wave summary information). The frequency of the WVS and EVS is every five years, so we pool data using this time interval. Results from EVS waves 3 and 4 transcend the five year boundary meaning the country's sample is split, so the entire sample is placed in the five year period containing the majority of the sample. There is no data for the period 1985-1989, leaving us with data for 6 periods — 1980 to 1984, 1990 to 1994, 1995 to 1999, 2000 to 2004, 2005 to 2009 and 2010 to 2014.

We want to include as many time periods as possible to expand the temporal scope of our study, but by doing this we also reduce the total number of questions common to all time periods. We balance this trade-off using Figure 3.1 which shows that increasing the temporal range starting in 1990 only means a small reduction in the number of common questions. However,starting in 1981 means a sharp reduction in the number of common questions (67 to 48), with only a 6% increase in total sample size.

The final WEVS dataset we take forward covers the time periods from 1990 to 2014, has 67 questions and 476,583 respondents. Respondents are from 109 unique countries which on average participated in 2.69 of the five time periods (see table 3.2).

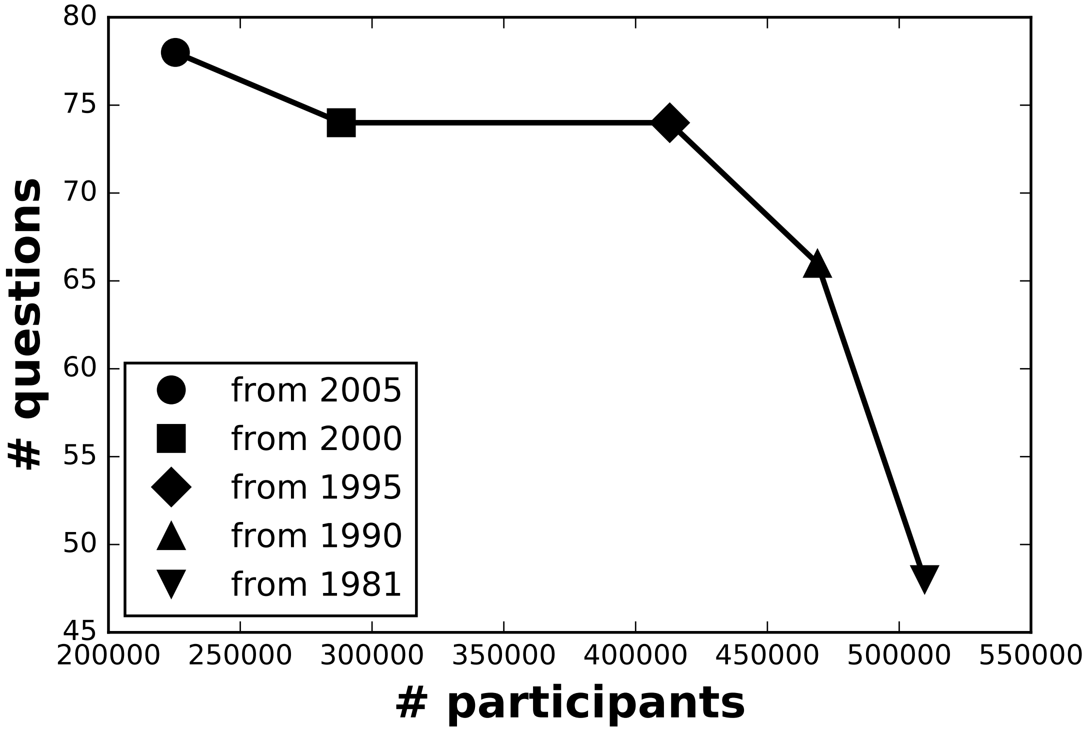


Figure 3.1: The decreasing number of common questions and increasing number of total participants from the addition of older waves of the WEVS into the total dataset.

3.3 Missing data mitigation

Dealing with missing data is an essential part of data analysis. It avoids biases and preserves precision. There are two fundamental approaches: omission and imputation. Omission involves removing entire observations which contain any missing values. Imputation replaces missing values with plausible real ones. Omission means information is lost and, if the data is not missing at random, can result in unexpected biases. Therefore, if possible, data should be imputed.

If the causes of missingness are known then choosing a missing data approach is easy. When missingness is genuinely random ('missing completely at random'), omission or basic imputation can be used without biasing the results. Unfortunately, missingness in the social sciences is rarely completely random. Often the best case scenario is 'missing at random' where, despite the structure of the missingness, the structure depends on observed factors. Hence missingness can be considered random if these dependent factors are controlled for. However, if missingness structure depends on unobserved factors — or even on itself — avoiding biases will require prior knowledge of the missingness mechanism.

There are clues regarding the missingness in the WEVS because we know how the data is collected — some questions may be untranslated for instance. However, as is often the case in social science, we do not know all the reasons for missing data, which makes testing for the structure of the missingness practically impossible. Though as mentioned before, if we know that the missingness is dependent on some known variables, then it can be treated as effectively random. Therefore the more variables we include, the greater the probability the missingness can be considered random [Gelman and Hill, 2007]. Another way of mitigating unknown missingness structure is through repeated imputation and sensitivity analysis. This proceeds by first acknowledging that the correct model is not knowable. Then, by creating many imputed datasets using a range of techniques, if the analysis of all these imputed datasets give the same result, we can conclude the missingness structure is not important.

We create three data sets using complete case analysis (CC), stochastic mode imputation (MI) and hot decking (HD). CC involves the omission of all individuals that did not respond to all 67 WEVS questions. This leaves us with 109,072 complete cases, this is 23% of the original participants. The other two are imputation techniques.

Our first approach is similar to 'stochastic mean imputation' which replaces the missing values within a single variable with random draws from a distribution defined using the observed sample. However, WEVS responses are on discrete scales, so we use 'stochastic modal imputation'. This means we impute based on the frequency of responses in the observed sample. Finally, by using stochastic imputation and not a deterministic regime, we preserve the observed variance. Though one shortcoming is that, because imputation is done marginally, the covariance between variables is depressed [Gelman and Hill, 2007].

The size of the WEVS is sufficiently large so that computationally expensive imputation techniques such as K-nearest-neighbor (KNN) are not practical. However, our second imputation method, 'hot decking' (HD), is similar and computationally cheaper. In KNN, all pairwise distances between observations must be calculated. HD forgos this expensive process by categorizing observations into domains based on similarity. It then imputes participants missing value using the observed value of a randomly selected participant from the same domain [Kowarik and Templ, 2016]. An advantage of HD compared to CC is that it takes into account covariance between variables. HD is implemented using the VIM package in R [Templ et al., 2017].

The three datasets produced by complete case analysis (CC), stochastic mode imputation (MI) and hot decking (HD) are taken forward to the subsequent stages of analysis. The same cultural factors emerge in all cases, so we conclude a lack of sensitivity to our choice of data imputation technique.

3.4 Finding the Cultural Factors

We have 67 WEVS questions representing a cultural value space, but we assume that these survey responses can be expressed in fewer dimensions. Here we introduce two ways of reducing the dimensionality of the WEVS data from different philosophical perspectives. Principal Component

Analysis (PCA) finds the reduced set of orthogonal axes which best explain the variance in the data and Exploratory Factor Analysis (EFA) assumes the survey responses are an emergent property of some smaller number of underlying factors.

3.4.1 Principal Component Analysis (PCA)

PCA maps the high dimensional data onto a new and reduced set of orthogonal components which more efficiently explain the variance. The first component (PC1) is the direction which explains the largest proportion of the variance. The second component (PC2) is the direction, orthogonal to PC1, which explains most of the remaining variance. Then each subsequent component (PCn) explains the largest proportion of the remaining variance, whilst being orthogonal to all previous components. We end up with a series of D components (D being the dimensionality of the original data) which explain a decreasing proportion of the total variance [Templ et al., 2017].

PCA uses Eigenvalue decomposition to express the high dimensional WEVS data as a smaller set of orthogonal Eigenvectors called components. The Eigenvalues represent the variance explained by each component and by scaling the Eigenvectors using the square root of its Eigenvalue, we calculate the component loadings. These loadings are the correlation coefficients of the original survey questions with the respective components [Templ et al., 2017].

3.4.2 Exploratory Factor Analysis (EFA)

EFA, unlike PCA, is a model based approach. EFA considers survey responses X_d as a weighted linear recombination of M underlying cultural values which are estimated (equation 3.1).

$$X_d = \sum_{m=1}^{M} \alpha_{d,m} F_m + \sigma_d \tag{3.1}$$

where, F_m are the underlying factors, $\alpha_{d,m}$ are the weights and σ_d are the errors [Fabrigar et al., 1999]. Maximum likelihood estimates are found using the ‘psych’ package in R [Revelle, 2016].

The WEVS questions are all on Likert scales and a histogram for each can be found in the Appendix for this chapter. From inspection, the majority of the questions have distributions close to normal. However, there are a few that have skewed distributions such as "Is family important in your life?" However, EFA is a linear model and, therefore, is robust to non-normality due to the large size of our sample [Ali and Sharma, 1996]. Another reason why EFA might be inappropriate, is that the Likert scales have different lengths. We mitigate this by normalising the response variance of each question to equal one. A similar methodology was used in another factor analyses of WEVS data [Inglehart and Baker, 2000].

3.4.3 EFA vs PCA

In practice, EFA and PCA are similar in that they attempt to approximate the correlation matrix of the data with rank D using a reduced one with rank M (where $M << D$):

$$R = GG' + U^2 \tag{3.2}$$

where R is the correlation matrix of D dimensional WEVS data, G is the M dimensional factor/component loading matrix and U^2 is the error matrix. The key technical difference is that PCA accounts for all the variance in the survey questions, whereas EFA accounts for only the common variance. The EFA solution will be similar to the PCA solution in cases where the variables are numerous or highly correlated because this will increase the common variance [Templ et al., 2017]. We estimated the average common variance using multiple correlation and found it to be 23%. Hence we do not expect PCA and EFA solutions to converge.

Philosophically, EFA offers a view of survey responses being an emergent property of some underlying hidden constructs. This assumption is in keeping with the view that the WEVS questions are the observable manifestation of a discrete set of cultural values. Therefore, we proceed with EFA, rather than PCA.

However, there is one potential pitfall. The discrete and bounded Likert scales in the WEVS violate EFA's normality assumption. This means Pearson correlations are an unnatural measure of question similarity and polychoric correlations are recommended instead [Baglin, 2014]. Furthermore, the length of Likert scales vary in the WEVS, but EFA requires all response vectors to have the same variance [Timmerman and Lorenzo-Seva, 2011]. We mitigate the second problem by normalizing all response vectors so variance equals one and mean equals zero. Although simulation studies show that polychoric correlations do perform better than Pearson correlations with low sample sizes [Holgado-Tello et al., 2010], this gap closes as sample sizes increase [de Winter et al., 2009; Muthén and Kaplan, 1985], hence standard EFA is appropriate for use on our sample of 476,583 respondents.

3.4.4 Interpretation of Factors

We view the latent constructs derived using EFA as discrete 'cultural values' which we call 'cultural factors'. However, we need a way of interpreting and labelling them. As we have already touched on, the factor loadings are the correlation coefficients between the known survey questions and the cultural factors: the larger the absolute factor loading, the closer the survey question and cultural factor are related. This offers a way of interpreting the cultural factors in light of known survey questions. Mathematically speaking, we want the factor loading matrix to have a 'simple structure'. This means that each cultural factor will be highly correlated with a small number of unique survey questions.

3.4.5 Number of Retained Factors

EFA requires that we specify the number of factors it estimates, which means we need some criteria for choosing. Here we review the two most common factor retention criteria and explain why we decided to use an alternative.

Henry Kaiser's (K1) method is perhaps the most common. This is where we retain all factors with associated Eigenvalues greater than one. This threshold is significant because it represents the average amount of variance explained by an original WEVS question [Ledesma and Valero-Mora, 2007]. The second common method is Raymond Cattel's 'Scree Test' (ST). This is a graphical method where the variance explained by successive factors is plotted and an elbow is identified. This elbow represents a point after which factors do not explain significantly more variance [Ledesma and Valero-Mora, 2007]. For the WEVS data, figure 3.2 shows that K1 suggests retaining 17 factors and ST suggests retaining around 7.

However, we used neither of these approaches. The cutoff suggested by K1 is criticized for being rigid and arbitrary and simulation studies have shown that it severely overestimates the correct number of factors to retain [Ledesma and Valero-Mora, 2007]. The number of factors ST recommends is considered inherently subjective and imprecise. We see in figure 3.2 that K1 suggests nearly two times as many factors as the other methods. Finally, both K1 and ST are variance based approaches, which makes them more appropriate for use with PCA, which is also variance driven. Given that EFA assumes the WEVS data is the observed manifestation of some latent set of cultural values, we want to retain only the factors that can be interpreted in terms of the WEVS questions.

As mentioned previously, a simple structured factor loading matrix is critical for interpreting factors. This is why we used 'Very Simple Structure' (VSS), a method that retains the number of factors leading to the most simple factor loading matrix. It does this by approximating the full factor loading correlation matrix (Σ) with a version of reduced complexity (SS^T):

$$\Sigma = SS^T + \Sigma_{res}$$

where complexity c is the number of highly correlated WEVS questions used to represent each factor in the factor loading matrix S. We then retain the number of factors which minimizes the residual matrix Σ_{res} [Revelle and Rocklin, 1979], thus maximizing VSS.

$$VSS = 1 - \frac{\Sigma_{res}}{\Sigma}$$

VSS is maximized for nine factors, whether we set $c = 1$ or $c = 2$ (see figure 3.2). The nine factors retained by VSS is lower than that suggested by K1 and higher than that suggested by ST. As we will see in subsequent chapters, these nine cultural factors also correlate with external variables of human development, which suggests they are valid cultural value units. VSS is implemented using the 'psych' package in R [Revelle, 2016]

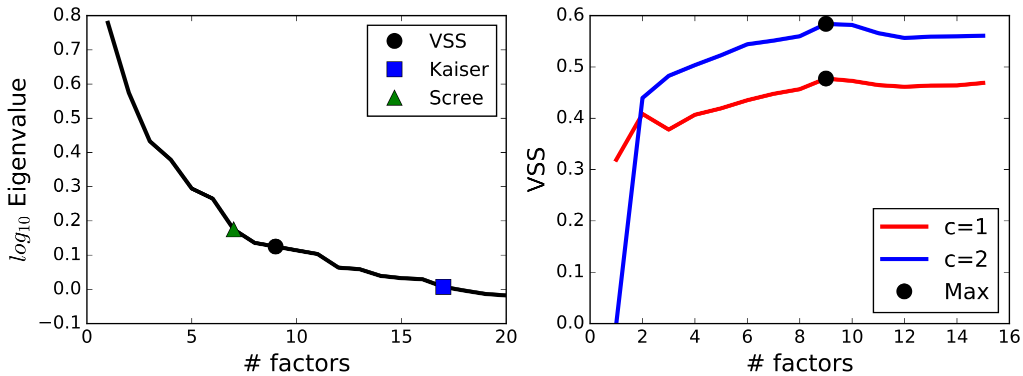


Figure 3.2: Left hand side: the Eigenvalues of successive factors from EFA, with the proposed number of factors to retain as suggested by the Scree test (green triangle), Kaisers K1 (blue square) and VSS (black circle). The Eigenvalues are expressed on a log_{10} scale for clarity. Right hand side: VSS score for factor retention showing, for complexity 1 and complexity 2, that nine is the number of factors which maximizes VSS (black circle)

3.4.6 Interpreting the Nine Factors

Our nine cultural factors were retained based on their interpretability in light of the WEVS questions. Recall this is done by maximising the simple structure of the factor loading matrix, which ensures each factor is highly correlated with a small set of unique WEVS questions. The left hand side of figure 3.3 confirms the presence of simple structure for each factor. The right hand side of figure 3.3 shows the majority of absolute loadings are less than 0.3 with a minority above 0.4, but none in between. Therefore, we define the threshold as 0.4, above which a factor loading is considered substantively significant and below which it can be ignored. This means each factor has between two and nine contributing survey questions which we use to assign a subjective interpretation. Given the assigned labels are inherently subjective, it is necessary to present a justification for our choices.

The interpretations of factors one, two, five, six and seven are self-evident and do not require justification — the labels are Religiosity, Institutional Confidence, Interest in Politics, Wellbeing and Political Engagement respectively. The questions correlated with factor four reflect whether cheating in society is justified when unobserved by others. As this type of cheating incurs no direct cost to the cheater we label it Prosociality, or in other words the tendency not to free ride [Chudek and Henrich, 2011]. Factor eight reflects the justifiability of a number of individual behaviors which are sometimes morally prohibited — homosexuality, divorce, abortion, prostitution, suicide and euthanasia. We have called factor eight Importance of Personal Prohibitions.

Factors three and nine concern the willingness to have a neighbor with a given stigmatized characteristic. The correlates of factor nine reflect openness to out-groups (other races and immigrants), so it is straightforwardly defined as Xenophilia. Factor three's substantive loadings combine stigmas from seemingly unrelated domains — homosexuals, drug addicts, heavy drinkers

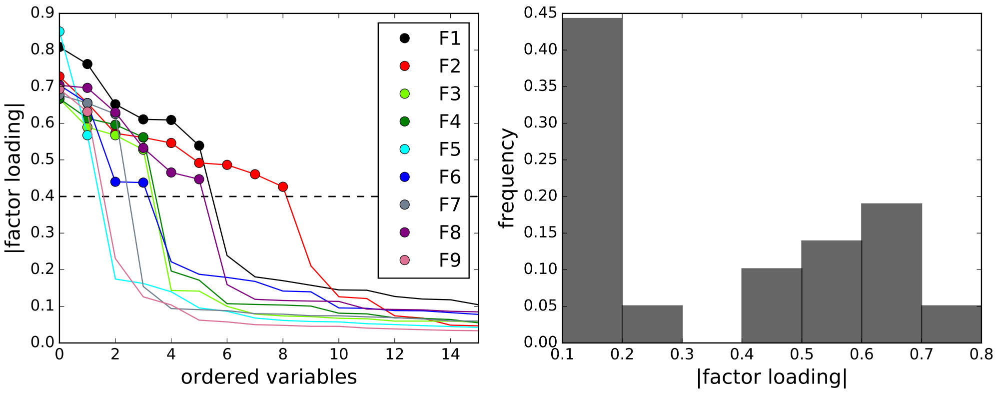


Figure 3.3: Left hand side: the absolute factor loadings of each factor ordered by magnitude, showing the cut-off of 0.4 above which the WEVS items associated with the loadings are used for interpretation. Right hand side: a normalized histogram of all pooled absolute factor loadings above 0.1, emphasizing the absence of mass between 0.3 and 0.4.

and people diagnosed with AIDS. The stigmas associated with Xenophilia relate to *extrinsic* attributes like color of skin or accent, whereas the ones correlated with factor three are *intrinsic* properties perceived to be the result of individual choice — in spite of evidence that homosexuality is not entirely culturally determined [Hamer et al., 1993]. We, therefore, call factor three Intrinsic Tolerance.

The substantive factor loadings for each factor can be found in their respective tables 3.3-3.11.

Factor Label (Abv.)	**F1—Religiosity (REL)**	**|corr.|**
Fac. Load.	Important in life: Religion	0.8
	How important is God in your life	0.76
	Religious person	0.65
	How often do you attend religious services	0.61
	Confidence: Churches	0.61
	Important child qualities: religious faith	0.54

Table 3.3: Factor 1 is interpreted as Religiosity using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	**F2—Institutional Confidence (IC)**	**|corr.|**
Fac. Load.	Confidence: Parliament	0.73
	Confidence: The Civil Services	0.66
	Confidence: The Government	0.57
	Confidence: The Police	0.56
	Confidence: The Political Parties	0.55
	Confidence: Labour Unions	0.49
	Confidence: The Press	0.49
	Confidence: Major Companies	0.46
	Confidence: Armed Forces	0.43

Table 3.4: Factor 2 is interpreted as Institutional Confidence using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	**F3 —Intrinsic Tolerance (IT)**	**|corr.|**
Fac. Load.	Neighbours: Drug addicts	0.67
	Neighbours: Homosexuals	0.59
	Neighbours: Heavy drinkers	0.57
	Neighbours: People who have AIDS	0.53

Table 3.5: Factor 3 is interpreted as Intrinsic Tolerance using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	**F4—Prosociality (PRO)**	**|corr.|**
Fac. Load.	Justifiable: cheating on taxes	0.67
	Justifiable: someone accepting a bribe	0.61
	Justifiable: avoiding a fare on public transport	0.6
	Justifiable: claiming government benefits	0.56

Table 3.6: Factor 4 is interpreted as Prosociality using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	**F5—Interest in Politics (IP)**	**|corr.|**
Fac. Load.	Important in life: Politics	0.85
	Interest in politics	0.57

Table 3.7: Factor 5 is interpreted as Interest in Politics using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	F6—Wellbeing (WB)	|corr.|
Fac. Load.	Satisfaction with your life	
	Feeling of happiness	
	How much freedom of choice and control	
	State of health (subjective)	

Table 3.8: Factor 6 is interpreted as Wellbeing using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	F7—Political Engagement (PE)	|corr.|
Fac. Load.	Political action: joining in boycotts	0.68
	Political action: attending lawful	0.66 demonstrations
	Political action: signing a petition	0.63

Table 3.9: Factor 7 is interpreted as Political Engagement using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	F8—Importance of Personal Prohibitions (PP)	|corr.|
Fac. Load.	Justifiable: divorce	0.7
	Justifiable: abortion	0.7
	Justifiable: homosexuality	0.63
	Justifiable: prostitution	0.53
	Justifiable: suicide	0.46
	Justifiable: euthanasia	0.45

Table 3.10: Factor 8 is interpreted as Importance of Personal Prohibitions using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

Factor Label (Abv.)	F9—Xenophilia (XEN)	|corr.|
Fac. Load.	Neighbours: People of a different race	0.69
	Neighbours: Immigrants/foreign workers	0.63

Table 3.11: Factor 9 is interpreted as Xenophilia using the listed substantive factor loadings (substantive loadings are all the WEVS questions that have absolute values greater than 0.4)

3.5 Individual vs Country Level

One of the ambitions of this thesis is to examine cultural value dynamics and to do this cultural values must be compared across time periods. The WEVS is not a longitudinal study in which the same individuals are surveyed through time, but takes representative cross-sectional samples within each participating country. Therefore, in order to quantify cultural value dynamics we need to make use of these country-level repeated measures. It is prudent, therefore, to consider the consequences of moving the analysis from the individual to the country level.

Although cultural values are manifest in human brains, they are really a group level phenomenon and must be considered separately to individual values (or personality traits). The *average* cultural value within a population seems to have a strong cultural component that is linked to historic factors and economic development [Inglehart and Welzel, 2005]. Whereas the variation within the population — which might be labelled individual level values — is determined by personality [Schwartz, 2006; Tuschman, 2013].

3.6 Comparisons with External Data

Our cultural factors established a nine dimensional cultural value space. It is more detailed than the Inglehart-Welzel (I-W) map with two, the Schwartz map with three and the Hofstede map with six. We have already noted some similarities among the other three cultural value maps [Schwartz, 2006]. For example, Schwartz and Hofstede's Individualism vs Collectivism dimensions are equivalent to the I-W's Survival-Self-Expression dimension [Inglehart and Oyserman, 2004].

Our nine cultural factors have more in common with the dimensions of the I-W map because both are derived from the WEVS dataset. However, some key differences exist. The I-W dimensions — traditional vs secular/rational (T-SR) and survival vs self-expression (S-SE) — are defined using Confirmatory Factor Analysis (CFA). This is a supervised method used to evaluate a pre-proposed factor-variable structure. Their analysis also only included ten WEVS questions that the authors considered important [Inglehart and Baker, 2000]. We, on the other hand, included as many WEVS questions as possible and used the unsupervised factor analysis EFA. Another critical difference is that the I-W map is a parsimonious description with orthogonal axes, whereas we relaxed this constraint favoring as many interpretable factors as possible.

We assessed the relationship between the two I-W dimensions and our nine cultural factors using linear regression (see table 3.12). Our nine factors give a more fine-grained view of cultural values, so it is unsurprising the regression results show the I-W dimensions only partially explain each of the factors. Furthermore, some of our cultural factors represent variation not covered by the I-W dimensions. The I-W dimensions explain less than 10% of the variance in Institutional Confidence (IC), Prosociality (PRO) and Interest in Politics (IP).

The Human Development Sequence (HDS) is the development model which includes the cultural value dimensions of the I-W map. It proposes that cultural values move from Traditional to Secular-Rational during industrialization. From the perspective of our nine cultural factors, this means a decrease in both Religiosity and the Importance of Personal Prohibitions. Also, all else being equal, Traditional societies tend to have higher Wellbeing; something noted by others [Easterlin et al., 2010]. The second phase of HDS involves the move from Survival values to Self-Expression during the post-industrial period. In our factors, we would see increases in

	T-SR	S-SE	R^2
REL	-0.84 (0.04)*	-0.21 (0.04)*	0.87
IC	-0.21 (0.11)	0.06 (0.11)	0.02
IT	-0.05 (0.07)	0.77 (0.07)*	0.55
PRO	-0.22 (0.11)	0.25 (0.11)	0.06
IP	-0.17 (0.11)	0.13 (0.11)	0.01
WB	-0.47 (0.06)*	0.90 (0.06)*	0.75
PE	0.37 (0.06)*	0.64 (0.06)*	0.69
PP	-0.54 (0.04)*	-0.62 (0.04)*	0.89
XEN	0.10 (0.08)	0.63 (0.08)*	0.44

Table 3.12: Linear regression results illustrating the predictive power of the two I-W dimensions ($T-SR$ = Traditional vs Secular-rational and $S-SE$ = Survival vs Self-expression) on each of our cultural factors. Each entry has the following format: coefficient (standard error), * if $p < 0.003$ (5% Bonferroni corrected statistical significance level)

Wellbeing, Political Engagement, Intrinsic Tolerance, Xenophilia and a further decrease in the Importance of Personal Prohibitions.

3.7 Conclusion

We have established nine cultural factors which explain the entire WEVS dataset. They represent a more fine grained description of cultural values compared to the more famous I-W map, whilst also capturing additional variance. Our analysis was independent of the missing data mitigation method because the same nine cultural factors were recovered regardless of whether hot-deck, complete case or mode imputation were employed to impute data. We chose Exploratory Factor Analysis to factor the WEVS data because there was good reason to see the survey responses as an emergent property of a hidden set of cultural values; whereas Principal Component Analysis simply aims to efficiently explain the total variance. Our EFA regime aims at factor interpretability by maximizing the ‘simple structure’ of the factor loading matrix. Using the small unique sets of correlated WEVS questions, we are able to interpret our nine factors as Religiosity, Institutional Confidence, Intrinsic Tolerance, Prosociality, Interest in Politics, Wellbeing, Political Engagement, Importance of Personal Prohibitions and Xenophilia.

This is the first cultural value space derived from the combined WEVS dataset using unsupervised methods. It is a more fine-grained representation than the prominent I-W map and, by analyzing the complete data set, we capture previously unexplained variance in the form of three cultural factors — Prosociality, Institutional Confidence and Interest in Politics.

The nine cultural factors derived in in this chapter represent the conceptual space in which we study cultural value dynamics and their interaction with human development variables. In chapter four we look at how the nine cultural factors exhibit a diversity of dynamics and chapter five uses the nine cultural factors as a basis for forming four cultural value clusters of nations.

In chapter seven we focus on Secularization and the Importance of Personal Prohibitions in the context of economic development and chapter eight summarizes the nine cultural factors as three orthogonal cultural components that explore the role of cultural values in human development more generally.

CHAPTER 4

Cultural Value Change

The WEVS consists of country-level cross-sectional samples collected since 1990. For 85 of the countries, we have repeated measures which means we can quantify their cultural value dynamics. In this chapter, we quantify rates of change within the nine cultural factors derived in the previous chapter. We then separate out two modes of cultural value change: generational and opinion. Generational cultural value change is due to stable differences between successive birth cohorts, whereas opinion change affects all birth cohorts equally during a given time period.

We also characterize the two modes of cultural value change. We do this using their rates of change, short term variability and global average trends. The presence of structure in these cultural trajectories provides convincing evidence that the measured temporal variation is non-random. Then, using regressions, we investigate the extent to which generational and opinion change explain: first the recent cross sectional trends since 1990 and second, modern day cultural value inequalities.

The WEVS has been released in five waves since 1990 which gives us, at most, a five point time series for each country. Given the small number of data and relatively short time frame (25 years), it is possible the variation will be dominated by measurement error (discussed in more detail later). That said, we have time series for 85 countries, so can pool data can detect general trends and reduce the influence of random measurement error.

4.0.1 Measurement and Sampling Error

Measurement error is when the recorded value of a survey response differs from the true value. Often, work employing the WEVS data assumes that measurement error is random, or in other words, uncorrelated with the true values [Inglehart and Baker, 2000; Inglehart and Welzel, 2005].

Measurement error causes hidden data distortions when errors are not independent and occur if survey items are processed differently by different participants, making them incomparable [Bound et al., 2001].

The rigorous survey design requirements of the WEVS helps to elevate these concerns. The modern translation techniques and use of local surveyors help to ensure the questions are understood uniformly across cultures [WVS, 2017]. Measurement error that is close to random means we can average across many individuals or survey questions (something Exploratory Factor Analysis effectively does; see chapter three), this makes us confident our measure converges to the true value.

To separate generational change from opinion change, we need to further subdivide the data by birth cohort. Fortunately, the WEVS uses full probability sampling or, at worst, stratified sampling. This means that, even at the level of the birth cohort, the sample will be demographically representative. That said, we will get different sample sizes based on the frequency of any given birth cohort and, therefore, different standard errors ($S.E = \sigma/\sqrt{N}$, where $S.E$ is standard error, σ is the population standard deviation and N is the sample size). We only consider sample sizes greater than 100 to make sure the standard error is valid — according to the central limit theorem. This cutoff also means the standard error remains less than 10% of the population standard deviation σ.

4.1 Results

Utilizing the representative cross-sectional samples provided by the WEVS, we use repeated measures at the country level to measure the rate of change in each of our nine cultural factors; whilst mitigating for missing time series values caused by the sporadic participation of countries in waves of the WEVS. Then we separate opinion O and generational G change from the cross-sectional t series. We do this by subdividing the data into birth cohorts, which also requires mitigating missing data caused by under-measured birth cohorts. We show that generational trends and opinion change are not systematically dependent, meaning we can consider these two modes of change separately.

We present evidence demonstrating the cultural values dynamics we have detected are non-random, therefore are not due to random measurement error. We analyze absolute displacement to show that opinion change is highly variable and subject to rapid short term fluctuations; but that generational change is gradual and steady. We finally show, using regressions, that volatile opinion change best explains the recent cultural value change measured using WEVS cross-sectional samples since 1990. And that contemporary global patterns of cultural value change are best explained by long-run generational change.

4.1.1 Two Stage Hierarchical Bayesian Model

We use a two step process to estimate each country's trajectory in the nine cultural factors. We can only consider the 85 countries which have participated in two or more WEVS waves (21 countries participated in two waves, 40 in three waves, 13 in four waves and 10 in five waves). The first stage is a Bayesian hierarchical model that imputes the missing values in the time series. The hierarchical structure means data from all countries are pooled so that slope estimates are regularized [McElreath, 2015]. Formally, the first stage is as follows:

(4.1)

$$\begin{aligned} X_{c,t} &\sim Normal(\alpha_c, \psi_c) \qquad \psi_c > 0 \\ \alpha_c &\sim Normal(\alpha^G, \phi) \qquad \phi > 0 \\ \psi_c &\sim Nornal(\psi^G, \chi) \qquad \chi > 0 \end{aligned}$$

$$\begin{aligned} X_{c,t} &= X_{c,t}^{pres} \cup X_{c,t}^{miss} \\ X_{c,t}^{pres} &\sim Normal(\bar{X}_{c,t}, SE_{c,t}) \end{aligned}$$

Model 4.1 applies to each of the nine cultural factors. The time series for each country $X_{t,c}$ is drawn from a normal distribution with mean α_c and variance ψ_c. Both α_c and ψ_c are drawn from global normal distributions with hyper parameters α^G and ϕ then ψ^G and χ respectively. The time series are constructed of both observed values $X_{c,t}^{pres}$ and missing values $X_{c,t}^{miss}$. Each observed value $X_{c,t}^{pres}$ is drawn from a normal distribution with a mean that is the sample average for the country c at time t $\bar{X}_{c,t}$ and a variance that is the standard error for that sample $SE_{c,t}$.

The second stage is the linear regression, from which we take the slope β_c as our measure of change. The first stage ensures realistically imputed missing values so large short term fluctuations will not lead to abnormally large estimates for β_c. The linear regression used to estimate β_c is as follows:

(4.2)
$$X_{c,t} \sim N(\beta_c t + \mu_c, \sigma_c) \qquad \sigma_c > 0$$

where β_c is the trajectory of the given country, μ_c is the intercept and σ_c is the error.

4.1.2 Inferring Bayesian Models

For a Bayesian model to be analytically solvable it must have a conjugate prior, which means that it must be from the same exponential family as the likelihood. This is rare, so generally speaking, Bayesian models are instead numerically inferred. Our model is inferred using STAN

[Carpenter et al., 2017] which uses Markov Chain Monte Carlo (MCMC) to sample complex probability distributions.

Most MCMC engines from the past — such as JAGS and BUGS — use Gibbs sampling [Carpenter et al., 2017]. STAN, on other hand, uses an adaptive Hamiltonian MCMC method called 'No-U-turn sampling' (NUTS). Hamiltonian sampling eliminates the need for inefficient random walk exploration used in Gibbs sampling, which means it converges on a numerical solution in fewer samples. That said, Hamiltonian MCMC has internal parameters and its sampling performance is sensitive to their settings; total number of steps L in particular. However by adapting it with the NUTS sampling method, these tricky choices are circumvented under most circumstances [Hoffman and Gelman, 2014]. The major shortcoming of Hamiltonian MCMC is that, because it uses physical concepts like momentum to choose candidate samples, it requires a continuous space so cannot easily handle discrete variables. Fortunately our model does not contain discrete variables and so we are unaffected by this issue.

4.1.3 Cross-Sectional Trends in Nine Cultural Factors

As we have described, we have defined the slope of the above Bayesian linear regression as the change each country has experienced within each of the nine cultural factors since 1990. We take the mean across all countries to give us the global average change in each of the nine cultural factors. The direction of change is ambiguous in all but three of the nine cultural factors. With 95% percent certainty, we can be sure global average Wellbeing (WB) is increasing, Political Engagement (PE) is decreasing and the Importance of Personal Prohibitions (PP) is decreasing. Although, even within these three there are many countries showing the opposite trend.

4.1.4 Subdivide Cross-Sectional Samples by Birth Cohort

As well as the cross-sectional sample trends presented above, we also want to analyze the separate effects of opinion and generational change. To do this we split each of the cross-sectional samples (in each time period) by birth cohort. For reasons already given, we only retain period-cohort samples greater than 100. To help ensure as many samples as possible are greater than 100, we pool birth cohorts by decade (1990's, 1910's, 1920's etc). Table 4.1 is an example of a period-cohort breakdown. Generational change G is obtained by treating successive generations g as the temporal variable and averaging over time periods p. Opinion change O is the trend through time periods p (similar to cross-sectional change t), but the samples are normalized by generation g.

4.1.4.1 Separability of Generational Trends and Period Effects

To discuss separate generational G and opinion O change, we need to check that they do not depend on each other in any systematic way. Previous work suggests that generational trends in cultural values are preserved through time and that these trends only translate due to causes

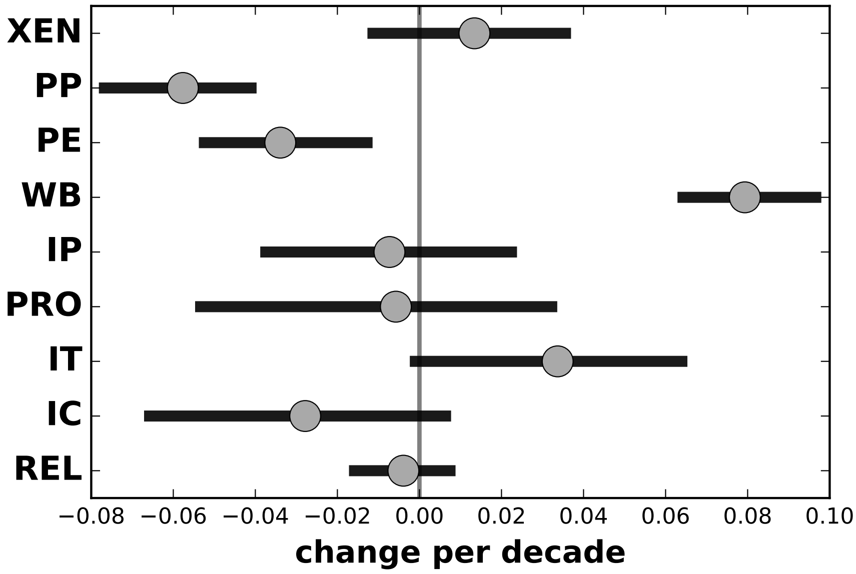


Figure 4.1: Global average change in the WEVS cross-sectional samples since 1990, in each each of the nine factors (where R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia). Circles are the mean value over all countries and bars are the errors defined as the 95 percent interval from a bootstrap sample of means.

g|p	**1990-1995**	**1995-2000**	**2000-2005**	**2005-2010**	**2010-2015**
1900					
1910	0.46 (0.063)	0.63 (0.056)			
1920	0.51 (0.04)	0.6 (0.04)			
1930	0.39 (0.049)	0.49 (0.039)		0.45 (0.07)	0.37 (0.069)
1940	0.33 (0.045)	0.43 (0.038)		0.27 (0.06)	0.2 (0.046)
1950	0.21 (0.04)	0.37 (0.031)		0.13 (0.05)	0.1 (0.042)
1960	0.21 (0.044)	0.4 (0.032)		0.11 (0.06)	-0.07 (0.047)
1970		0.14 (0.045)		0.12 (0.061)	0.02 (0.054)
1980				0.02 (0.077)	-0.18 (0.055)
1990					-0.19 (0.086)

Table 4.1: The generation-period breakdown of Religiosity (REL) for the USA. The rows are generations and the columns are time periods. Each entry is the sample mean with the standard error in brackets. A missing time period occurs due to non-participation in a WEVS wave. A missing generation occurs when it is underrepresented during a given time period (a sample of less than 100).

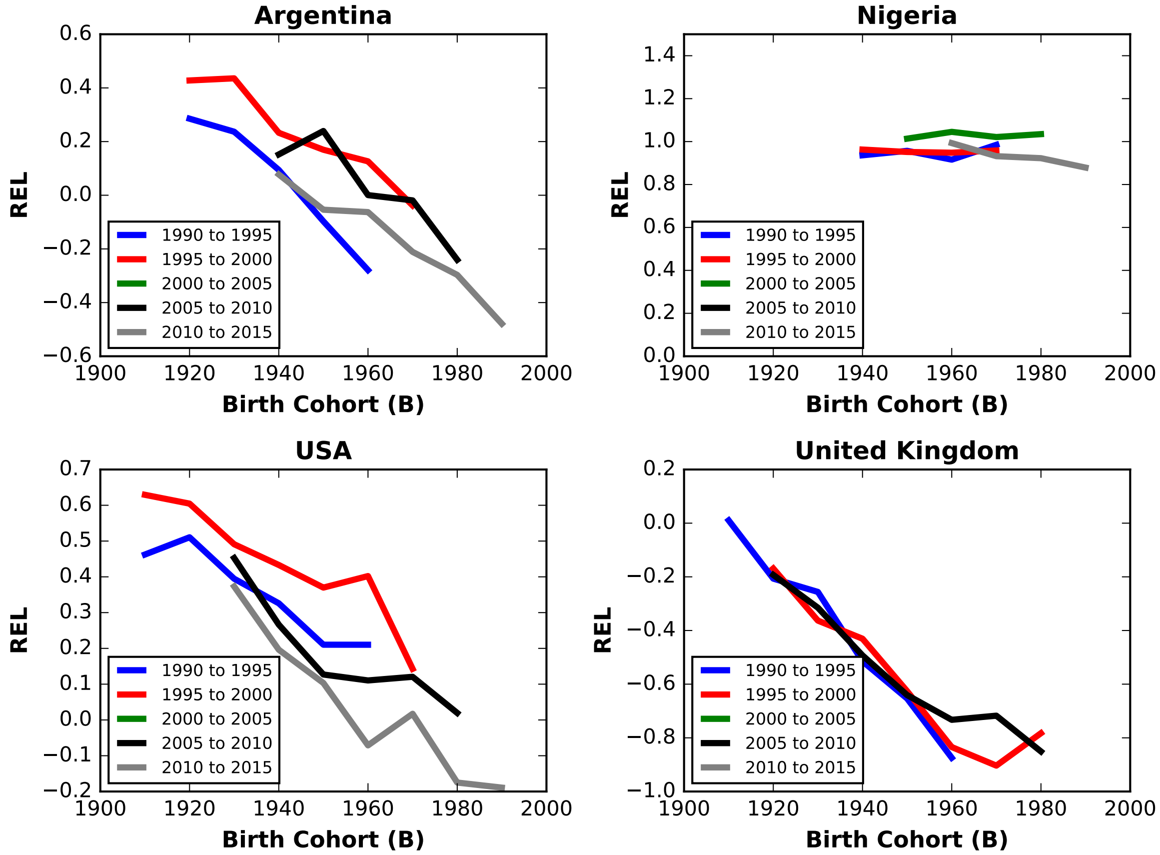


Figure 4.2: Example generational trends in Religiosity (REL) measured in different time periods. The four countries are Argentina, Nigeria, USA and United Kingdom.

acting on the entire population [Inglehart, 2008]; this is our definition of opinion change. This view also appears to be true regarding Religiosity (see Figure 4.2).

To test if the separability of generational and opinion change is generally true, we use linear regression. Specifically, we measure the additional explanatory power of including an interaction term between generation and time-period $p \cdot g$. We compare the following two equations:

$$X_{g,p} = \gamma_0 + \gamma_1 p + \gamma_2 g + \gamma_3 p \cdot g + \epsilon \tag{4.3}$$

$$Y_{g,p} = \delta_0 + \delta_1 p + \delta_2 g + \zeta \tag{4.4}$$

where, g = generation, p = time period, ϵ and ζ = random error. If there is no dependence between generation and opinion change then $\gamma 3 \approx 0$ and equation 4.3 will have equal explanatory power when compared to equation 4.4.

In practice adding more parameters to a regression will always give greater explanatory power (something called 'overfitting'). Therefore, the explanatory power of any model must be offset against its number of parameters and so we assess each model using the Akaike Information Criterion (AIC):

$$AIC = -2log(L) + 2k$$

where L is the maximum likelihood solution for the model and k is the number of parameters. We calculate the AIC for 4.3 and 4.4, we then subtract the former from the later to give an indicator of the additional explanatory power offered by the interaction term $p \cdot g$:

$$\Delta AIC = AIC(X_{g,p}) - AIC(Y_{g,p})$$

This means that ΔAIC is the additional information gained by assuming there is a systematic dependency between generation and opinion change. Also, because it is only an indicator, there is no absolute way of deciding if the interaction term is important, however there is a convention we can use as a rule-of-thumb. If ΔAIC is less than zero we conclude the interaction term is totally insignificant because $Y_{g,p}$ provides more information. A ΔAIC between 0 and 2 provides very weak evidence that $p \cdot g$ is important. A ΔAIC between 2 and 10 gives increasing support for $p \cdot g$. A ΔAIC greater than 10 means there is a strong interaction between generation and opinion [Burnham and Anderson, 2004].

We calculate a ΔAIC for each country and we generally see very little support for $p \cdot g$ in all nine cultural factors (see figure 4.3). The vast majority of countries show no, or very weak, evidence for an interaction between opinion and generation ($\Delta AIC < 2$), while nearly all provide no strong evidence for an interaction term ($\Delta AIC > 10$). Therefore, we can consider generation and opinion trends independently.

4.1.4.2 Missing Data Mitigation

We saw in chapter three that very few countries participated in all five WEVS waves, which presents itself as missing time-periods p. Furthermore, when we breakdown these samples by generation g, we see missing generations at particular time periods. This is because certain generations will be too old or young to compose a significant proportion of the population at that time.

Our measure of generational change averages birth cohorts over all time periods. Figure 4.2 illustrates that opinion changes can be large (see the translation of the trends between time periods), so we need to meaningfully impute missing generations to avoid biasing the time period average. Tables 4.2 illustrate the location of missing values and the ones which need to be imputed.

The early signs in our study (see figure 4.2) and previous work [Inglehart, 2008] suggest that generational change will be more steady than opinion change. We take advantage of this

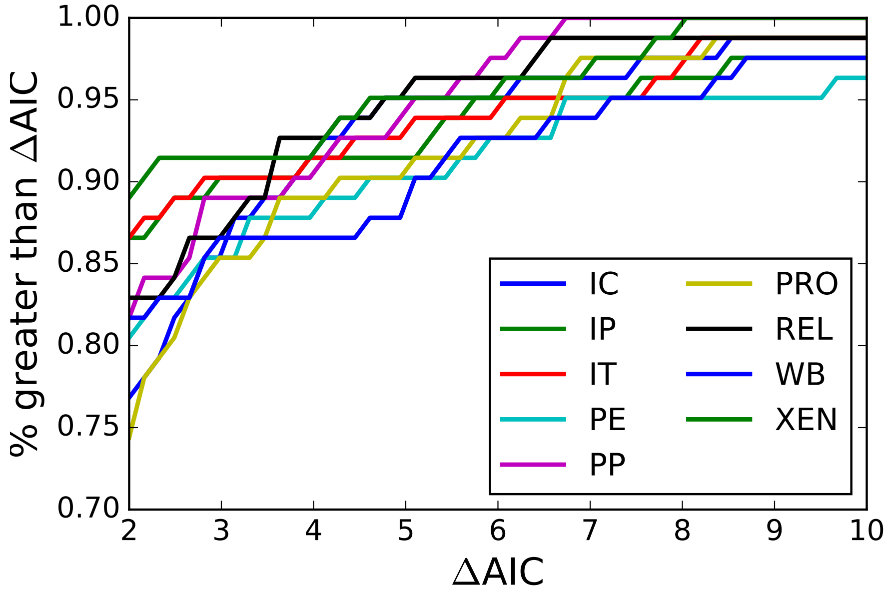


Figure 4.3: The proportion of countries in each cultural factor with no systemic interaction between opinion and generational change. The y axis is the proportion of countries which have a ΔAIC less than the value on the x axis (where ΔAIC is an indicator of the importance of the interaction between opinion and generational change). For each of the nine cultural factors which are abbreviated as follows: REL Religiosity; IC Institutional Confidence; IT Intrinsic Tolerance; PRO Prosociality; IP Interest in Politics; WB Wellbeing; PE Political Engagement; PP Importance of Personal Prohibitions and XEN Xenophilia.

predictability and impute missing generations using a linear model (we further discuss the relative steadiness of generational and opinion change in later sections). We are only interested in imputing missing generations which appear in at least one time period (illustrated in table 4.2), thus reducing the amount of extrapolation necessary. The following is the linear model used for imputation:

$$Z_{p,g} = \mu_p + A_p g_p + \epsilon_p$$

where $Z + p, g$ is the period-generation (p-g) matrix for each country, g is generation decade, p is time period and ϵ is the error.

4.1.5 Generational and Opinion Change

By averaging across time period in the newly imputed period-generation (p-g) matrix, we create the generational time series for 109 countries. Then by averaging across the generation dimension of the p-g matrix we create the complementary opinion change time series, but only for the 85 countries measured in two or more waves of the WEVS.

g|p	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015
1890					
1900					
1910	0.46 (0.063)	0.63 (0.056)		Impute	Impute
1920	0.51 (0.04)	0.6 (0.04)		Impute	Impute
1930	0.39 (0.049)	0.49 (0.039)		0.45 (0.07)	0.37 (0.069)
1940	0.33 (0.045)	0.43 (0.038)		0.27 (0.06)	0.2 (0.046)
1950	0.21 (0.04)	0.37 (0.031)		0.13 (0.05)	0.1 (0.042)
1960	0.21 (0.044)	0.4 (0.032)		0.11 (0.06)	-0.07 (0.047)
1970	Impute	0.14 (0.045)		0.12 (0.061)	0.02 (0.054)
1980	Impute	Impute		0.02 (0.077)	-0.18 (0.055)
1990	Impute	Impute		Impute	-0.19 (0.086)

g|p	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015
1890					
1900					
1910					
1920					
1930					
1940	0.94 (0.044)	0.96 (0.026)	Impute		Impute
1950	0.96 (0.028)	0.95 (0.017)	1.01 (0.021)		Impute
1960	0.92 (0.022)	0.95 (0.013)	1.05 (0.011)		0.99 (0.025)
1970	0.98 (0.036)	0.96 (0.012)	1.02 (0.009)		0.93 (0.018)
1980	Impute	Impute	1.03 (0.014)		0.92 (0.01)
1990	Impute	Impute	Impute		0.88 (0.018)

Table 4.2: Period-generation (p-g) matrices for Religiosity in the USA (top row) and Nigeria (bottom row). The rows are generations and the columns are time periods. Each entry is the sample mean with the standard error in brackets. A missing time period occurs when a country does not participate in a WEVS wave at that time and a missing generation occurs when it is underrepresented during a time period (a sample of less than 100). The entries labelled 'impute' are the values imputed using our linear model.

We measure the generation trend $G_{c,f}$ and opinion trend $O_{c,f}$ for each country c in the nine cultural factors f. We employ the same two-stage Bayesian framework used for the cross-sectional changes (see figure 4.1). To ensure missing generations are extrapolated reasonably, we use Bayesian hierarchical imputation (equation 4.1) and then quantify change fusing a linear regression (equation 4.2). The only differences to the cross-sectional case being that temporal dimension t will be substituted with generation g in the case of generational change and time period p in the case of opinion change. Figure 4.4 shows the global generational and opinion trends in each cultural factor by averaging over all countries.

We see that generational change (right hand side of figure 4.4) exhibits a homogeneous global pattern. We see increases in Xenophilia, Intrinsic Tolerance, Wellbeing and Political Engagement and also decreases in Religiosity, Institutional Confidence, Prosociality, Interest in

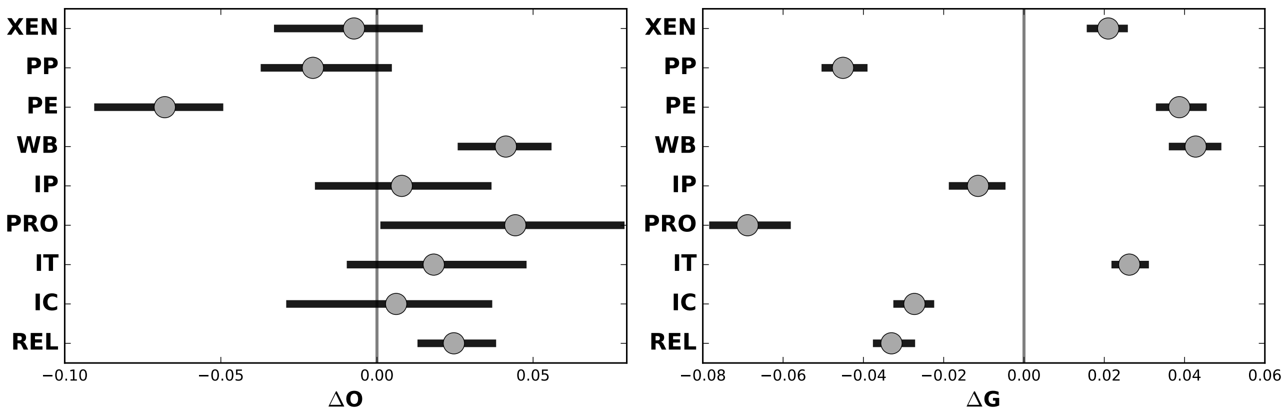


Figure 4.4: Left hand side: the globally averaged opinion change ΔO in each cultural factor (85 countries). Right hand side: is the equivalent plot for globally averaged generational change ΔG (109 countries). All errors are the 95% intervals of bootstrapped sample of means. Rates of changes are expressed as a proportion of the contemporary total variance. Cultural factor abbreviations: R=religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia.

Politics, Religiosity and the Importance of Personal Prohibitions.

In contrast opinion change, like the cross-sectional trends, show globally heterogeneous change. We only see global average trends towards higher Prosociality, Religiosity and Wellbeing and lower Political Engagement. This suggests a differing mechanism driving generational and opinion change because trends in Religiosity, Prosociality and Political Engagement run in opposite directions.

4.1.6 Are the Measured Changes Non-Random?

We have detected non-zero changes in cross-sectional samples (figure 4.1), opinion (left hand side of figure 4.4) and generation (right hand side of figure 4.4). The fact we observe globally directional changes suggests that these dynamics represent real signal and not just measurement error. To add more weight to this assertion we present the pairwise correlations between the nine cultural factors for both opinion and generational changes.

If the measured change in cultural values is random then we expect no correlation among the nine cultural factors. However, even in the case where dynamics are random perturbations, we would expect to measure some correlations by chance. To avoid the detection of false positives we set a high bar for their detection: each must meet statistical significance at the conservative Bonferroni corrected level ($p < 0.0014$). At this baseline even the detection of a single correlation would be evidence of non-random structure at 5% level.

The correlation matrix for opinion change shows six correlated pairs of cultural factors which

	REL	IC	IT	PRO	IP	WB	PE	PP	XEN
REL		0.04	0.09	0.3	-0.21	**0.38**	**-0.4**	**0.54**	0.06
IC			-0.01	-0.02	0.24	0.06	0.15	0	-0.27
IT				-0.04	0.1	0.04	-0.05	-0.07	0.07
PRO					-0.12	0.22	-0.17	**0.52**	-0.04
IP						-0.02	**0.56**	-0.27	0.02
WB							0.1	0.3	0.04
PE								**-0.39**	0.1
PP									-0.26
XEN									

Table 4.3: Pairwise Pearson correlation coefficients between the opinion changes in the nine cultural factors. The **bold** values are statistically significant at the Bonferroni corrected level ($p < 0.0014$). Cultural factor abbreviations: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia.

meet statistical significance (adjusted using the conservative Bonferroni correction. Table 4.3 show positive correlations between Religiosity and Wellbeing, Religiosity and the Importance of Personal Prohibitions, Political Engagement and Interest in Politics, Prosociality and the Importance of Personal Prohibitions. It also shows negative correlations between Religiosity and Political Engagement, the Importance of Personal Prohibitions and Political Engagement.

The complimentary correlation matrix for generational change shows even more evidence of non-random structure. Table 4.4 shows strong generational trend correlations between many factors. Though there are some interesting differences when compared to the opinion change matrix. For instance, generational changes in Political Engagement and Interest in Politics are uncorrelated, but their opinion changes are correlated. Generational trends in Wellbeing also show no significant correlation with any other cultural factor. Not only does this give evidence that the measured dynamics are non-random, but also suggests that opinion and generational change have different causes.

4.1.7 Speed and Variability of Cultural Value Change

The absolute speed of cultural change is an important measure to see whether it is opinion or generational change which shows greater displacement over short periods. This information is not captured by figure 4.4 because countries show both positive and negative changes which offset each other — this is particularly true for opinion change.

We also want to account for the possibility that changes occur at a faster rate than the full range of the time series. Again, this is particularly the case for opinion change which we suspect will vary at a higher rate than the 25 year range of the WEVS survey (possibly in response to exogenous economic shocks [Easterlin et al., 2010; Inglehart and Welzel, 2005]. Therefore, we define a second absolute speed similar to the first but measured at every 5 year interval. We are

	REL	IC	IT	PRO	IP	WB	PE	PP	XEN
REL		0.27	**-0.63**	**0.61**	0.08	-0.07	**-0.62**	**0.82**	**-0.52**
IC			-0.35	0.25	0.21	-0.19	-0.3	**0.42**	-0.36
IT				**-0.45**	-0.09	-0.02	**0.5**	**-0.73**	**0.7**
PRO					0.25	-0.23	**-0.47**	**0.72**	-0.31
IP						-0.1	0.34	0.11	-0.01
WB							0.16	-0.24	0.22
PE								**-0.73**	**0.64**
PP									**-0.71**
XEN									

Table 4.4: Pairwise Pearson correlation coefficients between the generational change in the nine cultural factors. The **bold** values are statistically significant at the Bonferroni corrected level ($p < 0.0014$). Cultural factor abbreviations: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia.

limited to a time resolution of 10 years for generational changes, but we half it so we can present it as a 5 year interval to facilitate comparisons between opinion and cross-sectional change. This interpolation is reasonable because, as we will show, generational change is steady even at much higher time resolutions.

The time series for both opinion and generational change contain many missing values. In the opinion change case, we can only measure 5 year differences if the country participated in two consecutive WEVS waves. However there is the risk that excluding countries which do not meet the participation criteria may bias our result. To address this, we have a version of the data with missing values imputed using the hierarchical Bayesian model (model 4.1). We present the results using both the imputed (O_{imp} and G_{imp}) and non-imputed datasets (O and G) and the right hand side of figure 4.5 shows the results are insensitive.

The left hand side of figure 4.5 shows the average displacement for opinion change is larger than for generational change. Even this an underestimation because the differences in displacement over the shorter 5 year period are even greater (right hand side of figure 4.5). It appears that generational change is steady and persistent with 5 year fluctuations on roughly the same order as its long-term average; whereas opinion change is large and highly variable.

The largest expected opinion displacement over 25 years is for Prosociality (16% per decade) and the lowest is for Religiosity (5% per decade). The differences between cultural factors are accentuated when we look at change over the 5 year period. The right hand side of figure 4.5 shows large bursts of change over 5 years — around 40% — for Institutional Confidence, Prosociality, Interest in Politics and Intrinsic Tolerance. This is much higher than that seen for Religiosity, Wellbeing, Political Engagement and the Importance of Personal Prohibitions, where the bursts are closer to 20%.

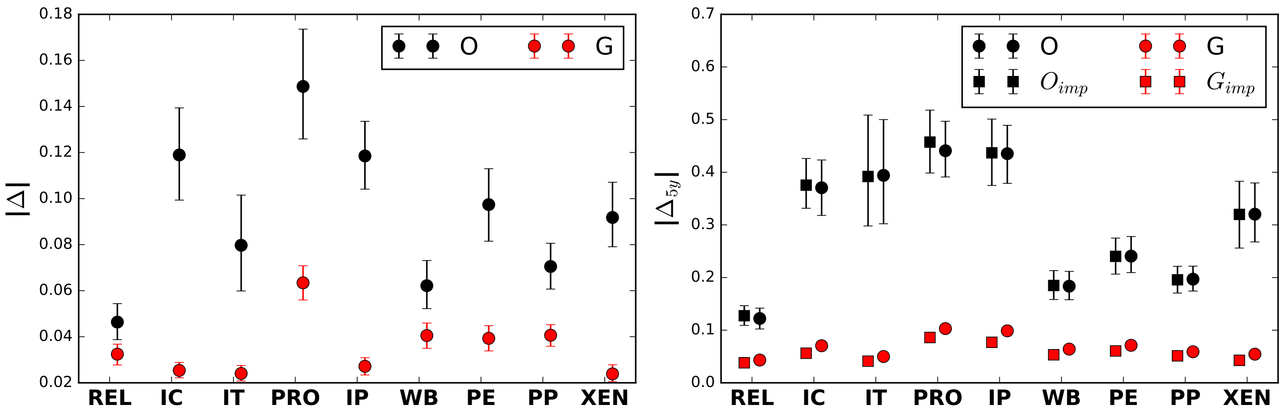


Figure 4.5: Left hand side: the global mean absolute displacement for generational change (red) and opinion change (black) — opinion change is averaged change over 25 years and generational change is averaged over 100 years. The right hand side: the equivalent plot except with global mean absolute displacement measured over 5 year time periods for opinion change and 10 year period for generational change. Circles represent data with imputed missing values and squares with omitted missing values. All changes are expressed as a percentage of the total contemporary observed variance in each cultural factor. Cultural factor abbreviations are as follows: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia.

4.1.8 Long term and short term change

We have shown that generational changes are gradual and steady, whereas opinion changes are rapid and volatile. Therefore, we might expect opinion change to be the main driver of cultural value change over the short term and, as opinion change averages out, generational change to be the driver over the long run.

To test this proposition we run two sets of regressions using generational change and opinion change as predictors. The first set of regressions test if either generational or opinion change predict the last 25 years of cultural value change measured using the cross-sectional WEVS samples (see figure 4.1). In the second set of regressions we test whether generational or opinion change predict the modern day distribution of cultural values — measured as the *average* cultural values from the last 25 years.

Table 4.5 presents the results for regressions 1-9 which determine the effect of opinion change ΔO and generational change ΔG on the last 25 years of cultural value change in each of the nine cultural factors. For all cultural factors, these account for nearly 100% of the variance. This means, unsurprisingly, that recent cultural value change is entirely explained by changes in opinion and the replacement of older generations with new ones. All the effects are statistically significant, but opinion change has a near one-to-one correspondence, compared to the weaker effect of generation ranging from 0.36 to 0.73. This suggests that opinion change is the dominant

	R1	**R2**	**R3**	**R4**	**R5**
Dep Var	Δ REL	Δ IC	Δ IT	Δ PRO	Δ IP
ΔG	0.64 (0.06)*	0.55 (0.13)*	0.36 (0.11)*	0.72 (0.11)*	0.58 (0.08)*
ΔO	1.01 (0.03)*	0.99 (0.02)*	0.99 (0.02)*	1.03 (0.03)*	0.98 (0.02)*
R^2	0.94	0.97	0.98	0.95	0.96

	R6	**R7**	**R8**	**R9**
Dep Var	Δ WB	Δ PE	Δ PP	Δ XEN
ΔG	0.73 (0.07)*	0.59 (0.06)*	0.48 (0.08)*	0.6 (0.1)*
ΔO	1.02 (0.03)*	0.97 (0.02)*	1.03 (0.03)*	1.04 (0.02)*
R^2	0.95	0.98	0.95	0.97

Table 4.5: Regression results showing the effect of opinion change ΔO and generational change ΔG on the last 25 years of cultural value change. This is for all cultural factors which are abbreviated as follows: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia. R^2 is the proportion of the variance explained and (*) means statistical significance has been met at the Bonferroni corrected level (p=0.003).

mode of cultural value change over periods in the order of 25 years.

Table 4.6 presents regressions 10-18 which show generational change ΔG is a better predictor of the modern-day distribution of cultural values when compared to opinion change ΔO. ΔG obtains statistical significance for Religiosity, Intrinsic Tolerance, Wellbeing, Political Engagement and Importance of Personal Prohibitions. Although, we also see ΔO reach statistical significance for Institutional Confidence and Xenophilia, but with much smaller effect sizes. This tells us that modern day cultural value inequalities have been shaped by the last 100 years of persistent generational cultural value change. That said, this is not true for all cultural factors; Prosociality, Interest in Politics, Institutional Confidence and Xenophilia have distributions not explained by generational change and, in the case of Institutional Confidence and Xenophilia, are partially explained by opinion change.

We saw that opinion and generational change entirely explain the last 25 years of cultural value change (see table 4.5). However, they only partially explain modern day cultural value inequalities (R^2 ranging from 0.09 to 0.58; see table 4.6). Variance explained exceeds 25% only in cases where there is an important contribution made by generation changes, providing further evidence that it is generational change that is the primary mode of change when explaining the modern day cultural value distribution. Our generational trends only stretch back 100 years, so it seems reasonable to speculate that the unexplained variance might relate to generational changes which occurred in previous time epochs.

As we have shown, opinion changes occur at much higher frequencies than 25 years, so we may detect their influence on the distribution of cultural values over shorter time periods. We run additional tests to see if the global cultural value distribution is affected by opinion change over just the preceding 5 years. To do this we rerun regressions 1-9 four times: one

	R10	**R11**	**R12**	**R13**	**R14**
Dep Var	REL	IC	IT	PRO	IP
ΔG	6.17 (1)*	2.9 (1.21)	6.56 (1.2)*	1.8 (0.66)	-2.17 (0.82)
ΔO	-1.09 (0.48)	0.57 (0.19)*	-0.19 (0.19)	0.19 (0.15)	0.26 (0.21)
R^2	0.34	0.15	0.29	0.09	0.1

	R15	**R16**	**R17**	**R18**
Dep Var	WB	PE	PP	XEN
ΔG	-6 (0.73)*	4.36 (0.84)*	6.9 (0.69)*	2.2 (1.17)
ΔO	-0.13 (0.31)	0.31 (0.26)	0.6 (0.24)	0.85 (0.25)*
R^2	0.48	0.27	0.58	0.18

Table 4.6: Regression results showing the effect of opinion change ΔO and generational change ΔG on the modern day distribution of cultural values. This is for all cultural factors which are abbreviated as follows: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia. R^2 is the proportion of the variance explained and (*) means statistical significance has been met at the Bonferroni corrected level (p=0.003).

for each transition between time periods, where the dependent variable is the static cultural value distribution at the end of the transition (for example REL_{1995} , REL_{2000}, REL_{2005} and REL_{2010}) and the independent variable is the opinion change that occurred in the 5 years prior to that period (ΔO_{1995}, ΔO_{2000}, ΔO_{2005}, ΔO_{2010}). We continue to include generational change in the regression and we expect its contribution to remain stable because generational change is slow and persistent; an assumption that is confirmed in table 4.7.

Table 4.7 shows that spikes in opinion change after 5 years can have a small but detectable effect on the global distribution of cultural values. We see this in 3/4 of the periods for the Importance of Personal Prohibitions and Institutional Confidence; 2/4 for Prosociality, Interest in Politics and Xenophilia and 1/4 for Intrinsic Tolerance, and Political Engagement.

Taken as a whole, these regression results confirm our belief that long-run generational change is important for explaining modern day cultural value inequalities, but that cultural value changes on the order of 25 years are largely the product of opinion change. That said, opinion changes can have transient effects on the global distribution of cultural values of the order of 5 years.

	R10$_{1995}$	**R11**$_{1995}$	**R12**$_{1995}$	**R13**$_{1995}$	**R14**$_{1995}$
Dep Var	REL_{1995}	IC_{1995}	IT_{1995}	PRO_{1995}	IP_{1995}
ΔG	5.63 (0.99)*	2.34 (1.18)	7.45 (1.35)*	1.99 (0.66)	-2.39 (0.82)
ΔO$_{1995}$	-0.42 (0.18)	0.12 (0.11)	0.08 (0.11)	0.04 (0.1)	0.23 (0.09)
R^2	0.32	0.06	0.29	0.1	0.16
	R15$_{1995}$	**R16**$_{1995}$	**R17**$_{1995}$	**R18**$_{1995}$	
Dep Var	WB_{1995}	PE_{1995}	PP_{1995}	XEN_{1995}	
ΔG	-6.88 (0.76)*	3.89 (0.85)*	6.34 (0.74)*	2.19 (1.12)	
ΔO$_{1995}$	0.44 (0.19)	0.31 (0.13)	0.44 (0.13)*	0.08 (0.11)	
R^2	0.53	0.27	0.59	0.06	

	R10$_{2000}$	**R11**$_{2000}$	**R12**$_{2000}$	**R13**$_{2000}$	**R14**$_{2000}$
Dep Var	REL_{2000}	IC_{2000}	IT_{2000}	PRO_{2000}	IP_{2000}
ΔG	5.89 (1.03)*	2.55 (1.19)	7.1 (1.32)*	2.31 (0.64)*	-2.06 (0.82)
ΔO$_{2000}$	0.47 (0.27)	0.48 (0.1)*	0.35 (0.06)*	0.26 (0.11)	0.18 (0.12)
R^2	0.32	0.26	0.38	0.18	0.1
	R15$_{2000}$	**R16**$_{2000}$	**R17**$_{2000}$	**R18**$_{2000}$	
Dep Var	WB_{2000}	PE_{2000}	PP_{2000}	XEN_{2000}	
ΔG	-6.42 (0.77)*	4.27 (0.85)*	7.51 (0.73)*	2.43 (1.11)	
ΔO$_{2000}$	0.25 (0.14)	0.19 (0.16)	0.19 (0.16)	0.5 (0.1)*	
R^2	0.46	0.24	0.57	0.29	

	R10$_{2005}$	**R11**$_{2005}$	**R12**$_{2005}$	**R13**$_{2005}$	**R14**$_{2005}$
Dep Var	REL_{2005}	IC_{2005}	IT_{2005}	PRO_{2005}	IP_{2005}
ΔG	6.95 (1)*	3.54 (1.33)	6.47 (1.27)*	2.41 (0.69)*	-1.58 (0.85)
ΔO$_{2005}$	-0.44 (0.3)	0.43 (0.1)*	0.07 (0.07)	0.38 (0.08)*	0.43 (0.1)*
R^2	0.37	0.22	0.25	0.23	0.23
	R15$_{2005}$	**R16**$_{2005}$	**R17**$_{2005}$	**R18**$_{2005}$	
Dep Var	WB_{2005}	PE_{2005}	PP_{2005}	XEN_{2005}	
ΔG	-4.96 (0.76)*	4.61 (0.87)*	7.88 (0.74)*	3.56 (1.26)	
ΔO$_{2005}$	0.1 (0.13)	0.45 (0.14)*	0.61 (0.16)*	0.48 (0.11)*	
R^2	0.35	0.33	0.61	0.27	

	R10$_{2010}$	**R11**$_{2010}$	**R12**$_{2010}$	**R13**$_{2010}$	**R14**$_{2010}$
Dep Var	REL_{2010}	IC_{2010}	IT_{2010}	PRO_{2010}	IP_{2010}
ΔG	6.73 (1)*	3.22 (1.46)	6.52 (1.22)*	1.35 (0.73)	-1.58 (0.9)
ΔO$_{2010}$	0.19 (0.27)	0.38 (0.11)*	0.19 (0.12)	0.43 (0.07)*	0.32 (0.08)*
R^2	0.36	0.15	0.27	0.31	0.17
	R15$_{2010}$	**R16**$_{2010}$	**R17**$_{2010}$	**R18**$_{2010}$	
Dep Var	WB_{2010}	PE_{2010}	PP_{2010}	XEN_{2010}	
ΔG	-4.62 (0.7)*	5.03 (0.91)*	8 (0.81)*	4.12 (1.4)	
ΔO$_{2010}$	0.24 (0.12)	0.23 (0.16)	0.58 (0.16)*	0.25 (0.12)	
R^2	0.4	0.31	0.56	0.14	

Table 4.7: We rerun regression 10-18 to see the effect of opinion change (of the order of 5 years) ΔO_{year} and generational change ΔG on the global distribution of cultural values. We do this for each of the four time-period transitions (1995, 2000, 2005, 2010). This is for all cultural factors which are abbreviated as follows: R=Religiosity, IC=Institutional Confidence, IT=Intrinsic Tolerance, PRO=Prosociality, IP=Interest in Politics, WB=Wellbeing, PE=Political Engagement, PP=Importance of Personal Prohibitions, XEN=Xenophilia. R^2 is the proportion of the variance explained and ($*$) means statistical significance has been met at the Bonferroni corrected level (p=0.003).

4.2 Discussion

We have representative cross-sectional samples for 109 countries, 85 of these have been measured repeatedly during the last 25 years. We use Bayesian regression, with a preliminary missing data imputation stage, to measures changes in the nine cultural factors we derived in chapter three. We then separate generational change (which occurs as old birth cohorts are replaced with new ones) and opinion change (where the entire population changes their mind at particular time) from the aforementioned cross-sectional data. Finally, we document the differing characteristics of these two modes of cultural value change and their effects on both recent cultural value change and the modern day distribution of cultural values.

We imputed missing values using a Bayesian hierarchical model which, by pooling data across countries, means imputations are constrained to take reasonable values [McElreath, 2015]. This is important when there are only a few data points and large change occurs. This shrinkage should moderate our expectations (after all, in certain cultural factors, we saw changes of 40% of the total observed range in just 5 years). The imputation stage ensures that these fluctuations do not lead an unrealistic regression slope. In other words, it prevents over-fitting.

The WEVS cross-sectional samples since 1990 reveal no average global cultural value dynamic. We see unambiguous average increases in Wellbeing and decreases in Political Engagement and Importance of Personal Prohibitions, but there are a still a number countries showing change in the opposite direction. The three possible modes that drive cultural value change are generational (the replacement of older generations by new ones), life-cycle (changing with age) and opinion (the entire population changes during a particular time period). Identifying their independent effects is analytically impossible [De Vries, 2005; Down and Wilson, 2013], hence we examine only generational and opinion change because previous long-term studies of cultural values show that life-cycle effects are relatively small [Inglehart, 2008].

Generational change is slow and persistent, whereas opinion change is rapid and highly variable; this may stem from their respective causes. Generational trends represent 'baseline' cultural values, formed through processes of socialization during formative years [Inglehart and Welzel, 2005]. Whereas opinion change occurs at a particular time and affects the entire population - potentially caused by high frequency economic changes like inflation and unemployment [Easterlin et al., 2010; Inglehart and Welzel, 2005]. We show statistically that generational and opinion changes are independent of each other. Due to the fact that opinion change affects the entire population equally [Inglehart, 2008], differences in cultural values between successive generations are preserved.

Opinion change, like cross-sectional change, is globally heterogeneous. So, unsurprisingly, we show the last 25 years of cultural value change (measured using the cross-sectional samples) is overwhelmingly determined by opinion change, with only a limited effect due to generational replacement. Democratic systems often operate within time windows of 25 years or narrower, so governments will want to manage public opinion within similar-sized time frames. It is important for them to understand that opinion change is highly variable and hard to predict. Moreover, changes in opinion are unrelated to the more persistent generational trends, the effects of which will dominate in the long run.

Generational change, unlike opinion change, has exhibited a clear homogeneous global average pattern during the last 100 years. To greater or lesser degrees, the world is increasing in Intrinsic Tolerance, Xenophilia, Wellbeing and Political Engagement; and decreasing in Religiosity, Institutional Confidence, Interest in Politics, Prosociality and the Importance of Personal Prohibitions. This suggests that the drivers of generational change are universal and can affect all countries simultaneously, whereas the idiosyncratic nature of opinion change suggests more local causes.

In chapter three, we identified cultural value variation not accounted for in the Inglehart-Welzel (I-W) cultural map [Inglehart and Welzel, 2005]. Coincidentally it is these three cultural factors — Institutional Confidence (IC), Interest in Politics (IP) and Prosociality (PRO) — that exhibit the most interesting dynamic behavior. In all three cases, the last 100 years of generational trends do not provide a statistically significant explanation for their modern day distributions (these are 3 of the 4 of cultural factors where this is the case). Moreover, opinion change within these cultural factors is particularly volatile (these are 3 out of 4 of the cultural factors where we see 40% changes over 5 year periods). The dominance of opinion over generational change means the respective trajectories of Prosociality, Institutional Confidence and Interest in Politics are harder to predict.

4.3 Conclusions

Using a unique two stage Bayesian regression framework we use the representative cross-sectional samples provided by the WEVS to measure cultural value change since 1990. We see that the last 25 years is characterized by idiosyncratic change with few clear global average trends. We identify and measure two distinct modes of cultural value change: generational and opinion change. We find that generational change is gradual and steady, where opinion change is rapid and variable.

We show that the last 25 years of cultural value change is predominantly explained by opinion change, but that modern day cultural value inequalities are determined by long-run generational changes. Although, in the three new cultural factors (Institutional Confidence, Interest in Politics and Prosociality), opinion changes, and not generational changes, dominate the dynamics.

CHAPTER 5

Cultural Value Clusters

Countries that are linguistically, religiously or geographically similar, tend to have similar economic development [Inglehart and Welzel, 2005], corruption [Treisman, 2000], life expectancy [Deaton, 2013] and, significantly for us, cultural values [Inglehart and Welzel, 2005]. Unfortunately, cultural value clusters are generally a-priori defined using the linguistic, religious or geographic consistencies we mentioned. We use an unsupervised clustering algorithm (k-means) to see if these cultural-historic clusters can be identified with minimal assumptions. We then describe the nature of these clusters within each of the nine cultural factors — for example, we might expect clusters to more separable in certain cultural factors. Next, we see how cultural-history influences the two independent modes of cultural value change derived in chapter four: opinion and generational change. We also bring in external data to characterize the clusters in terms of economic development.

5.1 Cultural Classifications in Anthropology and Ethical Considerations

Using quantitative methods to cluster countries according to cultural values is important in human development studies. Using quantitative methods and data makes the debate more objective by shifting the argument away from descriptive approaches. Arguments about the human condition are fraught because our cognitive biases evolved for use in the very same social realm that we are seeking to study [Kahneman, 2011]. Quantification moves the argument into the abstract domain, meaning the resultant topics of debate — such as modeling assumptions and data collection techniques — are less emotionally charged. Moreover, using unsupervised learning methods minimizes the modeling assumptions we have to make in the first place. Once clusters have been detected, they can be the basis of a number of different research questions. In this chapter, we will ask to what extent our clusters are explained by shared cultural-history and which cultural mechanisms might explain them [Matthews et al., 2016; Spolaore and Wacziarg, 2016].

We made reference to a number of prominent qualitative cultural value clusterings in the literature review [Basanez, 2016; Huntington, 1996; Inglehart and Baker, 2000], but there is also a history of classifying cultures in anthropology. Most notably, Ruth Benedict's 'Patterns of Culture' [Benedict, 1937] where she classified cultures on a value dimension ranging from the wild abandon of 'Dyonisians' to the strict rules of the 'Apolonians'. Benedict's methodologies no doubt influenced Margaret Mead's work in Samoa [Mead, 1928]. More recently, building on work by Pertti Pelto [Pelto, 1968], Michelle Gelfand has classified countries according to loose or tight adherence to cultural norms [Gelfand et al., 2011].

There are ethical considerations surrounding the classification of cultures that need to be taken seriously. Victorian-era theories about hard-wired differences between different racial groups [Galton, 1869; Spencer, 1857] led to pseudoscientific disciplines like eugenics and phrenology that were based on false premises. The human species is actually unusually genetically homogeneous [Ebersberger et al., 2002] and there is no teleology leading societies to become ever more complex [Currie et al., 2010; Flannery and Marcus, 2012].

The cost of ignoring between-cultural differences, is the possibility that unscientific assumptions regarding group differences go unchallenged. Risking the proliferation of pernicious stereotypes [McCrae and Terracciano, 2005]. Therefore, quantitative cross-cultural comparisons are a vital tool for understanding human development as objectively as possible in the social sciences.

5.2 Methods

There are a number of unsupervised clustering techniques we could employ. They can be categorized under two headings: flat and hierarchical clustering. Flat clustering methods can be deterministic (like k-means) or probabilistic (like soft k-means). Hierarchical methods can be bottom up (like agglomerative hierarchical clustering) or top down (like divisive hierarchical clustering). Dimensionality reduction tools like Principal Component Analysis or Exploratory Factor Analysis are also used for clustering. However, we limit our discussion to the two most common techniques: k-means and agglomerative hierarchical clustering.

K-means clustering is a flat clustering method. K-means aims to find cluster centers that minimize the euclidean distance between the observations (countries in our case) and their nearest cluster center. Formally:

$$RSS_k = \sum_{x \in \omega_k} (x - \mu_k)^2 \tag{5.1}$$

$$RSS = \sum_{k=1}^{K} RSS_k \tag{5.2}$$

where RSS_k is the total deviation of the assigned observations ω_k from the centroid of cluster μ_k, x is the vector of all observations and RSS is the total deviation between all observations and their respective cluster centers.

The k-means clustering algorithm uses the following iterative procedure: first, cluster centers are set to randomly selected observations from the data (seeds), then each observation is assigned to its nearest cluster center, the cluster centers are then adjusted to the mean of the observations assigned to it, then the observations are reassigned to their nearest cluster based on these new centers. This process is repeated until the cluster centers have converged. In certain cases this may require an impractical amount of time, so a compromised result is often used once a maximum iteration limit as expired or when an acceptable threshold for RSS or ΔRSS has been reached.

K-means is computationally cheap compared to hierarchical clustering; it boasts linear time complexity ($O(IKNM)$), where I is the number of iterations, K is the number of clusters, N is number of observations and M is the number of vector distances that must be calculated. This makes k-means a better candidate for very large datasets

One shortcoming of K-means is that is not deterministic — in that the algorithm does not guarantee we arrive at the global optimum. Under our regime, we increase our chances of finding the global optimum by running the k-means algorithm using many different random seeds and taking the best result from the ensemble of results. Sometimes a preliminary method is used to intelligently select the initial seeds, but this would still not ensure we obtain the global minimum RSS.

Perhaps the most striking shortcoming of k-means is that we need to choose the number of clusters K a-priori. There is no foolproof way of choosing this parameter. We know that RSS will decrease monotonically with the number of clusters (asymptomatically $RSS = 0$, when $k = N$; where N is the number of observations.) Therefore, similar to the Scree plots we used in chapter three, used to decide the number of factors to retain in Exploratory Factor Analysis, we can look for an elbow in the RSS vs number of clusters (K) plot which indicates the point where additional improvements in RSS gained by adding extra clusters is diminished [Manning et al., 2008].

Hierarchical clustering is an iterative bottom-up clustering method. It begins with each observation making up its own cluster ($K = N$), then with each iteration the two clusters which are considered 'nearest' are merged into one. This is repeated until just a single cluster remains. This forms a hierarchy of similarity, where the number of clusters (K) depends on the chosen clustering depth. Hierarchical clustering is flexible in that it can be used with a wide variety of data, just so long as a distance metric can be defined. On the down side, the algorithm is more computationally expensive because it has to compute pairwise comparisons of all clusters in each iteration. This leads to a computational cubic time complexity $O(n^3)$ which makes it unsuitable for large datasets.

The outcome of hierarchical clustering hinges on the definition of 'nearest'. There are a number of ways the distance between clusters is measured and each gives a different result. Single linkage defines the distance between two clusters using the nearest observations within each. This tends to create long thin clusters because a cluster containing many observations has a greater probability of any one of its observations being near to any other cluster. Complete linkage uses the farthest point in each cluster. This forms clusters of more equal diameter because it favors merging clusters with the smallest diameter (generally those with fewest points). However, sensitivity to outliers is a problem with complete linkage. The maximum value in a sample scales with the size of that sample, this means large clusters are more likely to absorb other clusters if there are outliers. Using some scale-invariant measurement of maximum value (like 95th percentile) would solve this problem.

There are a few other definitions of 'nearest' cluster that are less common. Average linkage takes the average pairwise distance between all members of each cluster; Ward linkage tries to to minimize the variance within each cluster — analogous to k-means clustering — and centroid linkage merges the two clusters which have the nearest centroids [Manning et al., 2008].

5.3 Results

Our ambition is to cluster the 109 countries which participated in the WEVS using the nine cultural factors derived in chapter three. Each country's position in the nine cultural factor space is determined by its mean value measured over the last 25 years. Taking the 25 year average minimizes the influence of rapid and variable opinion changes (see chapter four).

We chose to use k-means instead of hierarchical clustering for two main reasons. The first being that k-means takes into account the global variance with every iteration of the algorithm, whereas hierarchical clustering can only make local merge choices based on the state during that particular iteration. Secondly, we are not interested in knowing the depth structure of the clusters, so flat clustering is fine for our purposes. Plus, the similarity structure between countries is really a network, and any attempt to describe it in a lower dimensional space like a hierarchy is necessarily imposing some constraint which could be arbitrary. There are network analysis methods, such as community identification, which might be a better way to discover clusters with depth [Newman and Girvan, 2004].

As mentioned before, when using k-means it is hard to be sure we have reached the globally optimum solution. To improve our chances, we run k-means 1000 times with different randomized seeds and use the cluster centers which provide the lowest residual RSS from the ensemble. Figure 5.1 shows that 1000 random seeds is sufficient for the effective global minimum RSS to be obtained; even when the parameter space becomes complex as K increases. It shows that the

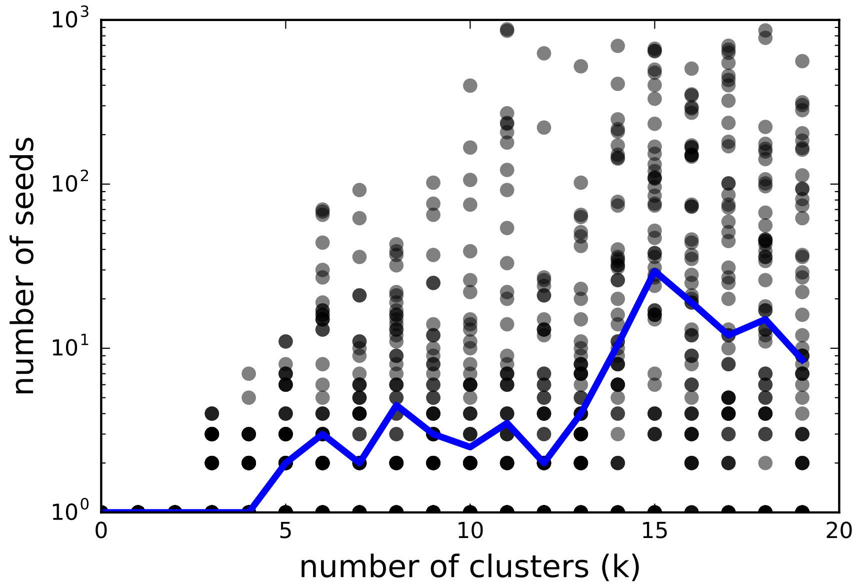


Figure 5.1: The number of random seeds used in k-means clustering to reach an effective global minimum RSS (improvements below a threshold $\Delta RSS < 1$ are considered insignificant). The blue line is the median number of seeds needed to reach minimum RSS. The k-means algorithm is run for 200 iterations in all trials. Each black circle represents a trial (50 trials for each cluster number and number of seeds combination). The y axis is on a log scale for clarity.

median number seeds to reach the minimum is always under 100 (the blue line). It also shows that only in rare cases does it take more than 100 seeds (see the black circles).

5.3.1 Number of Clusters (K)

Choosing the number of clusters K is an important, yet fairly subjective, part of k-means clustering. One criterion is to choose the number of clusters which minimizes the total squared residual (RSS). However, as we have discussed, the more clusters we add, the smaller RSS will get. This is because we are adding nine parameters (one for each cultural factor) every time we add a cluster; this is called over-fitting. As we saw in chapter four, we can use the Akaike Information Criterion (AIC) to penalize additional parameters and find the optimum number of clusters. Formally:

$$AIC_K = RSS + 2mK$$

where m is the number of dimensions (nine cultural factors) and K in the number of clusters.

Figure 5.2 illustrates that the AIC is lowest when K =2, 3 and 4; this suggests the optimum number of clusters falls in this range. The top map in figure 5.3 shows the geographical distribution of countries when we assume two clusters ($k = 2$). The divide is roughly between rich

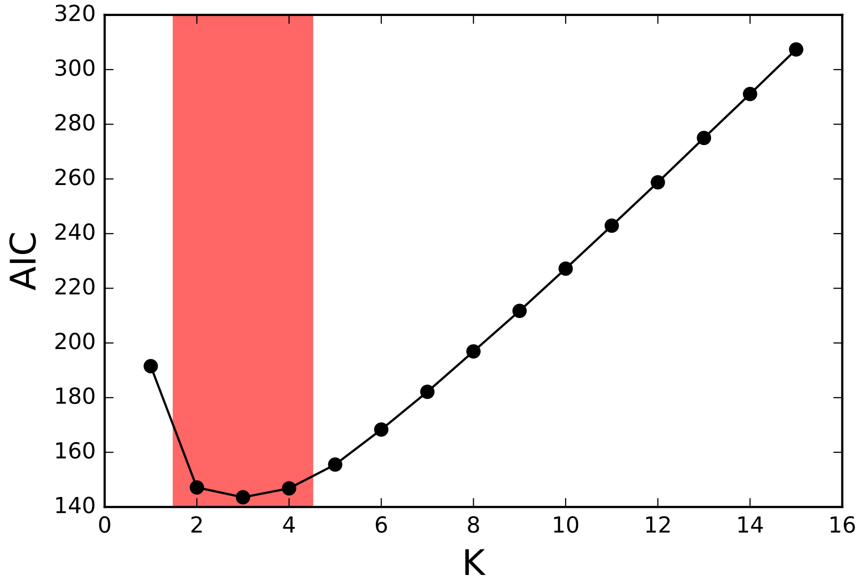


Figure 5.2: AIC vs the number of clusters in the k-means algorithm (k). AIC evaluates the goodness of fit of the k-means algorithm for a given cluster number k, but it penalizes additional clusters to avoid overfitting. The AIC is lowest for k = 2, 3 and 4, highlighted by the red region.

countries, in northern latitudes above Southern Europe, and poor ones in southern latitudes. The notable exceptions are the rich southern hemisphere countries like Australia and New Zealand. Also, Argentina and Uruguay fall into the rich cluster unlike all other Latin American countries (we will discuss the anomaly of Uruguay later). Certain Eastern European countries fall into the poor cluster.

When we chose $k = 3$ (the bottom map in figure 5.3), we see the same divide between rich western countries and the poorer (largely African-Islamic) countries in the southern latitudes. However, an intermediate cluster emerges consisting largely of the former communist countries in Eastern Europe. Interestingly, Latin America is divided among the three clusters: Uruguay and Argentina remain with the western countries, Chile and Peru fall in with the former communist counties and the others remain clustered with the poor southern latitude countries. It is difficult to see why Latin American countries would be clustered in this way.

We decided that $k = 4$ was the correct number of clusters because it better reflects cultural-history (see figure 5.4). The new fourth cluster consists of Catholic countries — those of Latin America and prominent European Catholic countries like Ireland, Poland and Italy. For illustrative purposes, we try adding a fifth cluster, but this only serves to arbitrarily divide the African-Islamic cluster; see figure 5.5. This split is not on cultural-historic grounds, so we conclude that the correct number of clusters is $k = 4$. That said, there are still interesting anomalies even with four clusters, we will explore these later. We implemented k-means using the statistical

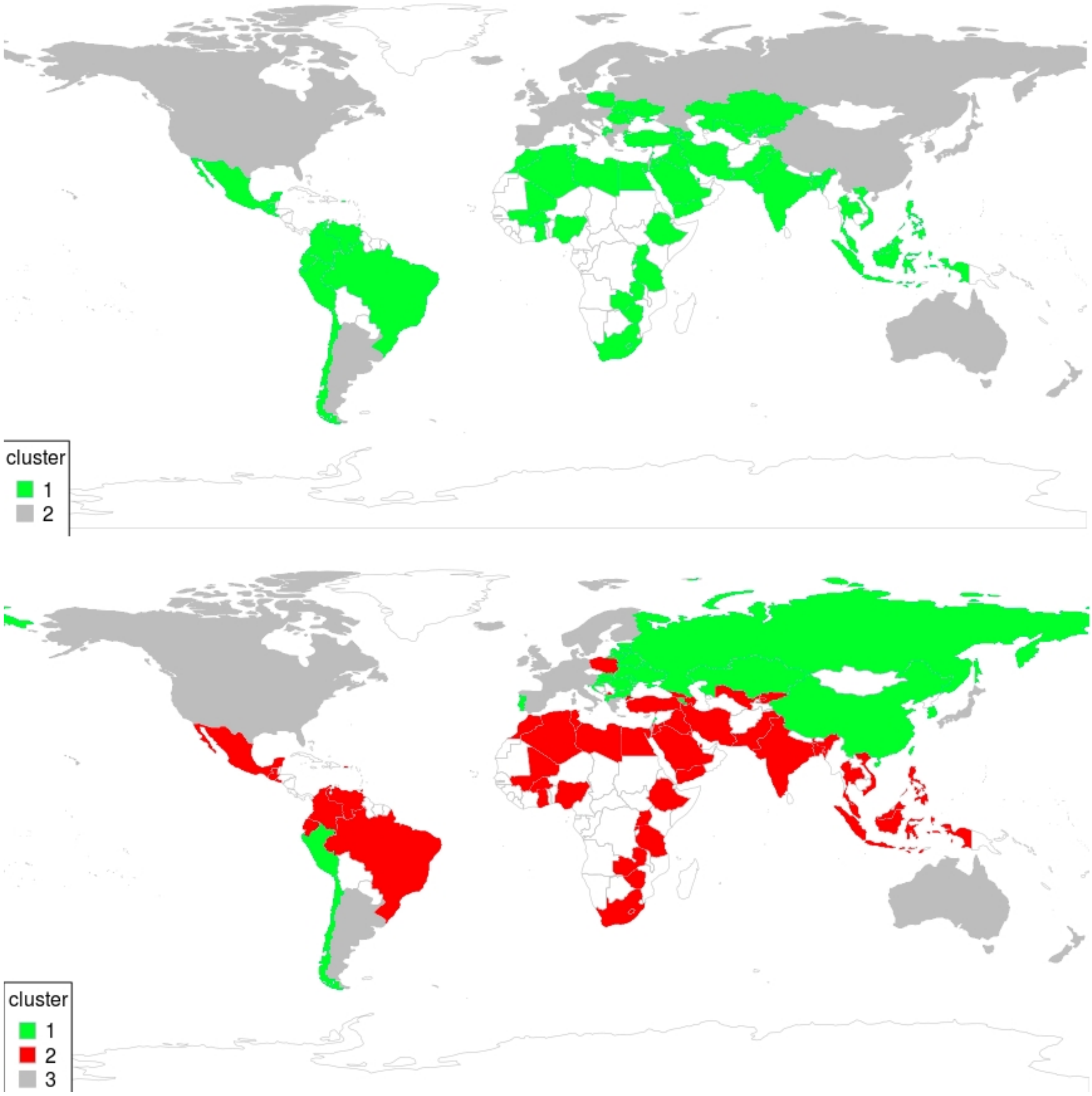


Figure 5.3: Top map: the geographical distribution of countries when we assume there are two clusters ($k = 2$). Bottom map: the distribution of countries when we assume there are three clusters ($k = 3$). Countries which have no data are left white.

programming language R.

5.3.2 Cluster Membership

The 109 countries of the WEVS are assigned to the four clusters as follows:

1. Czech Rep., Japan, Spain, Switzerland, Australia, Finland, Great Britain, New Zealand,

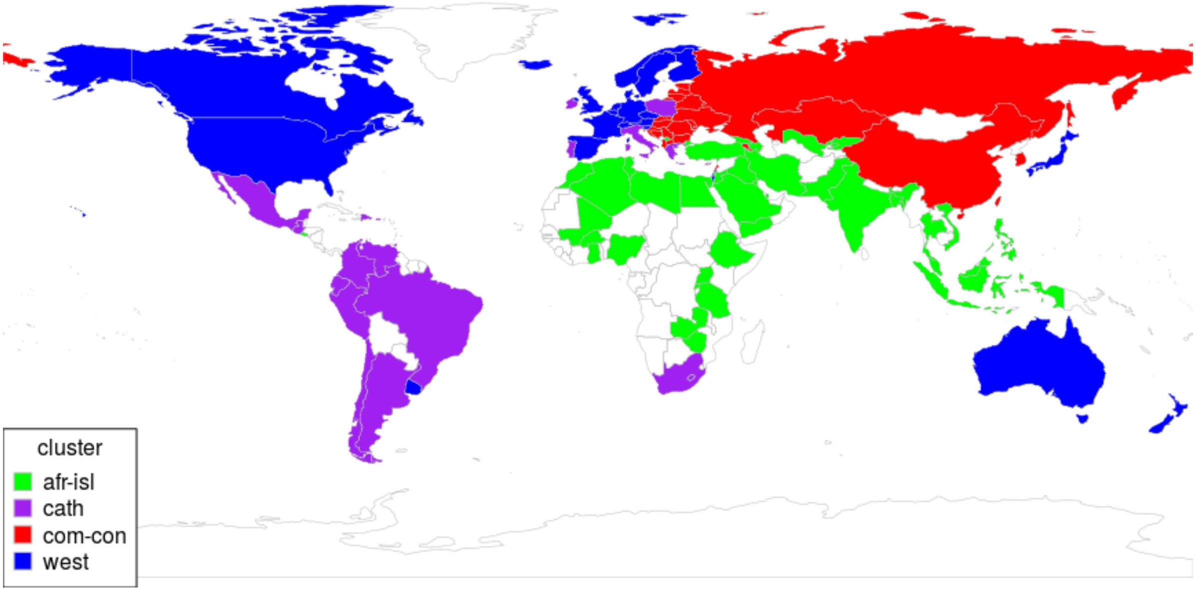


Figure 5.4: Geographical distribution of countries when we assume four clusters ($k = 4$). The colored clusters are labeled as follows: Western (blue), Catholic (purple), Communist-Confucian (red) and African-Islamic (green). Countries which have no data are left white.

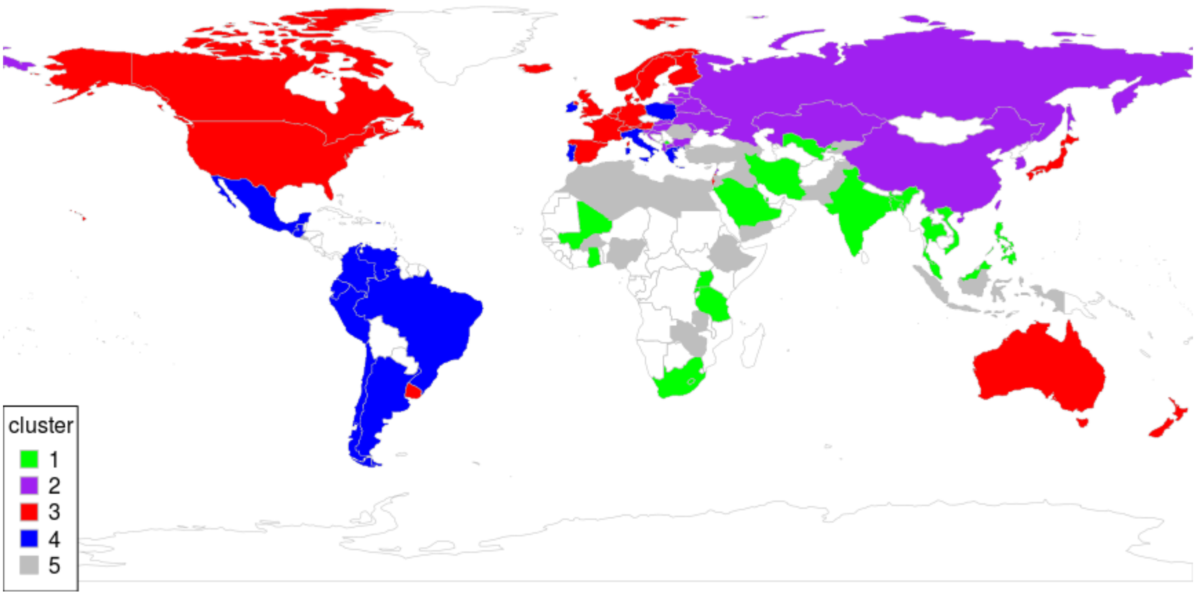


Figure 5.5: Geographical distribution of countries when we assume there are five clusters ($k = 5$). Countries which have no data are left white.

Norway, Sweden, Uruguay, United States, Germany, Slovenia, Canada, Israel, Andorra, France, Netherlands, Austria, Belgium, Denmark, Iceland, Luxembourg.

2. India, Nigeria, Turkey, Bangladesh, Pakistan, Philippines, El Salvador, Azerbaijan, Georgia, Algeria, Egypt, Indonesia, Iraq, Iran, Jordan, Kyrgyzstan, Morocco, Saudi Arabia, Tanzania, Uganda, Vietnam, Zimbabwe, Burkina Faso, Ghana, Malaysia, Mali, Rwanda, Thailand, Zambia, Ethiopia, Qatar, Uzbekistan, Palestine, Libya, Yemen, Tunisia, Bahrain, Kuwait, Cyprus (T), Kosovo

3. Belarus, China, Russia, Slovakia, South Korea, Albania, Armenia, Bosnia, Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Serbia and Montenegro, Romania, Ukraine, Taiwan, Hong Kong, Kazakhstan, Lebanon

4. Argentina, Brazil, Chile, Mexico, Poland, South Africa, Colombia, Peru, Puerto Rico, Dominican Rep., Venezuela, Singapore, Trinidad and Tobago, Cyprus (G), Italy, Guatemala, Ecuador, Greece, Ireland, Malta, Portugal, North Ireland

Using the cultural-historic character of the countries assigned to each cluster, we have tentatively labeled them as follows: 1 = Western, 2 = African-Islamic, 3 = Communist-Confucian and 4 = Catholic. Figure 5.6 is two pairwise plots which illustrate clear cultural value differentials between the clusters. The ellipse diameters are the sample standard deviation of the members of each cluster. As we can see, the clusters are statistically non-overlapping.

5.3.2.1 Establishing Clusters Using Posterior Samples

As we saw in chapter three, the majority of countries did not participate in all five of the WEVS waves. The resulting missing values in the time series were imputed according to our Bayesian hierarchical model (chapter four). This means that the average cultural factor scores during the last 25 years are actually posterior distributions, not the fixed values we have used thus far (the fixed values we use are the mean values of the posterior distributions).

It is important to check the significance of this uncertainty and its effect on the cluster assignments. To do this, we run the same k-means clustering algorithm on each of the posterior samples (giving us 2000 different cluster assignments). However, when we try to compare the posterior samples we have the problem of 'label switching', which stems from the fact that cluster labels are arbitrary. A country could be assigned to cluster A in one posterior sample and cluster B in another, yet the other countries within that cluster may be largely the same. The important information for deciding whether a pair of countries are similar is the frequency with which they are clustered together.

Once we have calculated the pairwise probabilities of countries falling into the same cluster (based on the 2000 k-means outcomes, one for each posterior sample), we are left with a network of probabilities and a community detection problem [Newman and Girvan, 2004]. Ideally, we

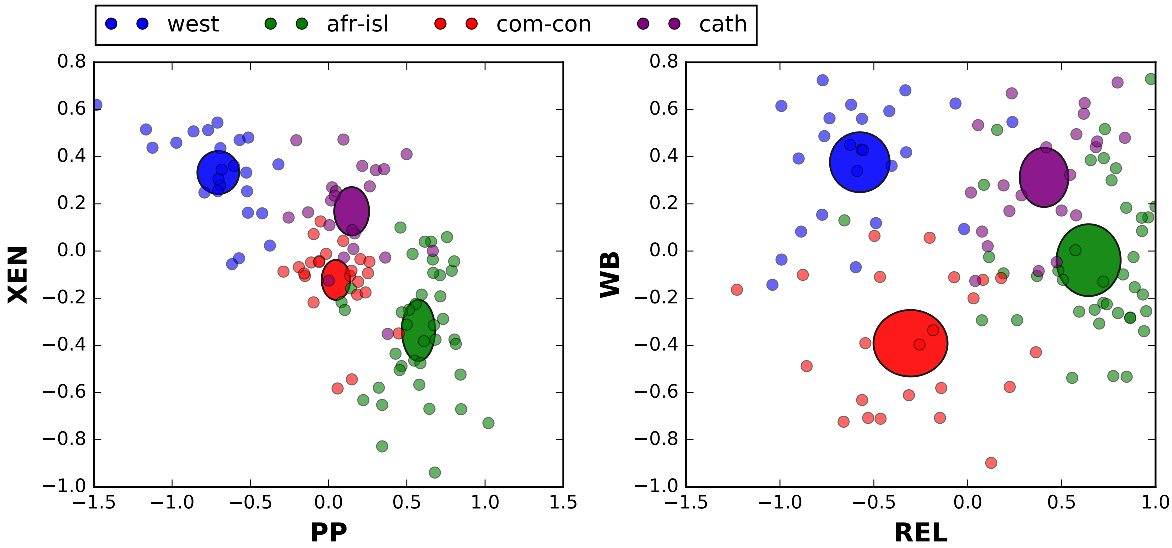


Figure 5.6: Illustration of the distributions of the four cultural value clusters using two pairwise examples. Left hand side: Xenophilia (XEN) vs Importance of Personal Prohibitions (PP). Right hand side: Religion (REL) vs Wellbeing (WB). The small circles each represent individual countries (N=109). The ellipses represent each of the clusters, where the centers are the cluster centers and the diameters are the within cluster standard deviation. The clusters are colored as follows: blue = Western, green = African-Islamic, red = Communist-Confucian, purple = Catholic.

would like to know which countries are highly likely to fall into the same cluster, so we employ a conservative cutoff point: if the probability of two countries clustering is less than 0.95, we assume the countries are not related.

This result is four isolated components in the network. They correspond well with our original four clusters:

1. Japan, Spain, Switzerland, Australia, Finland, Great Britain, New Zealand, Norway, Sweden, Uruguay, Germany, Canada, Andorra, France, Netherlands, Austria, Belgium, Denmark, Iceland, Luxembourg.

2. Nigeria, Turkey, Bangladesh, Pakistan, Philippines, Georgia, Algeria, Egypt, Indonesia, Iraq, Jordan, Morocco, Saudi Arabia, Tanzania, Uganda, Zimbabwe, Ghana, Malaysia, Mali, Rwanda, Qatar, Palestine, Kuwait, Kosovo

3. Belarus, China, Russia, Slovakia, South Korea, Albania, Bulgaria, Estonia, Hungary, Latvia, Lithuania, Moldova, Serbia and Montenegro, Ukraine, Taiwan, Hong Kong

4. Argentina, Brazil, Chile, Mexico, Poland, Colombia, Peru, Puerto Rico, Dominican Rep., Trinidad and Tobago, Italy, Guatemala, Ireland, Portugal, North Ireland

However, there were a number of countries that were singleton isolates. In other words, they were not conclusively attached to any of the four network components. They were Czech Rep., India, South Africa, El Salvador, United States, Venezuela, Armenia, Azerbaijan, Bosnia, Croatia, Macedonia, Romania, Slovenia, Iran, Israel, Kyrgyzstan, Singapore, Viet Nam, Burkina Faso, Cyprus (G), Thailand, Zambia, Ethiopia, Uzbekistan, Kazakhstan, Ecuador, Libya, Yemen, Lebanon, Tunisia, Bahrain, Cyprus (T), Greece and Malta.

A number of these singleton countries were also those which fell into surprising clusters during the standard k-means (such as Singapore and South Africa being in the Catholic cluster for instance). Therefore, by taking into consideration the uncertainty surrounding contemporary cultural values, we are able to explain why certain countries were not clustered according to their cultural-history.

5.3.3 Clustering Within Cultural Factors

Though the k-means algorithm has identified four clusters, we may not expect the clusters to be separable in all nine cultural factors. We define clusters as being distinct from one another if the sum of the distributions is bimodal. For example, in a situation where all the clusters are separated, we would expect the total summed distribution to have four peaks, and, in cases where they are mixed, just one.

We know a mixture of two distributions is bimodal if $|\mu_2 - \mu_1| > \sigma_1 + \sigma_2$. In other words, when the sample standard deviation region of the first distribution (with parameters $mean = \mu_1$ and $SD = \sigma_1$) and the standard deviation region of the second distribution (with parameters $mean = \mu_2$ and $SD = \sigma_2$) do not overlap [Schilling et al., 2002]. Figure 5.7 shows the cluster distributions in two illustrative cultural factors: one where there is complete mixing (right hand side) and one where the clusters are largely separated (left hand side).

Figure 5.8 shows that Institutional Confidence (IC), Interest in Politics (IP) and Prosociality (PRO) show no separation between the clusters. We see a bimodal distribution in the case of Religiosity (REL), where Communist-Confucian mix with Western countries, and Catholic and African-Islamic countries mix at different ends of the scale. We also see bimodal distributions for Xenophilia (XEN) and Intrinsic Tolerance (IT), but this time Catholic countries mix with Western ones and Communist-Confucian are at the intolerant end with African-Islamic countries. The final bimodal cluster is Political Engagement (PE), where the West alone is highly politically engaged, the other three are mixed at the politically disengaged end of the scale. Finally, there are two factors which are tri-modal. The first is Wellbeing (WB), where the West and Catholic countries have the highest wellbeing, followed by African-Islamic and lastly Communist-Confucian countries which have very low Wellbeing. The second tri-modal factor is the Importance of Personal Prohibitions (PP), where Western countries find them unimportant, Communist-Confucian and Catholic countries are mixed and Islamic-African countries find them important.

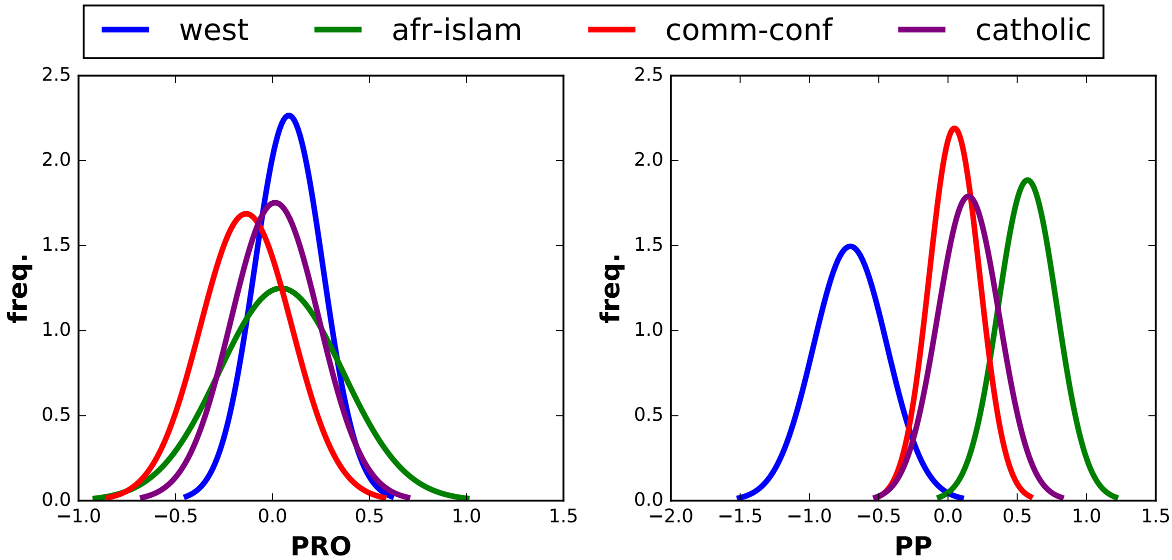


Figure 5.7: Illustration of cluster separability in two cultural factors. Left hand side: Prosociality (PRO). Right hand side: Importance of Personal Prohibitions (PP). The colored lines represent the distributions of countries within the following clusters: blue = Western, purple = Catholic, red = Communist-Confucian and green = African-Islamic.

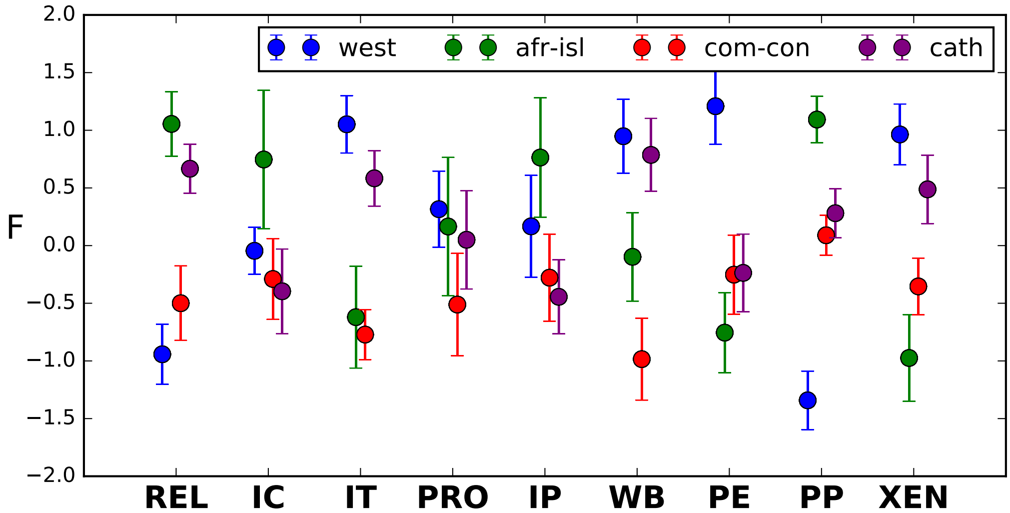


Figure 5.8: The distribution within each cluster in each of the nine cultural factors. The circles are the cluster mean and the bars are the sample standard deviation of the countries within each cluster. Each cluster is colored as follows: blue = Western, green = African-Islamic, red = Communist-Confucian and purple = Catholic. Cultural factor abbreviations are as follows: REL = Religiosity, IC = Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia.

5.3.4 Cluster Heterogeneity

Aside from the separability of the clusters, we want to know the absolute variance within each cluster because it gives an idea of the 'tightness' of the cluster. To do this, we utilize a measure we call Heterogeneity H, which is the average absolute distance of each cluster member to its center. Formally:

$$H_{k,f} = E[|D_i|] \tag{5.3}$$

where, D_i is the distance between country i and its respective cluster center k in the cultural factor f.

The top row of figure 5.9 shows that the heterogeneity of the clusters within each of the cultural factors are usually comparable. We see the same similarity when measuring H across all nine cultural factors — making use of the multi-dimensional version of Heterogeneity $H_k = E[|Di|]$, where the distance measure is $Di = \sqrt{\sum_{f=1}^{f=F} D_f^2}$. By this measure, we see that Western, Catholic and Communist-Confucian clusters have roughly equal heterogeneity ($H_{west} = 4.18 \pm 0.37$, $H_{cath} = 4.36 \pm 0.18$ and $H_{com-con} = 4.43 \pm 0.36$, where the error of the bootstrapped samples are in the 95th percentile). The exception is the African-Islamic cluster which is far looser ($V_{afr-isl} = 5.88 \pm 0.3$). This is driven by a large range of opinion in Institutional Confidence (IC), Interest in Politics (IP),Tolerance of Intrinsic Differences (IT) and Xenophilia (XEN).

If we look at the combined cluster heterogeneity in each cultural factor (bottom row of figure 5.9), there are some interesting differences. We see tight clusters for the Importance of Personal Norms ($H_{PP} = 0.32 \pm 0.04$) and Religiosity ($H_{REL} = 0.42 \pm 0.05$), but loose clusters for Institutional Confidence ($H_{IC} = 0.64 \pm 0.09$), Interest in Politics ($H_{IP} = 0.66 \pm 0.07$) and Prosociality ($H_{PRO} = 0.75 \pm 0.08$).

5.3.5 Value Change Within Clusters

In chapter four, we separated generational change (the socialized change occurring in successive birth cohorts) and opinion change (transient change which affects the entire population at a particular time). We did this by splitting the representative cross-sectional samples provided by the WEVS by birth cohort. We compare the opinion and generational change within each cultural value cluster.

Figure 5.10 shows the generational and opinion changes within each cluster in each of the nine cultural factors. The bottom row of figure 5.10 shows that generational change is stronger in Western compared to African-Islamic countries (6/9 of the cultural factors); also very often Communist-Confucian and Catholic countries show intermediate generational change. Two of the exceptions are Institutional Confidence and Interest in Politics, which incidentally are two of the cultural factors where the clusters are not separable. Futhermore, African-Islamic countries generally exhibit near zero generational change (8/9 of the cultural factors), the exception being

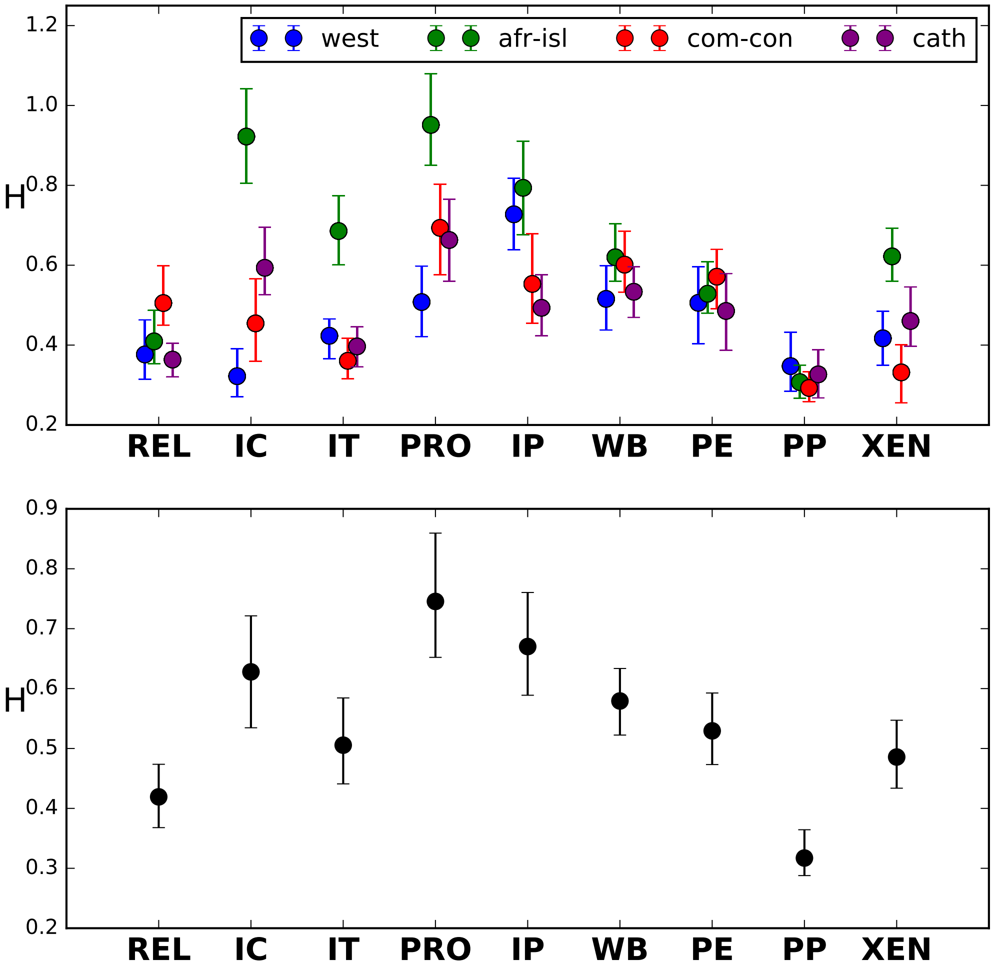


Figure 5.9: Top row: the heterogeneity H for the four clusters in each cultural factor. Bottom row: the combined heterogeneity H of all clusters in each cultural factor. The circle is the mean H and the error bars are the 95th percentile of a bootstrap sample (N=200). The four cultural value clusters are colored as follows: blue=Western, green=African-Islamic, red=Communist-Confucian and purple = Catholic. Cultural factor abbreviations are as follows: REL = Religiosity, IC = Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia.

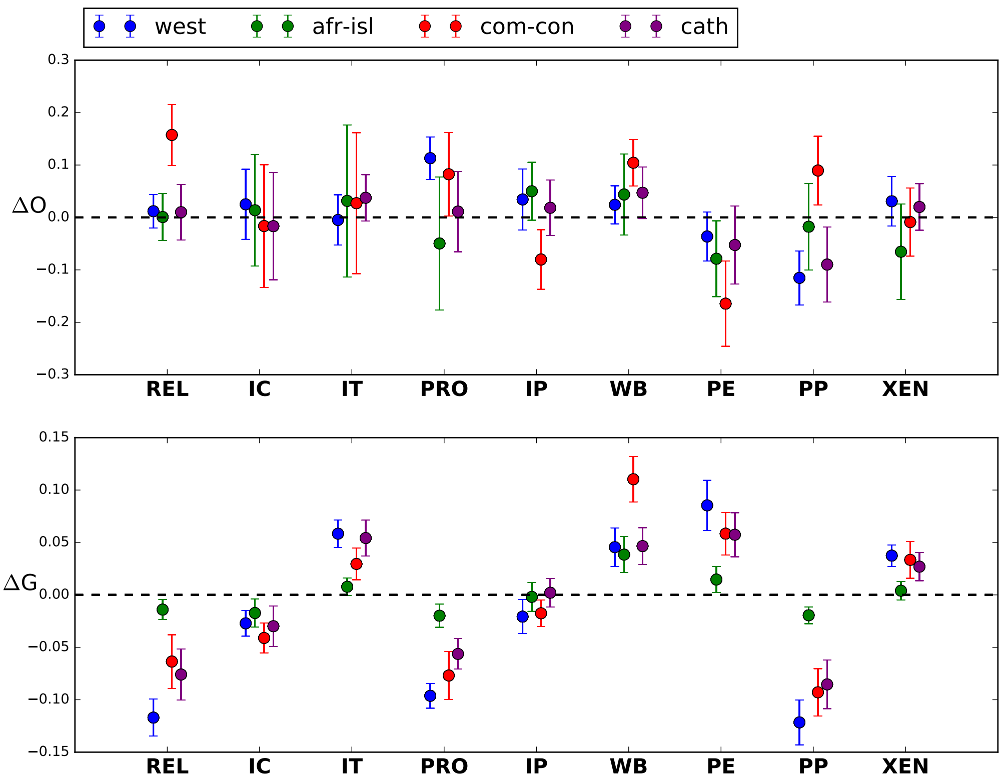


Figure 5.10: Top row: the mean opinion change (ΔO) for each cluster in each cultural factor. Bottom row: the equivalent plot, but for generational change (ΔG). The rates of change are calculated in chapter four using the two stage Bayesian linear regression. The error bars are the 95th percentile of a bootstrap sample (N=200) and the circles are its median. The colors representing each cluster are blue = Western, green = African-Islamic, red = Communist-Confucian and purple = Catholic. Cultural factor abbreviations: REL = Religiosity, IC =Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia.

Wellbeing where the expected change is the same as Catholic and Western countries. Wellbeing is also unusual because Communist-Confucian countries show larger generational increases than all other clusters; this is the only cultural factor where a non-Western cluster clearly exhibits the largest change.

There is a lot of within-cluster variation for opinion change — evidenced by the large error bars in the top row of figure 5.10 — suggesting that cultural-history does not predict changes in opinion. The exception seems to be the Communist-Confucian cluster, where we see non-zero average changes in Religiosity, Importance of Personal Prohibitions, Wellbeing, Interest in Politics and Political Engagement. The other three clusters show fewer examples of clearly directional average change (west: changes in two factors, Catholic: one factor and African-Islamic: one factor). Given that the beginning of the WEVS in 1990 corresponds with the fall of Communism, it is possible that the countries from the Communist-Confucian cluster are independently experiencing similar environmental shocks. The sudden decrease in Political Interest and Political Engagement has been attributed to a post-honeymoon effect which often follows a successful revolution [Inglehart and Catterberg, 2002]. The increase in Religiosity could be a bounce-back effect following the end of communist-era religious repression. The increase in Wellbeing might also be a bounce-back, but from the collective depression felt when an all-encompassing belief system (like communism) collapses [Inglehart and Baker, 2000]. This would also explain the extremely low levels of Wellbeing measured in the Communist-Confucian cluster during the last 25 years (see figure 5.8).

5.3.6 Cluster Economic Development

The second part of this thesis analyzes the relationship between cultural values and human development. Here we briefly introduce GDP per capita, we do so to characterize the average economic development of each of the cultural value clusters. We use GDP per capita (normalized to 2005 US dollars) from the Word Bank (referred to simply as GDP from this point onwards). The distribution of GDP is highly skewed, with many countries at the poor end of the scale [Deaton, 2013]. To account for this, we present log GDP, as well as linear GDP. When we treat GDP as a linear variable, we see clearly that the Western cluster is far richer than the others (left hand side of figure 5.11) and, if we ignore the errorbars, the second richest cluster is Catholic, followed by Communist-Confucian and lastly African-Islamic. When we look at log GDP, this ordering of wealth by cultural-history is even more conclusive — the errorbars overlap less on the right hand side of figure 5.11). This means that that GDP (or at least $log(GDP)$) corresponds with cultural-history. The Western cluster is the richest and the African-Islamic cluster the poorest, with Catholic and Communist-Confucian countries in the middle.

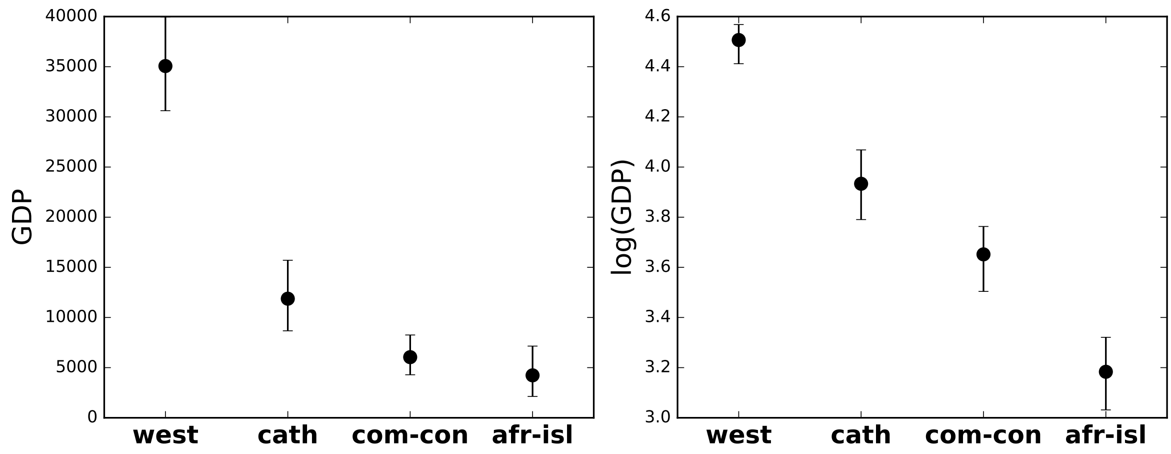


Figure 5.11: Left hand side: mean GDP per capita (GDP) of countries in each of the four cultural value clusters. Right hand side: the equivalent plot but using $log_{10}(GDP)$. The error bars are the 95th percentile for a bootstrap sample (N=200). Cluster name abbreviations: west=Western, cath=Catholic, com-con=Communist-Confucian and afr-isl = African-Islamic.

5.3.7 Cultural, Geographic and Historical Features

Cluster membership correlates with economic development, but it also seems to correlate with deep rooted cultural-historic features. Here we test whether membership of the four clusters can be predicted by 16 cultural-historical variables. Our choices for linguistic and religious categories were guided by data constraints and a desire to capture cultural diversity.

Linguistically it makes sense to divide countries by language family. However, the countries that predominately speak Indo-European languages comprise 61% of the WEVS sample. Therefore, to capture more linguistic information, we split the Indo-European language tree into six subtrees.

The big state religions make more natural categories (Catholicism, Islam, Protestantism etc) to which countries can be easily assigned. But some countries do not have a clear state religion and have populations that subscribe to many different religions (China for example [Fukuyama, 2012]). For simplicity 'The Religious Characteristics of States' data that we used, categorizes these non-state religions as 'Animism' [Brown and James, 2015]. This is based on the assumption that high god religions [Norenzayan, 2013] evolve from less complex religions based on ancestor worship and animism [Murdock, 1967].

The cultural-historic variables we used are of three types:

Religion — the predominant religion in the country during the year 1900. The religious variables are Catholic, Protestant, Orthodox, Islam, Buddhist and Animist. These six religions were chosen because they represent the predominant religion in more than three of the 109 WEVS countries. We used religion from 1900 because our belief is that our four clusters reflect deep history, so using modern day predominant religions would bias our results. The data is taken from the 'Religious Characteristics of States' dataset'(RCS). It collates data from a wide range of sources, to measure the historical prevalence of religious sects in 220 states [Brown and James, 2015].

Linguistic — the language family of the predominant language in the country. The linguistic variables are Italic, Balto-Slavic, Germanic, Indo-Aryan, Turkic and Semitic. Again, these categories were chosen because they are the predominant language family in more than three of the 109 WEVS countries. Linguistic data were taken from the Ethnologue website [Lewis, 2009]. It documents all known extant languages and the countries in which they are spoken. Unfortunately, unlike religious denomination, we are forced to use modern-day language predomination because the historic data are not available.

Colonial History — was the country ever a part of the British Empire, Spanish Empire, Ottoman Empire or Former Communist. These data were drawn from the Encyclopedia Britannica [Encyclopedia Britannica, 2018].

We want to see if membership of our cultural clusters overlap with any of these cultural-historic variables. Seeing as all the variables concerned are binary, we compare them using the Phi coefficient ϕ. Formally:

$$\phi = \frac{n_{1,1}n_{0,0} - n_{1,0}n_{0,1}}{\sqrt{(n_{1,1}+n_{1,0})(n_{1,1}+n_{0,1})(n_{0,0}+n_{1,0})(n_{0,0}+n_{0,1})}} \tag{5.4}$$

where $n_{0,0}$ is the number of observations which are zero in both binary vectors; $n_{1,1}$ is the number of observations where both equal one; $n_{1,0}$ is the number where just the first vector equals one and $n_{0,1}$ is the number where just the second value equals one. It is equivalent to the Pearson correlation coefficient applied to binary variables [Warner, 2013].

If we take $\phi = 0.4$ to be a substantive threshold, we find that each cluster is characterized by a religion and a language family.

The Western cluster is correlated with Germanic languages and Protestantism, the Catholic cluster with Italic languages and the Catholic religion, the Communist-Confucian cluster with Balto-Slavic languages and the Orthodox religion and the African-Islamic cluster with Semitic languages and Islam. In addition, two of the clusters are correlated with colonial history: the Catholic cluster with the Spanish Empire and the Communist-Confucian cluster with Former Communist countries.

We also see clear geographic structure in figure 5.4. On the Afroeurasian landmass, Western Europe falls into the Western cluster, East Europe and North Asia are Communist-Confucian, South Asia and Africa are African-Islamic, Latin America is Catholic, along with Catholic European countries on the boundaries of Western Europe. Some of these correlations may seem obvious, but that is because we drew the cluster labels from an intuitive grasp of the cultural-historic similarity between cluster members.

	Western	**Catholic**	**Comm-Conf**	**African-Islamic**
Religious	Protestant (0.59)	Catholic (0.48)	Orthodox (0.41)	Islam (0.56)
Linguistic	Germanic (0.48)	Italic (0.47)	Balto-Slavic (0.54)	Semitic (0.41)
Colonial		Spanish Empire (0.5)	Communist (0.61)	

Table 5.1: Substantively significant ϕ coefficients which measure the membership overlap between cultural-historic categories and the four cultural clusters. The columns are the four cultural value clusters and each row represents the three cultural-historic super-categories. Each cell contains the variables from each cultural-historic super-category where $\phi > 0.4$. The bracketed values are the ϕ coefficients themselves (statistical significance: $p << 0.001$ for all noted ϕ.)

5.3.8 Cultural Anomalies

Despite the cultural value clusters aligning with linguistic, colonial, religious and geographic variables, many countries are clustered in non-obvious ways. The anomalous countries are as follows: the Western cluster contains Japan, Uruguay and Israel; the African-Islamic cluster contains El Salvador, the Communist-Confucian cluster contains Lebanon and the Catholic cluster contains Singapore and South Africa. Figure 5.12 illustrates the positions of these countries relative to the four clusters (we only present six cultural factors because, as we saw in figure 5.8, the clusters are not separable in Prosociality, Interest in Politics and Institutional Confidence).

Figure 5.13 shows that four out of seven of the anomalous countries — Israel , El Salvador, Singapore and South Africa — are equally near a second cluster. These alternative clusters sometimes match the countries geography and culture: South Africa and Singapore are both also close to the African-Islamic cluster and El Salvador is close to the Catholic cluster. The Israeli result is unusual because, based on its language and geography, it should be close to the African-Islamic cluster, which in fact is the farthest removed. Israel is actually close to the Catholic cluster, as well as the Western one.

Based on cultural-history, we expect to find Lebanon in the African-Islamic cluster, but it is instead in the Communist-Confucian one. Closer inspection shows it is aligned with the African-Islamic cluster in terms of Wellbeing and Political Engagement. However, it is less Religious and places less Importance on Personal Prohibitions (PP); see figure 5.12. An unusual feature of Lebanon, is its high tolerance of Intrinsic Differences, yet very low levels of Xenophilia; these are two cultural factors which are generally positively correlated.

When we quantified the uncertainty about a country's cluster membership (using k-means on the the posterior distribution from the Bayesian hierarchical imputation model), many countries cannot be placed with confidence. These countries include many of the anomalies we discuss: such as Lebanon, Israel El Salvador, South Africa and Singapore. However, even taking into account this uncertainty, both Japan and Uruguay still fall into the Western cluster.

Japan has a fairly unique cultural-historic profile, so its not clear where it should cluster. Although, based on geography alone, it should be with the Communist-Confucian countries, which happens to be the next nearest cluster. Figure 5.14 compares the 20th century generational

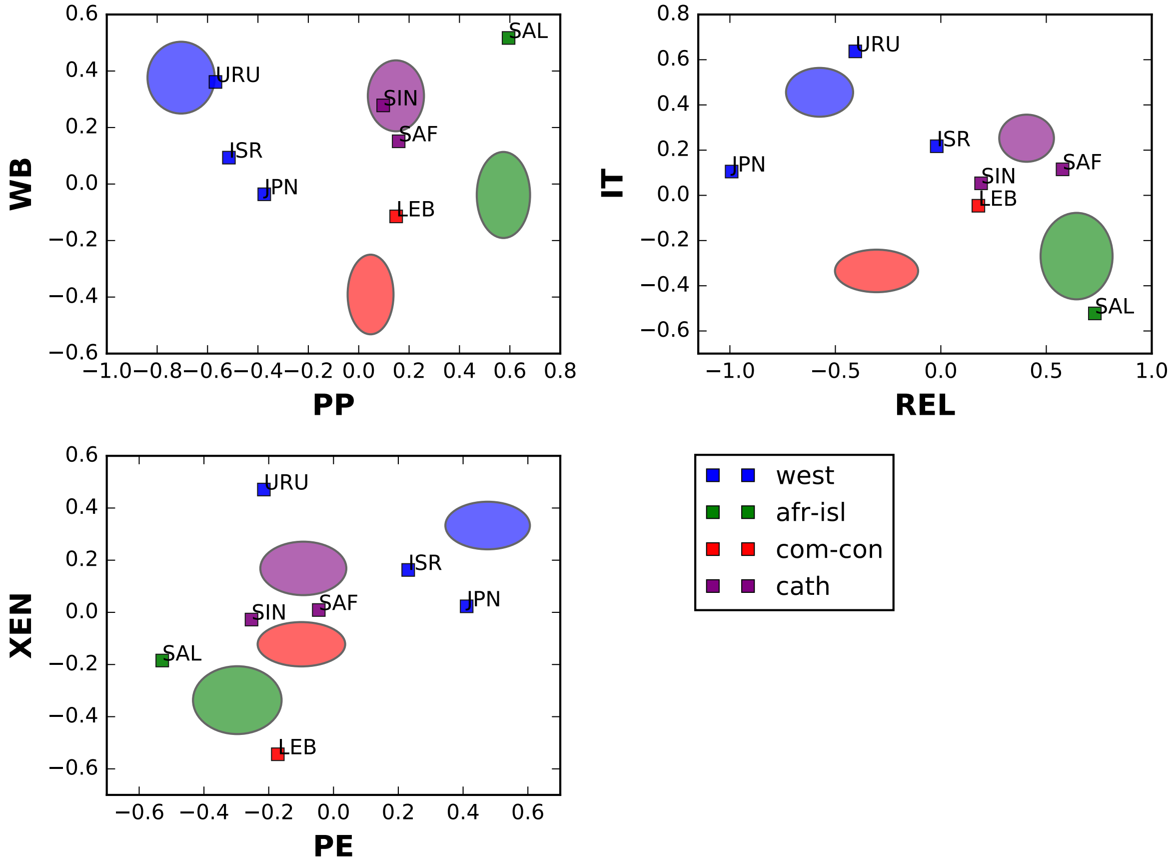


Figure 5.12: Illustration of the anomalous countries in relation to the four cultural value clusters. Three pairwise cluster plots where each axes represents one of the six cultural factors in which the clusters are separable. The seven anomalous countries are plotted on each and are labeled using the following abbreviations: JPN=Japan, URU=Uruguay, ISR=Israel, SAL=El Salvador, LEB=Lebanon, SIN=Singapore and SAF=South Africa. The colored ellipses represent the clusters, they are centered on the cluster mean and have diameters equal to the standard deviation. The clusters are colored as follows: blue=Western, green=African-Islamic, red=Communist-Confucian and purple=Catholic. Cultural factor abbreviations: REL = Religiosity, IT = Intrinsic Tolerance, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions and XEN = Xenophilia.

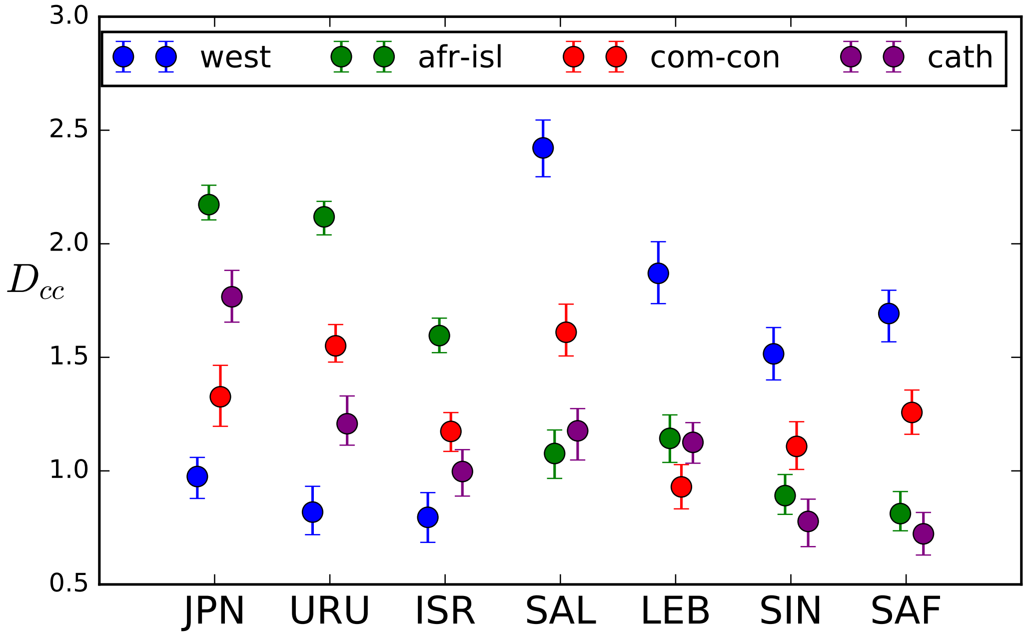


Figure 5.13: The distance between the seven anomalous countries and each of the four cluster centers (D_{cc}). The error bars represent the 95th percentile of a bootstrap sample (N=200), the circles are the medians. Cultural value clusters: blue=Western, green=African-Islamic, red=Communist-Confucian and purple=Catholic. Anomalous country abbreviations: JPN=Japan, URU=Uruguay, ISR=Israel, SAL=El Salvador, LEB=Lebanon, SIN=Singapore and SAF=South Africa.

changes in cultural values of Japan and China (a country of theoretically similar cultural-history). It shows that Japan diverged from China in many of the cultural factors which characterize the difference between Western and Communist-Confucian countries — Intrinsic Tolerance, Xenophilia and the Importance of Personal Prohibitions.

Unlike Japan's recent divergence from China, when we look at the generational changes in Uruguay — compared to a typical Catholic country like Mexico — we see evidence of much older divergence. Figure 5.15 shows non-intersecting lines, which indicate that the historical time when Uruguay and Mexico shared cultural values is deeper in history than for China and Japan. In the Importance of Personal Prohibitions (one of the cultural factors which defines the difference between Catholic and Western countries) the trends are roughly parallel, suggesting that Uruguayans and Mexicans might never have agreed on this issue. Although, Uruguay does show generational changes in Wellbeing and Political Engagement which are identical to those of Mexico.

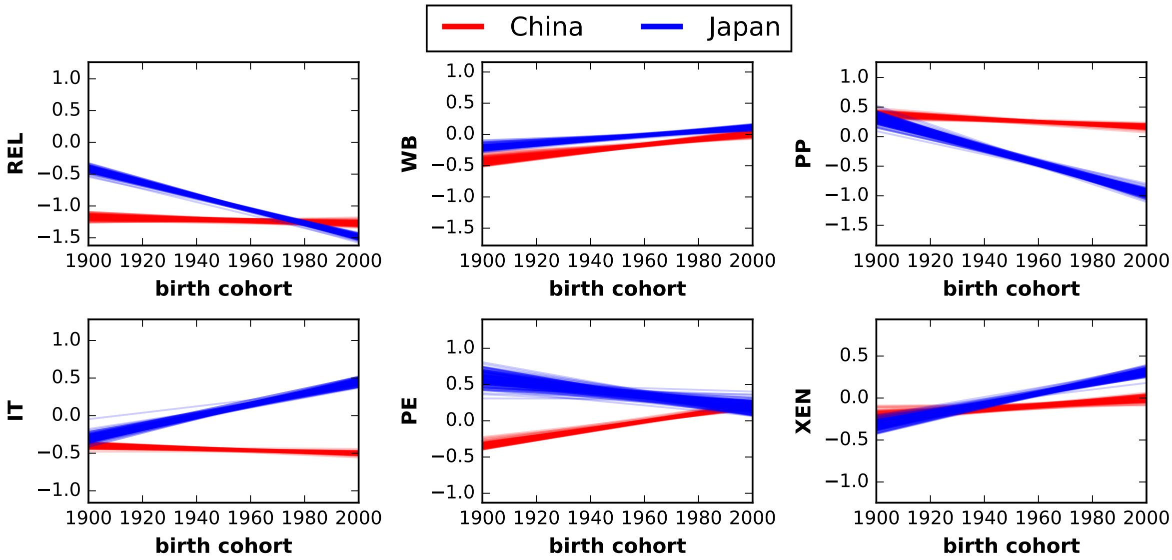


Figure 5.14: Generational changes of Japan (blue lines) and China (red lines) during the 10 decades of the 20th century. Each regression line represents a sample from the posterior distribution, derived using the two-stage Bayesian linear regression (see chapter four). Cultural factor abbreviations: REL = Religiosity, IT = Intrinsic Tolerance, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions and XEN = Xenophilia.

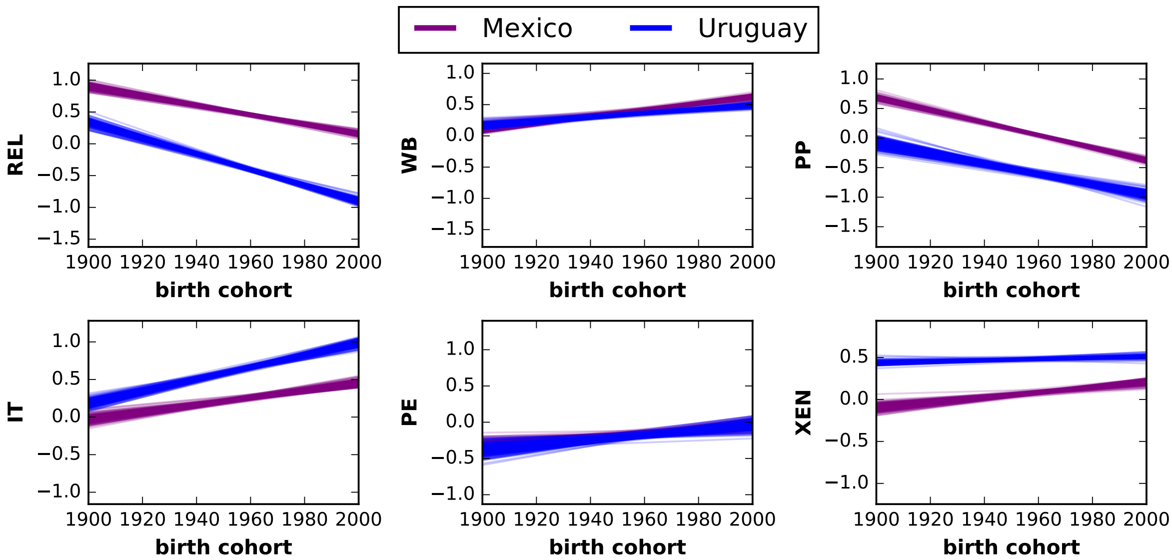


Figure 5.15: Generational changes of Uruguay (blue lines) and Mexico (purple lines) during the 10 decades of the 20th century. Each line represents a sample from the posterior distribution, derived using the two-stage Bayesian linear regression (see chapter four). Cultural factor abbreviations: REL = Religiosity, IT = Intrinsic Tolerance, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions and XEN = Xenophilia.

5.4 Discussion

We have identified four cultural value clusters which correspond with geography, linguistics, religion and colonial history. Although AIC analysis shows that a choice of two or three clusters would also be valid, cluster membership in these cases does not neatly correspond with cultural-historic variables. In the same way, adding a fifth cluster seemingly splits the African-Islamic group arbitrarily, although closer inspection may uncover deep rooted cultural differences. Four clusters is fewer than most scholars have entertained [Huntington, 1996; Inglehart and Baker, 2000], but is similar to Miguel Basanez's model of three global macro-cultures: cultures of joy, honor and achievement [Basanez, 2016].

Cultures of joy correspond with our Catholic cluster, cultures of achievement is roughly in line with our Western cluster (although Basanez includes the Confucian culture in this category), cultures of honor align with our African-Islamic cluster (although Basanez includes Christian Orthodox countries). The key difference between our clusters and those of Basanez is our fourth cluster: Communist-Confucian. It contains mainly Christian Orthodox and Confucian countries, which Basanez included in cultures of honor and achievement respectively. This cluster may have been overlooked because the colonial history which unites them is Communism which, compared to other colonial histories, is a fairly recent event.

The most consistent cultural value differential is between the Western and African-Islamic clusters. They are different in six out of nine of the cultural factors (the remaining three cultural factors are Prosociality, Institutional Confidence and Interest in Politics, and they exhibit no separability between clusters). Western countries are less religious (REL), more tolerant (IT and XEN), find personal prohibitions less important (PP), more politically engaged (PE) and happier (WB). In addition, Western countries have seen the most generational change in the last 100 years which, as we saw in chapter four, goes a long way in explaining the cultural value inequalities we see today. The cultural value differences between Western and African-Islamic clusters are mirrored by levels of economic development (see figure 5.11).

Catholic and Communist-Confucian countries inhabit both an economic and cultural value middle ground, so we might view them as developing countries. Yet Catholic and Communist-Confucian countries have different cultural value profiles, possibly presenting evidence of two possible development pathways. Catholic countries are high in Xenophilia, Intrinsic Tolerance and Wellbeing; whereas Communist-Confucian countries are low on all these variables, but considerably less religious. We should be cautious with this developmental pathway hypothesis because their generational change profiles are fairly similar (bottom row of figure 5.10), so the differing profiles may just reflect different starting points in recent history.

The fact that we have 'cultural zones' defined by economic development is not new; neither is the idea that these same cultural zones are determined by cultural-historic variables [Inglehart and Baker, 2000]. We provide support for the second point by showing that cluster membership is substantively correlated with linguistic family, religion and colonial history. These cultural relationships correspond with a geographic structure which makes them hard to distinguish in statistical analysis.

That said, Luke Matthews [Matthews et al., 2016] showed that cultural proximity is a superior explanation for economic and political innovations than geographical proximity. Although, the countries involved in this study were limited to those who speak an Indo-European language. This is because Mathews' used phylogenetic methods, so was limited to using languages from a single phylogenetic tree because a 'super-phylogenetic' tree does not exist (that is a single tree connecting all the languages on Earth). This means phylogenetic analysis is not an option for our global sample. Enrico Spolaore suggests a possible work around by using genetic distance (for which global similarity matrices are available) as a proxy for cultural differences [Spolaore and Wacziarg, 2016].

We confirm previous work showing that cultural value clusters are not separable in the Prosociality cultural factor [Minkov et al., 2013]. However, we also discovered that cultural value clusters are not separable in Institutional Confidence and Interest in Politics. These three factors are the new variance that is absent from the standard Inglehart-Welzel (I-W) cultural map (see chapter three). Figure 5.9 shows that the clusters are loose in these dimensions, particularly for African-Islamic countries. This means that cultural-history does not explain the distribution of countries in Institutional Confidence, Prosociality or Interest in Politics.

Although cultural-history and geography go a long way in explaining cluster membership, we identified some interesting anomalous countries. There are three countries classified as Western which, cultural-history dictates, should be in different clusters. Japan adopted Western cultural values possibly because it adopted Western institutions. Following the Meiji restoration in 1868, Japan embarked on rapid modernization. It imported many Western institutions, such as education, science and technology, communication systems and banking [Encyclopedia Britannica, 2018], which could also have led to Western style cultural values.

In the case of Israel it was not just institutions that were transplanted, but the population itself. Before Israel's founding in 1948 (and since), there have been massive immigrations of Jews from the diaspora, the majority of which came from Europe [Sicherman et al., 2018]. This was accompanied by occasional expulsions of Arabs, who had previously made up the majority of the population [Sicherman et al., 2018]. Given the heritable nature of cultural values and norms, we might expect their cultural values to persist and be more reflective of European rather than African-Islamic culture. That said, immigrants to a new culture will tend towards the cultural values of the existing population [Norris and Inglehart, 2012], which could explain why Israeli exhibit levels of religiosity and tolerance tending towards that of African-Islamic countries.

Uruguay's classification as a Western country may be seen as a combination of population and institutional transplantation. It certainly has adopted many western style institutions — such as the rights of women to divorce and vote, the abolition of the death penalty and legalized abortion [Goni, 2016]. Figure 5.15 indicates that the divergence between Uruguay and other

Catholic countries occurred more than 100 years ago which means it might stretch back to the colonial period. The Uruguayan population is 88% white European [CIA, 2018], suggesting that these settlers may have brought with them European institutions and cultural values. Although this alone cannot be the explanation because other Latin American countries, such as Chile and Argentina, also have very high white European populations.

Lebanon, for a Middle Eastern country, has a long history of economic and social liberalism — particularity in its capital Beirut [Totten, 2013]. Prior to 1975, Lebanon was one of only two countries in the Middle East and North Africa (along with Israel) which was considered free in terms of civil liberties and political rights. Despite the civil war between 1975 to 1990, Lebanon is still less Religious (REL) and less concerned with Personal Prohibitions (PP) than other African-Islamic countries. It is also far more tolerant of behaviors like homosexuality, drug abuse etc (IT), but it is very intolerant of foreigners and immigrants (XEN). This unusual divergence could be due to outside interference by a multitude of other countries (particularly Syria) during its civil war, resulting in a breakdown of trust [Totten, 2013].

We use purely statistical criteria to select for the number of clusters, but because AIC recommended somewhere between two and four clusters, we subjectively chose four clusters because they reflected interesting cultural-historic commonalities. Statistics is a process of summarizing complexity with the goal of identifying general patterns; outliers are a feature of this type of analysis. It is right, therefore, that our cluster labels reflect commonalities shared by the majority of a cluster's countries. That said, we offer only speculative explanations for the outliers; such as Japan's presence in the Western cluster.

Identifying these four clusters was an important step in finding an explanation for the grouping of countries according to stable cultural features like language and religion. Cultural values of Secular-Rationalism and Cosmopolitanism originated in Western Europe during the Enlightenment and have been diffusing to other countries ever since along geographic and cultural pathways, hence countries closer to Western Europe (geographically and culturally) are more likely to hold these values [Ruck et al., 2019].

5.5 Conclusion

We used an unsupervised clustering algorithm — k-means clustering — to identify groups of countries with similar cultural values. Contrary to the majority of previous work, which generally assumes somewhere on the order of ten clusters, we found that four clusters best reflect cultural-historic variables like language, religion and colonial history. The four clusters are Western, African-Islamic, Communist-Confucian and Catholic.

We show that African-Islamic countries have experienced almost no stable generational value change in the 20th century and Western countries have experienced the most. This is mirrored in their respective levels of economic development. We go on to show that Catholic and

Communist-Confucian countries occupy an economic and cultural value middle-ground, yet their cultural value profiles are different. The previous unquantified variance discovered in chapter three — Prosociality, Institutional Confidence and Interest in Politics — is not explained by the cultural-history of nations.

CHAPTER 6

Generational Cultural Values and Human Development

In chapters two to four we built a description of recent cultural value dynamics. We discovered nine cultural factors which offer a reduced form explanation of the WEVS data. We then separated two modes of cultural value change from the WEVS cross-sectional samples — opinion and generational change. Finally, we identified four clusters of culturally similar countries that reflect cultural-historic variables. The focus for the next three chapters is to place changing cultural values in the wider context of society and development.

We confirm that the modern day distribution of cultural values is highly correlated with external variables of development, but go on to show that long-term generational *changes* are also correlated. This suggests that development and cultural variables are related, but establishing causal pathways is difficult. We attempt to rule out certain classes of causal models by testing whether macro-level variables precede others using time-lagged regressions. We aim to provide some clues for answering the big question, 'do improvements in development cause cultural value shifts, or vice versa?'

We analyze the temporal relationships between cultural values and two key developmental variables: economic development and democratic institutions. One-hundred-year time series are available for both of these development variables [Bolt et al., 2014; Marshall et al., 2017] and by using generational trends as a proxy for historic change, we also have comparable time series for cultural values. Treating birth cohorts as representative of an historical period is not new [Foa et al., 2016; Inglehart and Welzel, 2005], however using them in formal time-lagged regressions is.

6.1 Development Data

The two aspects of human development we focus on are economic development and democratic institutions.

Our novel methodological step, supported by the analysis in this chapter, is to extend cultural value time series to the entire of the 20th century by acknowledging that cultural values are formed during the first few decades of life [Henrich and Henrich, 2007; House et al., 2013; Ruiz-Mallén et al., 2013; Sears and Funk, 1999]. Hence, we must select measures of human development which are reliable across the last 100 years. For example, the income Gini index (the standard measure of economic inequality) is unsuitable for our purposes because limits in the survey data mean international data only stretches back to around 1980 [Milanovic, 2005].

In another case, the standard human development index is a high dimensional concept incorporating data for education, life expectancy and economic development [Spaiser et al., 2014]. The interrelatedness of measures of socioeconomic development has been a feature of complex human states for millennia [Turchin et al., 2018]. Therefore, given this robust co-occurrence of development variables, we use GDP per capita as proxy for human development because it has a well attested 100-year time series, [Acemoglu et al., 2018; Bolt et al., 2014; Gundlach and Paldam, 2009; Murtin and Wacziarg, 2014], unlike the human development index.

Democracy is not part of the human development index and does not appear in the United Nations millennium goals [United Nations, 2018]. However, it is an oft cited institutional indicator of human development [Acemoglu et al., 2018; Spaiser et al., 2014] and also has well attested long-run time series for multiple countries [Jaggers and Gurr, 1995; Marshall et al., 2017; Miguel et al., 2004; Murtin and Wacziarg, 2014].

Here we present detailed descriptions of the data sets we exploit: the Madison Project data for economic development and the Polity IV data for democratic institutions.

6.1.1 Economic Development

The Madison Project provides historical economic development data [Bolt et al., 2014] consisting of GDP per capita estimates for over 150 countries. It is a commonly cited resource in the study of historical economics and development [Acemoglu et al., 2008; Gundlach and Paldam, 2009; Murtin and Wacziarg, 2014]. To enable comparison between countries with different population sizes and prices, it normalizes GDP to per capita to international prices (in 1990 U.S dollars). It makes estimates stretching back 2000 years (in the case of the Roman Empire for example), but we are only interested in data from around 1870 onwards which means we do not need to be concerned with excessive missing data. Nonetheless, missingness is present in countries for which data is hard to come by — sub-Saharan African countries — and where countries did not exist in the recent past — such as states which formed after the collapse of the Soviet Union. In some cases, historical GDP was estimated for states which no longer exist, but which correspond to modern states. For example, the Cape Colony has been equated with South Africa; Holland with the Netherlands; North and Central Italy with Italy and Great Britain and England with the United Kingdom. In addition, Eritrea and Ethiopia are considered to be equivalent.

The Madison Project acquires GDP estimates from a variety of sources. Recent estimates (since roughly 1950) are taken from respectable international agencies that provide highly calibrated data, such as the United Nations, World Bank and Organization for Economic Cooperation and Development (OECD). Before 1950, systematic calculations of GDP were not carried out but, through expert analysis and interpretation of historical data, GDP per capita estimates can be made. The Madison project uses economic historians to gather information about past economies such as wages, trade and income. Using this information they can run standard GDP calculations. Moreover, by obtaining historic data on population sizes and prices, they can also perform the required normalizations for cross-country comparison [Bolt et al., 2014].

The resolution of generational cultural value trends is 10 years and we need our GDP data to be comparable. Therefore, we take the average observed GDP per capita in each decade from 1870 to 2010. There are certain WEVS countries that were not present in the Madison data — Northern Ireland, Malta, Luxembourg, Iceland, Andorra and Cyprus. All of these countries have small populations and all are European countries, which happens to be the region most represented in the WEVS data (44 European countries out of 109 total). Therefore we decided to omit these countries from future analysis, leaving us 103 countries corresponding with generational cultural value change.

The resolution of both the cross-sectional samples and opinion change is 5 years (ranging from 1990-1995 to 2010-2015). So to make the Madison data comparable with these time series, we take 5-year averages from 1975 to 2020. We only have cross-sectional/opinion trends for 85 countries because they must have participated in at least two WEVS waves. Unfortunately, six of the seven of WEVS countries which do not appear in the Madison data (Northern Ireland, Malta, Luxembourg, Iceland, Andorra and Cyprus) do actually appear in the cross-sectional/opinion data. This leaves us GDP data for 79 countries that correspond with opinion and cross-sectional changes.

We used GDP per capita as our measure of economic development because, unlike more detailed measures like the Human Development Index (HDI) [Spaiser et al., 2014], the Madison project offers unprecedented depth of time.

6.1.2 Democratic Institutions

We measure the quality of democratic institutions using data from the Polity IV project (compiled by the 'Centre for Systemic Peace') [Marshall et al., 2017]. It is a commonly used a measure for historic democracy [Jaggers and Gurr, 1995; Miguel et al., 2004; Murtin and Wacziarg, 2014]. All 167 countries with a population of greater than 500,000 are included and it has a time range stretching back to 1800. Polity IV is a live dataset where historical scores are revised in light of

	DEM	ATH
XRCOMP	Election +2 Transitional +1	Selection +2
XROPEN	only if XRCOMP is Election or Transitional: Dual/election +1 Election +1	only if XRCOMP is Selection : Closed +1 Dual/designation +1
XCONST	Executive parity or subordination +4 Intermediate category +3 Substantial limitations +2 Intermediate category +1	Unlimited authority +3 Intermediate category +2 Slight to moderate limitations +1
PARREG		Restricted +2 Sectarian +1
PARCOMP	Competitive +3 Transitional +2 Factional +1	Repressed +2 Suppressed +1

Table 6.1: The Polity IV project's criteria used to asses the democratic DEM and authoritative AUT nature of a country's intuitions. Each row is an evaluation criteria and each entry shows the points that can be accrued for meeting, or partially meeting, the criteria (only one score from each entry can be accrued). Therefore DEM and AUT are both scored inclusively between 0 and 10. The criteria abbreviations are as follows: XRCOMP is competitiveness of executive recruitment, XROPEN is openness of executive recruitment, XCONST is constraints on chief executive, PARREG is regulation of participation and PARCOMP is competitiveness of participation [Marshall et al., 2017]

new evidence or suggestions from experts in the field. It is difficult to assess democracy quality in the moment, so the most recent data are subject to change as new information comes in [Marshall et al., 2017].

Polity IV presents two scores for each country. The first is the democratic score DEM which is marked out of ten. Points are accrued when certain criteria are met (see table 6.1 for details). Highly democratic institutions should have competitive political participation, constraints on the chief executive and, competitive and open elections. The second score is the authoritarian score ATH which is also marked out 10. The criteria for the ATH is the obverse of DEM (again, see table 6.1 for details). The authority score is high when executives are secretly selected by government insiders, where there are are no constraints on the authority of the chief executive and where participation in the political process is restricted and noncompetitive.

The polity score POL is obtained by subtracting ATH from DEM, resulting in a value between -10 and 10. Both the democratic and authoritarian scores are used because democratic institutional features are not mutually exclusive to the autocratic ones. In other words, countries can have a mixture of democratic and autocratic features. We normalize the score so all values fall between 0 and 1 $POL_{norm} = (POL + 10)/20$.

Like we did with the historical GDP data, to facilitate comparison with the generational cultural value data, we take 10-year averages of the polity score between the years 1870 and 2020. Likewise, to make the Polity IV data comparable to the cross-sectional/opinion change data we took 5-year averages between the years 1975 and 2020. As we mentioned, countries with small populations are not included. WEVS countries which are too small to be evaluated by Polity IV are Andorra, Turkish Cyprus, Hong Kong, Iceland, Malta, Northern Ireland, Palestine and Puerto Rico. This leaves us with 101 countries corresponding with the generational change data and 81 corresponding with the cross-sectional/opinion change data.

There are many examples of state fragmentation during the last 20th century. The case of the Soviet Union in 1990 being a striking recent example. This means there are a number of modern states which are not assigned data before the date of the fragmentation. However given that democratic institutions are effective at the state level, we think it is appropriate to assign the historic democratic scores of the collapsed state to its children states. We made the following adjustments: North Yemense scores are assigned to pre-1990 Yemen; Pakistan scores to pre-1970 Bangladesh; Yugoslavia to pre-1990 Serbia and Montenegro, Croatia, Bosnia, Slovenia and Macedonia; Czechoslovakia to pre-1990 Czech Rebublic and Slovakia and Soviet Union to pre-1990 Moldova, Belarus, Ukraine, Russia, Kazakhstan, Georgia, Azerbaijan, Estonia, Latvia, Lithuania, Kyrgyzstan, Uzbekistan and Armenia. The Baltic states (Latvia, Lithuania and Estonia) were temporarily independent from the 1920's until the 1950's, and so the Soviet Union scores were not used.

6.1.3 Cultural Value Links to Economic Development and Democratic Institutions

Figure 6.1 shows that both democratic institutions DEM and economic development GDP are highly correlated with our cultural factors (the exceptions being Institutional Confidence, Interest in Politics and Prosociality). This confirms previous work showing strong links between cultural values and the variables of human development [Inglehart and Welzel, 2005].

The more interesting question is whether *changes* in cultural values are linked to *changes* in democratic institutions and economic development. Figure 6.2 shows us that generational changes are strongly correlated with changes in human development. Whereas opinion changes only show a weak correspondence. Changes in the cross-sectional samples are also poorly correlated because, as we saw in chapter four, they largely reflect opinion change. It is instructive that the cross-sectional samples correlate slightly better than opinion change because cross-sectional samples are still slightly influenced by generational change. We conclude that sustained human development is linked with the socialized baseline set of cultural values acquired during formative years.

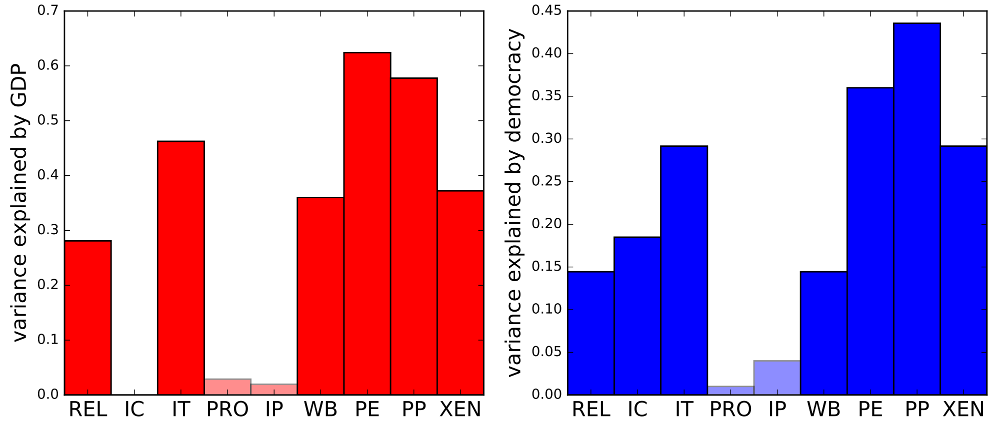


Figure 6.1: Left hand side: the red bars represent the proportion of the variance in each of the cultural factors explained by GDP per capita (comparing averages since 1990; number of countries=106). Right hand side: the blue bars represent the proportion of the variance in each of the cultural factors explained by democracy (comparing averages since 1990; number of countries=99). The opaque bars mean Bonferoni corrected 5% significance level ($p < 0.006$) has been reached. Abbreviations: REL = Religiosity, IC =Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia.

6.2 Multi-Level Time-Lagged Linear Regression (General Form)

We have made the case in this chapter that strong linkages exist between generational cultural value change and human development indicators (economic development and democratic institutions). Next we want to find out which way the causal arrow runs. We use a time-lagged linear regression to help answer this question. Such models normally compute data with a single time series for each variable. We, on the other hand, have many short time series, each representing a WEVS country. We include all the data in a single multi-level model which includes a random effect for each country γ_i, thus maximizing statistical power.

In cross-cultural studies, it is vital to control for the historical non-independence of countries; this avoids 'Galton's problem'. Galton's problem arises when we are not sure if a correlation between two variables exists because of some interesting exogenous cause, or just because the countries are culturally related [Mesoudi, 2011]. One way of controlling for cultural relatedness is to include language phylogenies as a proxy [Mace and Jordan, 2011; Pagel et al., 2007]. Unfortunately, this means you are limited to studying countries from within a single language tree and we have a global sample of countries from many language trees. Therefore, we need some other way of controlling for cultural relatedness.

In chapter five, we found four clusters of countries which correspond to stable cultural features like language, religion and colonial history (the four clusters are: African-Islamic, Western,

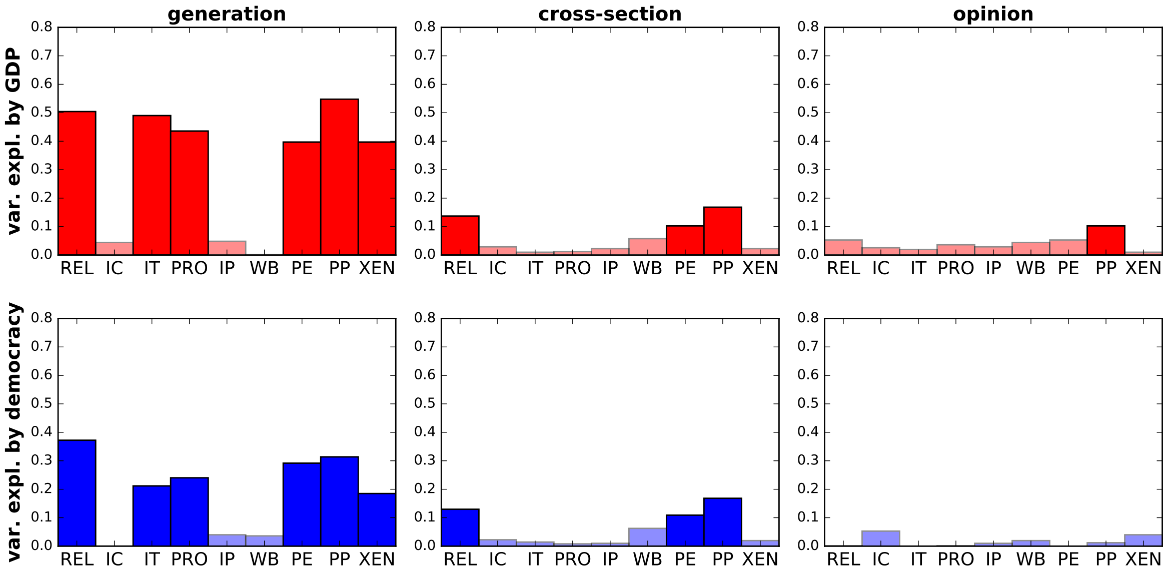


Figure 6.2: Top row: the red bars represent the variance explained by the rate of change in GDP per capita for the rate of change in each cultural factors. Bottom row: the blue bars represent the equivalent plot, but instead the variance explained by the change in democratic institutions. The first column uses the rate of generational change, the second row uses the change in the cross-sectional samples and the third row uses opinion change. The opaque bars mean Bonferoni corrected 5% significance level (p < 0.006) has been reached. Abbreviations: REL = Religiosity, IC =Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia.

Catholic and Communist-Confucian). Also the multi-level model we are using insists that cultural similarity be described using discrete categories. For these reasons, we use membership of our cultural-historic clusters to control for the cultural non-independence between countries. We do this by adding a second random effect to the regression δ_h. The multi-level time-lagged regression takes the general form:

$$Y_t = \mu + \alpha Y_{t-T} + \beta X_{t-T} + \gamma_{h|i} + \epsilon \tag{6.1}$$

where Y is the non-lagged target vector to be predicted by a series of lagged predictors X_{t-T} and a lagged version of itself Y_{t-T}. The vector β is the effect vector for the predictor variables, and α is the effect of the lagged version of Y. The variable μ is the universal intercept, and γ_i and δ_h are adjustments for country i and cultural-historic cluster h respectively. T is the time lag.

For example, Y could be religiosity and X could consist of the two development variables — economic development and democratic institutions. In this case, the vector β would contain two parameters quantifying the effect of past economic development and democracy on religiosity

T years in the future. δ_h checks that the variation in religiosity is not better explained by the cultural relatedness of the countries and γ_i controls for the different cultural value histories of individual countries.

The multi-level time-lagged linear regression is applied to generational change, as well as opinion change and cross-sectional data. That said, we expect similar results when both cross-sectional and opinion change data are used because opinion change dominates the variation in the cross-sectional data (see chapter four).

The regressions are implemented using the 'lmer' package in R [Bates et al., 2015], which uses maximum likelihood to estimate mixed-effect models. However, it does not calculate the variance explained by the model (R^2). So, following [Nakagawa and Schielzeth, 2013], we find R^2 using the following formula:

$$R^2 = \frac{\sigma_\beta^2 + \sigma_h^2 + \sigma_i^2}{\sigma_\beta^2 + \sigma_h^2 + \sigma_i^2 + \sigma_\epsilon^2}$$

where, σ_β^2 is the variance explained by the fixed effects, σ_h^2 is the variance explained by the cultural-historic random effect, σ_i^2 is variance explained by the country-level random effect and σ_ϵ^2 is the model residual.

6.2.1 Robustness Checks

It is important to know when a particular generation becomes active in the adult population because we are using this newest generation as a proxy for the entire population at a particular time. It is hard to imagine that people born in the 1950's meaningfully affect human development in the 1960's, but when do they begin to contribute? The neuroscientifc evidence is unclear [Petanjek et al., 2011; Sowell et al., 1999], but the precise age is likely to vary within a population and across countries. To ensue our results are robust to this uncertainty, we perform the multi-level time-lagged linear regression (equation 6.1) three times. The first time we assume a generation becomes active before the age of 10, in the second before the age of 20 and the third before the age of 30. We do so in the hope our findings will be robust to this choice; the simulation study in the next section tests this hope.

6.3 Simulation Study

Here we simulate two mechanisms that potentially explain the correlation between mass cultural values and emergent development variables. We first suggested these in the literature review and they are as follows:

1. Through processes of socialization, the cultural values of a generation will be proportional to the level of human development in their formative years

2. Human development emerges from the cultural values of the adult population, so the level of human development at a particular time will be proportional to the average level of socialized cultural values in the adult population

In the simulation we use the cultural value and human development variables that are the subject of both the next chapter and our recent published paper [Ruck et al., 2019]: economic development GDP and secularization SEC, where secularization is the inverse of the religiosity cultural factor derived in chapter three.

We know both these variables have increased over a long period of time, so when we simulate both causal mechanisms we know that the independent causal variable will be increasing with time.

We assume that the independent causal variable (whether it be GDP or SEC) increases according to a biased random walk and that the dependent variable (whether it is GDP or SEC) changes proportionally. The simulation begins in 1750 which is approximately the onset of the industrial revolution and we assume flat economic development and secularization before that time. We must also decide at what age the formative years end and adulthood begins which, as we discussed previously, is uncertain. For arguments sake, we set it at 20 years for these simulations, but we will show later that we do not actually need to know this to recover the causal effect.

Once we have run the simulation, we end up with a time series for both GDP and SEC. We then use a time lagged regression (similar to the general form equation 6.1) to see if the simulated causal effect can be detected as the causal variable's time series preceding the other variable's time series:

$$GDP_t \sim \alpha GDP_{t-d} + \beta_{sec} SEC_{t-d} + \epsilon \tag{6.2}$$

$$SEC_t \sim \alpha SEC_{t-d} + \beta_{gdp} GDP_{t-d} + \epsilon \tag{6.3}$$

where equation 6.2 tests whether SEC precedes GDP and equation 6.3 tests whether SEC precedes GDP. When economic development causes secularization, we expect β_{gdp} to be substantively significant. When secularization causes economic development, we expect β_{sec} to be substantively significant.

In simulation one, where GDP causes SEC, we expect to find a positive effect of GDP on SEC and a zero effect of SEC on GDP. In simulation two, where SEC causes GDP we expect to detect the opposite: a positive effect of SEC on GDP and a zero effect of GDP on SEC.

6.3.1 Simulation One: Economic Development Causes Secularization

We assume that economic development increases exogenously according to a biased random walk between 1750 and 2000 in 10-year increments:

$$GDP_t = GDP_{t-10} + normal(\mu, \sigma)$$

where t is decade, μ is the bias on the random walk ($\mu = 10$) and σ is its variation ($\sigma = 10$). Initial GDP_{1750} is set to 1.

Economic development affects levels of secularization during a generations formative years. A generation does not enter the adult population until they are 20. Therefore, the secularization score of a generation just entering the adult population will be proportional to average value during the previous two decades. So the SEC time series is generated using:

$$SEC_t = \gamma \frac{GDP_{t-20} + GDP_{t-10}}{2}$$

where GDP_{t-10} and GDP_{t-20} are the levels of economic development in the first and second decades of a generations life; SEC_t is the secularization score in decade t and γ is the weight of the linear dependency between SEC and GDP (set to $\gamma = 0.6$).

Once we have the two simulated time series, we use regressions 6.2 and 6.3 to see if we can unambiguously recover the simulated causation. The left hand side of figure 6.3 shows that past GDP predicts future SEC with a very small error, meaning we have recovered the causal effect from economic development to secularization. However, the regression sometimes erroneously detects a spurious relationship between past SEC and future GDP. The histogram on the right hand side of figure 6.3 shows that when we run this causal simulation 200 times, we can detect both positive and negative spurious effects, but that the expected value is close to zero. This means we must be wary of false positives when analyzing the WEVS data.

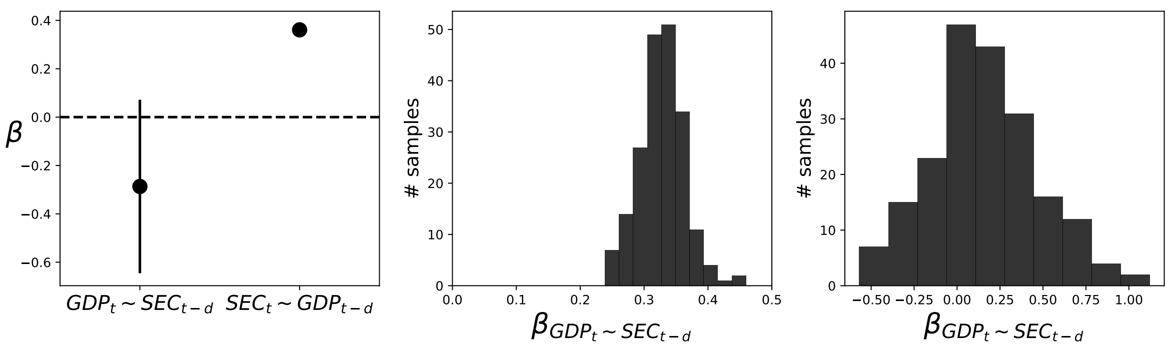


Figure 6.3: Detected effect sizes from simulation one, where economic development GDP causes secularization SEC. Left hand side: the detected effect size (β) of past secularization on economic development ($GDP_t \sim SEC_{t-d}$) and past economic development on secularization ($SEC_t \sim GDP_{t-d}$). The circles are the expected effect sizes and the error bars represent standard errors. Center: histogram of measured true effects of past GDP on future SEC using 200 runs of simulation one. Right hand side: a histogram showing the distribution of expected spurious effect sizes of past SEC on future GDP using 200 runs of simulation one, where GDP causes SEC. Time lag: $d = 10$

6.3.2 Simulation Two: Secularization Causes Economic Development

For this simulation we assume that secularization SEC exogenously increases according to a biased random walk between 1750 and 2000 in 10 year increments:

$$SEC_t = SEC_{t-10} + normal(\mu, \sigma)$$

where t is decade, μ is the bias on the random walk ($\mu = 10$) and σ is its variation ($\sigma = 10$). Initial SEC_{1750} is set to 1.

Economic development is an emergent property from the adult population and their socialized secularization levels. For the sake of simplicity we assume that economic development is proportional to the mean secularization in the adult population. So we simulate the GDP time series using:

$$GDP_t = \gamma mean[SEC_{adult}]$$

where GDP_t is the economic development in decade t, SEC_{adult} is the secularization score of each generation over the age of 20 and γ is the coefficient of proportionality ($\gamma = 0.6$).

As figure 6.4 shows, the regressions 6.2 and 6.3 successfully recover the causal effect of SEC on GDP. Although, like in the first simulation, the regressions can sometimes detect a spurious effect in the other direction. The histogram on the bottom row of figure 6.4, shows that significant positive and negative effects can be spuriously detected, but that the expected effect size is around zero (as per 200 runs of the simulation). Therefore, as with simulation one, we need to be weary of false positives when analyzing the WEVS data.

When using birth cohort as a proxy for historical time period, we only have access to the youngest generation from that population not the entire population from which human development is emergent. We have laid out in this chapter why data from the youngest generation gives us all the necessary information about the entire population. Here we can use the simulated data to demonstrate why this is the case. The top row left hand side of figure 6.4 shows that the causal effect is still detectable even when we only analyze data from the youngest generation.

We also do not know the age when a birth cohort first enters the adult world. Our simulation assumes this happens as the cohort reaches their third decade (age 20-30), but this might not be the case in reality. To test if the time-lagged regression can still detect the simulated causal effect in the presence of this uncertainty, we run the regressions whilst pretending not to know the true age of adulthood. We fit the regressions three times, first making the assumption that a generation enters adulthood in the first decade (age 0-10), then the second decade (age 10-20) and finally the third decade 20-30 (the age set in the simulation). The right hand plot in figure 6.4 shows that the causal effect remains detectable regardless of when we assume a generation enters adulthood.

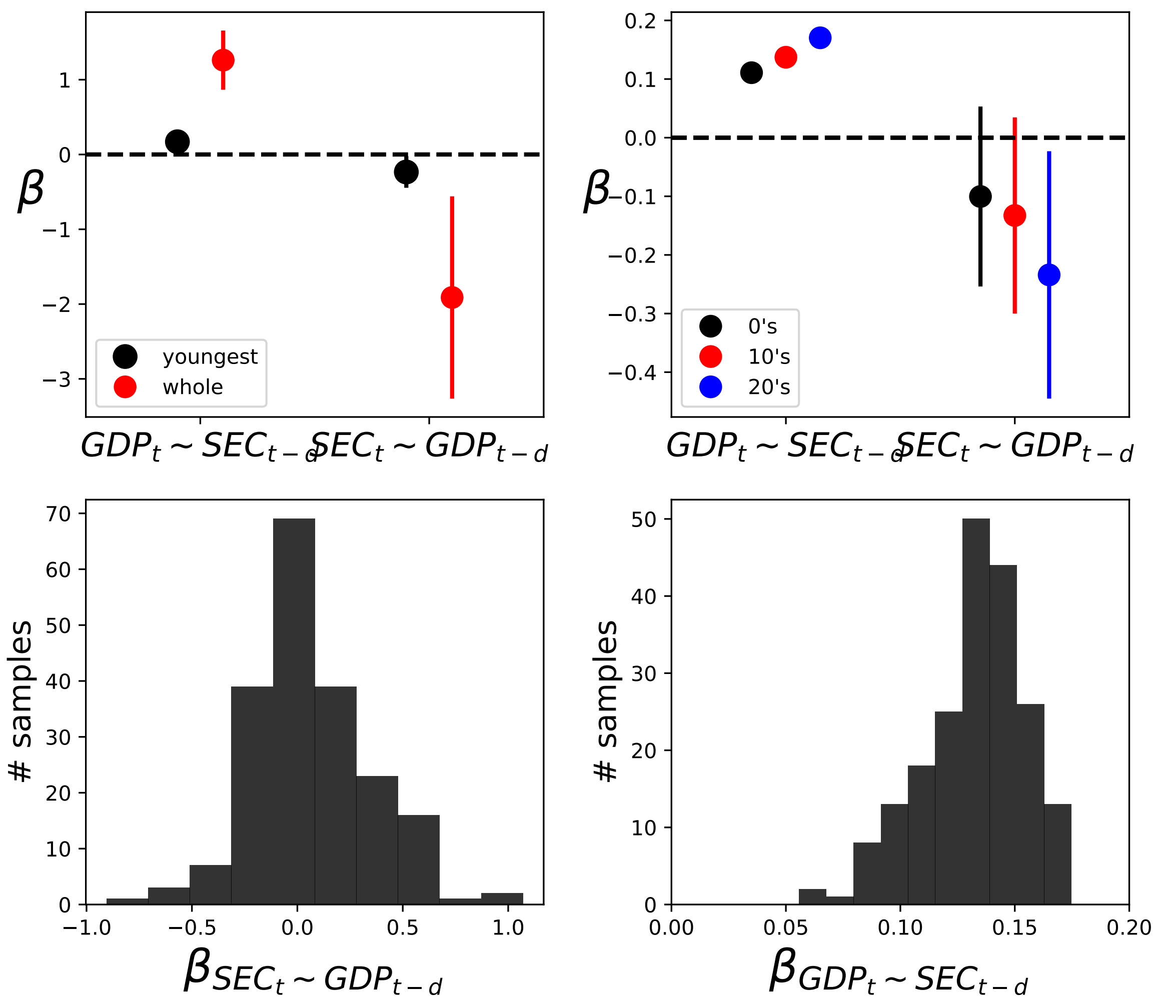


Figure 6.4: Detected effect sizes from simulation two where secularization SEC causes economic development GDP. Top row left hand side: effect sizes of past economic development on secularization ($SEC_t \sim GDP_{t-d}$) and vice versa ($GDP_t \sim SEC_{t-d}$)). The red line shows the effect size when SEC is measured as the average level secularization in the adult population, whereas the black line shows the effect size when SEC is measured as the average of the only the youngest generation in the adult population. Top row and right hand side: a similar plot showing the effect sizes when we do not know the age at which a generation enters the adult population (the simulation assumes that the true age is between 20 and 30 years). We run three time-lagged regressions which assumes the following age of adulthoods: 0 to 10 (black line) 10 to 20 (red line) and 20 to 30 (blue line). In both of the top row plots, the circles represent expected values, and the bars are standard errors. Bottom row left hand side: the histogram of spurious effect sizes of past economic development on secularization ($SEC_t \sim GDP_{t-d}$); these are taken from 200 runs of simulation two in which SEC causes GDP. Bottom row right hand side: histogram of true effect sizes of past economic development on secularization ($GDP_t \sim SEC_{t-d}$); these are taken from 200 runs of simulation two in which SEC causes GDP

6.4 Conclusion

We confirmed the finding that a country's cultural values are predictive of key human development variables like economic development and quality of democratic institutions. We go on to show that the linkages are also strong when we compare long-run changes in human development and generational changes in cultural values. We do not see the same strong links between human development and opinion changes. It is the same story for the representative changes in cross-sectional samples because the variance is dominated by opinion change. This shows that generational trends — and not the cross-sectional samples — hold the key to understanding the linkages between human development and cultural values.

Once we accept that long term cultural value change is driven by generation changes, we can ask the question: do these cultural values cause changes in development or vice versa? We introduce a multi-level time-lagged linear regression which can determine whether changes in human development *precede* those in cultural values or vice versa. This allows us to rule out certain classes of causal model. We run a simulation to confirm that our regression is able to detect a causal relationship should it exist.

CHAPTER 7

SECULARIZATION AND ECONOMIC DEVELPMENT

In the last chapter we showed that changes in human development are closely linked with generational changes in cultural values, but not with opinion changes. We also showed that birth cohorts are representative of historical time periods, thus expanding our cultural value time horizon to around 100 years. In this chapter, we use our time series data and time-lagged linear regression to see if changes in secularization precede those in economic development, or whether the opposite is true. We do so while controlling for cultural non-Independence, autonomy and the tolerance of prohibition violators.

The key results from this chapter are published in the peer reviewed journal Science Advances. The paper presents the time-lagged linear regressions showing that secularization precedes economic development, but that increased tolerance of personal prohibitions is a better explanation of a country's economic development.

7.1 Cultural Value Determiners of Economic Development

In the literature review we discussed the robust correlation between economic development and secularization and the disagreement regarding its cause. The Importance of Personal Prohibitions (PP) is a candidate explanation for this. It relates to personal morality such as the justifiability of behaviors like homosexuality, abortion, divorce etc. Countries where PP is high tend to be economically unequal and poor; possibly because these factors create low trust [Andersen and Fetner, 2008] which is vital for connecting people in economically productive networks [Hidalgo, 2015].

We test secularization's relationship with economic development in response to the large and unsettled literature on this subject. Religious prosociality is a well attested explanation for large scale cooperation in early states [Norenzayan, 2013], but these states were characterized by fragile economic growth and constant recessions [North et al., 2009]. This is why, as chapters four and five show, countries that have experienced the most economic growth during the last 100 years also experienced the largest *decrease* in prosociality.

We define Secularization SEC as the inverse of our Religiosity cultural factor and Tolerance of Prohibition Violators TOL as the inverse of the Importance of Personal Prohibitions cultural factor. The reason we changed the signs of these variables was to ensure positive correlations with economic development, thus making the regression results easy to read.

Our nine cultural factors did not include a measure of autonomy — whether a population favors group conformity or individual achievement — but it has been implicated as a cause of economic development [Gorodnichenko and Roland, 2011]. Even though it could not be learned by our Exploratory Factor Analysis in chapter three, we thought it was important to control for it.

We import a measure of autonomy used in past WEVS studies [Inglehart and Welzel, 2005]: the 'autonomy index'. It is composed of questions relating to which beliefs parents think are important to instill in their children: (1) religious faith; (2) obedience; (3) independence and (4) determination/perseverance. The first question is conceptually and statistically related to our Religiosity cultural factor (see chapter three). To avoid confounding it with Religiosity, we only use questions two to four when we define Autonomy AUT. We compress the responses to these three WEVS questions to a single Autonomy variable using Principal Component Analysis. The component captures 42% of the variance and the component loadings are as follows: independence 0.68, determination 0.49 and obedience -0.75.

The three cultural value variables (SEC, TOL and AUT) are normalized so the standard deviation equals one. This means we can interpret the regression results in terms of changes per standard deviation. Economic development data is GDP per capita taken from the Madison project (detailed in the last chapter). GDP per capita is divided by 10,000 to approximate the scale of the cultural value data.

7.2 Regressions

Building on the general form regression outlined in the last chapter, we present the specific regressions used to determine the temporal relationship between Economic Development GDP and Secularization SEC. All regressions have a random effect for country (γ_i) and cultural-historic cluster (γ_h), a universal intercept μ and error term ϵ. We first test whether Secularization precedes Economic Development or vice versa. We then add Autonomy AUT and Tolerance of Personal Prohibition Violators TOL to see if either offer a better explanation for GDP.

7.2.1 Secularization and Economic Development

We evaluate the temporal relationship between Secularization SEC and Economic Development GDP. We do so using generation changes — the mode of change with the strongest link to GDP (see chapter six). We also run the analysis using the last 25 years of representative cross-sectional samples and, finally, using opinion changes over the same period.

7.2.1.1 Generational Change

Here we present the two sets of regressions which test whether generational change in SEC precede long term changes in GDP or vice versa. Equation 7.1 tests if SEC precedes GDP and 7.2 tests if GDP precedes SEC:

$$GDP_{t,i,h} = \mu + \alpha GDP_{t-g,i,h} + \beta SEC_{t-g,i,h} + \gamma_{h|i} + \epsilon \tag{7.1}$$

where α is the effect of past GDP on current GDP, β is the effect of past SEC on current GDP, subscript g denotes the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

$$SEC_{t,i,h} = \mu + \alpha SEC_{t-g,i,h} + \beta GDP_{t-g,i,h} + \gamma_{h|i} + \epsilon \tag{7.2}$$

where α is the effect of past SEC on current SEC and β is the effect of past GDP on current SEC. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

As discussed in chapter six, there is uncertainty about the age when a generation becomes economically active, so we run each regression three times assuming this age is 0 to 10 years, then 10 to 20 years and finally 20 to 30 years. Therefore, in total, we run each regression nine times

7.2.1.2 Cross-Sectional and Opinion Change

The regressions for cross sectional samples and opinion change have the same structure because both have time period as the temporal dimension (in five years increments since 1990). The two regressions presented in this section are used to test whether cross-sectional/opinion changes in SEC precede changes in GDP or vice versa. Equation 7.3 tests if SEC precedes GDP and 7.4 tests if GDP precedes SEC:

$$GDP_{t,i,h} = \mu + \alpha GDP_{t-p,i,h} + \beta SEC_{t-p,i,h} + \gamma_{h|i} + \epsilon \tag{7.3}$$

where α is the effect of past GDP on current GDP, β is the effect of past SEC on current GDP, subscript p denotes the time period time lag (we run three regressions for p = 5, 10 and 15 years), i is country, h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

$$SEC_{t,i,h} = \mu + \alpha SEC_{t-p,i,h} + \beta GDP_{t-p,i,h} + \gamma_{h|i} + \epsilon \tag{7.4}$$

where α is the effect of past SEC on current SEC and β is the effect of past GDP on current SEC. The subscript p is the time period time lag (we run three regressions for p = 5, 10 or 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

We run each regression three times. We expect the results using cross-sectional and opinion change data to be roughly the same because opinion change largely explains recent change in cross-sectional samples (see chapter four).

7.2.2 The Role of Autonomy and Tolerance of Personal Prohibition Violators

The regressions in this section are similar to those in the last, but we include variables for Tolerance of Personal Prohibition Violators TOL and Autonomy AUT. This allows us to test if either TOL or AUT offer a better explanation for Economic Development GDP than Secularization SEC. We can also see if there are interesting temporal relationships between the three cultural value variables (SEC, TOL and AUT).

7.2.2.1 Generational change

We extend the set of generational change regressions from the previous section (equations 7.1 to 7.2) to include variables for TOL and AUT leading to four equations. We have dropped the i and h subscripts for the SEC and GDP terms for clarity, given the long equations.

$$\begin{aligned} GDP_t = \mu + \alpha GDP_{t-g} + \beta_1 SEC_{t-g} + \beta_2 TOL_{t-g} \\ + \beta_3 AUT_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.5}$$

where α is the effect of past GDP on current GDP and the vector β contains the effect sizes of past SEC, TOL and AUT on current GDP. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

$$\begin{aligned} SEC_t = \mu + \alpha SEC_{t-g} + \beta_1 GDP_{t-g} + \beta_2 TOL_{t-g} \\ + \beta_3 AUT_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.6}$$

where α is the effect of past SEC on current SEC and the vector β contains the effect sizes of past GDP, TOL and AUT on current SEC. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

$$\begin{aligned} TOL_t = \mu + \alpha TOL_{t-g} + \beta_1 SEC_{t-g} + \beta_2 GDP_{t-g} \\ + \beta_3 AUT_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.7}$$

where α is the effect of past TOL on current TOL and the vector β contains the effect sizes of past GDP, SEC and AUT on current TOL. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

$$\begin{aligned} AUT_t = \mu + \alpha AUT_{t-g} + \beta_1 SEC_{t-g} + \beta_2 GDP_{t-g} \\ + \beta_3 GDP_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.8}$$

where α is the effect of past AUT on current AUT and the vector β contains the effect sizes of past GDP, SEC and TOL on current AUT. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness), μ is the universal intercept and ϵ is the error.

Again, we are uncertain when a generation becomes economically active and this is significant due to the youngest generation being used as representative of an entire population from a historical time period. We run each regression three times assuming the age when a generation becomes economically active is 0 to 10 years, 10 to 20 years and 20 to 30 years. Therefore, in total, we fit each regression nine times

7.2.2.2 Cross-Sectional and Opinion Change

Again, this series of regressions is just an extension of the cross-section/opinion change equations 7.3 and 7.4 from the previous section. These four equations can be applied to either cross-sectional or opinion change data because they both use time period as the temporal dimension. Once again, we drop the the subscripts for country i and cultural-historical cluster h from the fixed effect terms — this is for clarity given the long equations.

$$\begin{aligned} GDP_t = \mu + \alpha GDP_{t-p} + \beta_1 SEC_{t-p} + \beta_2 TOL_{t-p} \\ + \beta_3 AUT_{t-p} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.9}$$

where α is the effect of past GDP on current GDP and the vector β contains the effect sizes of past SEC, TOL and AUT on current GDP. The subscript p is the time period time lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

$$\begin{aligned} SEC_t = \mu + \alpha SEC_{t-p} + \beta_1 GDP_{t-p} + \beta_2 TOL_{t-p} \\ + \beta_3 AUT_{t-p} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.10}$$

where α is the effect of past SEC on current SEC and the vector β contains the effect sizes of past GDP, TOL and AUT on current SEC. The subscript p is the time period time lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

$$\begin{aligned} TOL_t = \mu + \alpha TOL_{t-p} + \beta_1 SEC_{t-p} + \beta_2 GDP_{t-p} \\ + \beta_3 AUT_{t-p} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.11}$$

where α is the effect of past TOL on current TOL and the vector β contains the effect sizes of past GDP, SEC and AUT on current TOL. The subscript p is the time period time lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

$$\begin{aligned} AUT_t = \mu + \alpha AUT_{t-p} + \beta_1 SEC_{t-p} + \beta_2 GDP_{t-p} \\ + \beta_3 GDP_{t-p} + \gamma_{h|i} + \epsilon \end{aligned} \tag{7.12}$$

where α is the effect of past AUT on current AUT and the vector β contains the effect sizes of past GDP, SEC and TOL on current AUT. The subscript p is the time period time lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

We expect the regression results using cross-sectional and opinion change data to be roughly the same. This is because opinion change largely determines cultural value change in the last 25 years of cross-sectional data. In each case, we run the four regressions three times (where the time period lag is p = 5, 10, and 15 years).

7.2.3 Collinearity

The nine cultural factors are highly intercorrelated (see chapter four), correlated with cultural-historic cluster (see chapter five) and correlated with economic development (see chapter six). In linear regression, highly correlated predictor variables can lead to a statistical problem called collinearity which leads to less identifiability in the model and increased standard errors. Although linear regression is fairly robust — the ordinary-least-square (OLS) parameter estimates are still unbiased and give minimum variance — it is still a problem to be taken seriously. The standard error of parameter β is s_β and the effects of collinearity upon it are expressed in the equation:

$$s_\beta = \sqrt{\frac{(1-R^2)}{(1-R^2_{x_\beta})(N-K-1)}} \frac{s_Y}{s_{x_\beta}} \tag{7.13}$$

where R^2 is the proportion of the variance in the target variable Y explained by all K of the predictors, $R^2_{x\beta}$ is the variance explained in predictor variable x_β by all the other predictor variables, N is the size of the sample, $s_{x\beta}$ is the standard error of the predictor variable in question and s_Y is the standard error of the target variable [Berry and Feldman, 1985]. When collinearity is present $R^2_{x\beta}$ will be high, making the denominator in the equation 7.13 small and thus s_β large.

The most concerning aspect of collinearity is the increased sensitivity of the model parameter estimates to input data. When predictor variables are correlated they explain the same variance. This means the OLS estimator will attempt to use the small amount of independent variation to distinguish between them [Studenmund, 2014] and this fringe variation might be highly specific to the sample, leaving the analysis prone to overfitting.

We test for the presence of collinearity by calculating the Variance Inflation Factor VIF for each parameter β:

$$VIF = \frac{1}{(1-R^2_{x_\beta})}$$

where $R^2_{x_\beta}$ is the variance in variable x_β explained by all the other predictor variables. VIF measures how much the uncertainty in predictor x_β has been increased by the presence of other predictors. There is no rule for knowing when collinearity is problematic, but we can use the following heuristic: if $VIF > 2.5$ then collinearity *may* be problematic, and if $VIF > 5$ then it is *likely* that it is problematic [Studenmund, 2014].

As we mentioned, the big problem of collinearity is overfitting. We test the robustness of our results by running the regressions many times using random samples of 50% of the WEVS data. If collinearity does not effect the estimates, then the ensemble of estimates should center around a clear expected value.

7.3 Results

When we fit the regressions, we see that generational shifts in Secularization SEC robustly predict future levels of Economic Development GDP and not the other way around; although, Tolerance of Personal Prohibitions TOL offers a better explanation. Conversely, running the same regressions, but using the cross-sectional samples instead of generational changes to measure cultural values, we find that GDP actually weakly predicts SEC; but this relationship is driven by transient opinion change.

7.3.1 Generational change

Here we present the regression results which test the temporal relationship between generational changes in Secularization SEC and long run Economic Development GDP (see regressions 7.1 and 7.2). We also present the regression results which include Tolerance of Personal Norm Violators TOL and Autonomy AUT (see regressions 7.5 to 7.8). We include the full set of regression results in tables in the appendix for this chapter.

Regressions 7.1 and 7.2 clearly show that changes in SEC precede those in GDP and not the other way around. In no case does GDP have a statistical or substantively significant effect on future GDP and, in all cases, SEC has a statistical and substantively significant effect on future GDP which increases with time (see figure 7.1). This result is robust to the age we believe a generation reaches adulthood (it does not matter whether we assume it is 0 to 10, 10 to 20 or 20 to 30 years).

Supporting findings in chapter five, we see that cultural-historical cluster γ_h is a good indicator of both future GDP and SEC in most cases. The exception being that it does not reach statistical significance when predicting future GDP after 10 years, though this could be a false negative because effect sizes after 10 years are generally small. We have used a conservative p value correction (Bonferroni correction).

Regressions 7.5 to 7.8 show that, in fact, TOL offers a better explanation of future GDP than SEC. Surprisingly, we also see that TOL predicts a future decrease in AUT. In all nine regressions (where g = 10, 20 or 30 years and with the three age-of-adulthood robustness checks for each), we see TOL significantly predicts GDP every time and the effect size increases with time (see the top row of figure 7.2). Importantly, including TOL in the regression eliminates any effect of SEC.

We unexpectedly discovered that an increase in TOL results in a *decrease* in AUT (a statistically significant result in seven out of nine of the regressions). The bottom row of figure 7.2 illustrates this result and also that the effect size increases with time. Again the statistically insignificant results occur after 10 years, which could be attributed to a false negative due to small effect sizes after 10 years and our conservative p value correction.

There are two other relationships which show limited statistical significance: AUT predicts future GDP in three out of nine of the regressions and SEC predicts future AUT in one out of nine. Although the evidence for the GDP to AUT relationship appears stronger, we are more inclined to believe the AUT to SEC relationship because it is increasing in size with time, like the other significant effect sizes (see figure 7.2). Figure 7.3 shows that we see this pattern for AUT to SEC (bottom row), but not for GDP to AUT (top row).

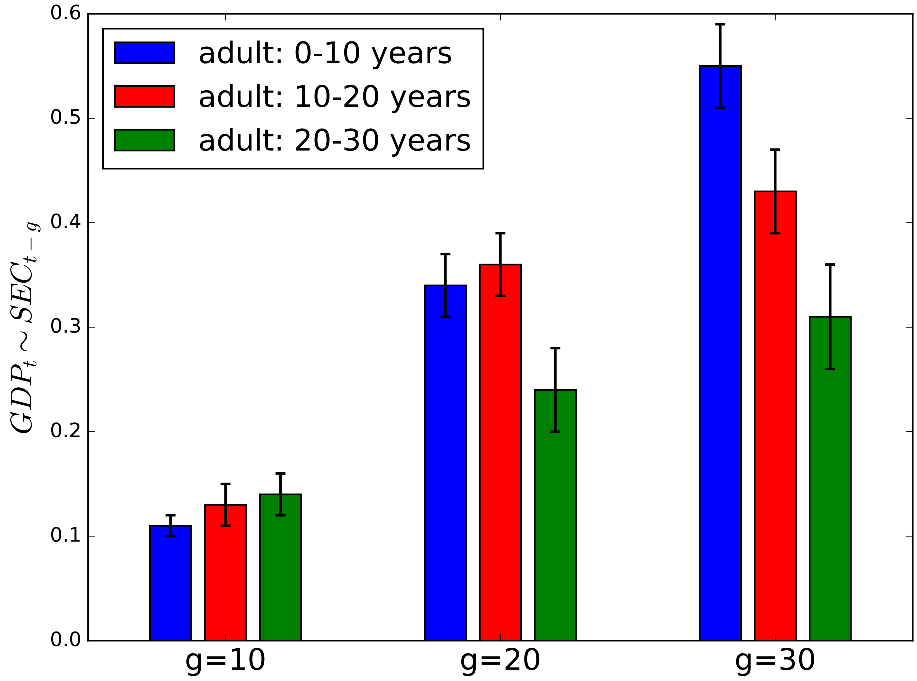


Figure 7.1: Detected effect size of generational changes in Secularization SEC on future economic development GDP, where g is the number of years after a generation has reached adulthood and become economically active. The blue bar is the effect size if we assume a generation reaches adulthood between 0-10 years, the red bar assumes 10-20 years and the green bar assumes 20-30 years. The bar height is the the effect size and the black error bars are the associated standard errors. The faded bars mean 5% statistical significance was not met (Bonferroni corrected $p < 0.004$).

The cultural-historic cluster explains a statistically significant proportion of the variance in all cases where a cultural value variable is the dependent variable in the regression (SEC, AUT or TOL). However, when GDP is the dependent variable, statistical significance is not met after 10 years; this result fits with the finding from the minimal regressions in equations 7.1 and 7.2 (those including only SEC and GDP as fixed effects).

7.3.2 Cross-Sectional and Opinion Change

Here we present regression results investigating the temporal relationships between Economic Development GDP and Secularization SEC based on cross-sectional and opinion change data. We saw in chapter four that the recent cultural value changes expressed in the cross-sectional data are largely explained by opinion change. Therefore, we expected the regression results using these two data sets to be nearly the same. This turns out to be the case; confirming further that recent cultural value change is dominated by opinion change. For these reasons, we will only present the deeper analysis for the cross-sectional results safe in the knowledge that the opinion

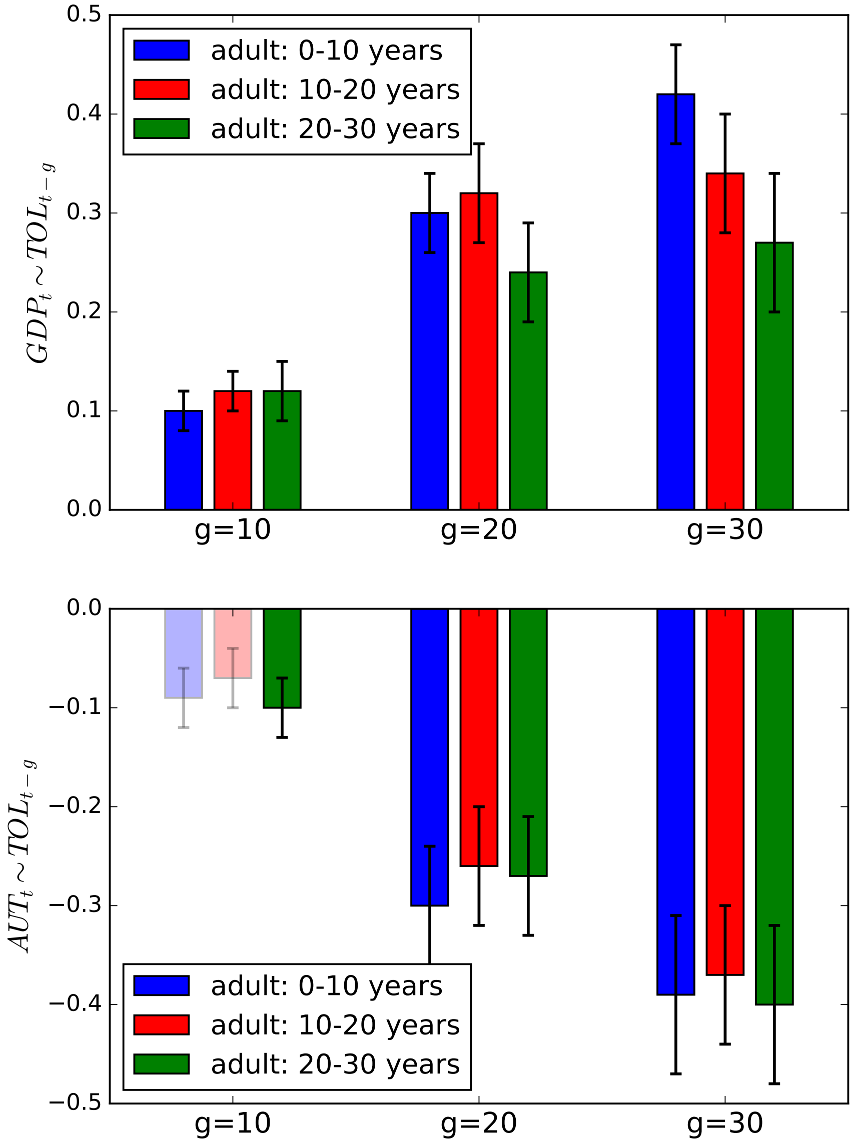


Figure 7.2: The top row: the effect of past generational changes in Tolerance of Personal Norm Violators TOL on future Economic Development GDP. Bottom Row: similar plot showing the effect of past TOL on future Autonomy AUT. In both plots, g is the number of years after a generation has reached adulthood and has become economically active. The blue bar is the effect size if we assume a generation reaches adulthood between 0-10 years, the red bar assumes 10-20 years and the green bar assumes 20-30 years. The bar height is the the effect size and the black error bars are the associated standard errors. The faded bars means 5% statistical significance was not met (Bonferroni corrected $p < 0.004$).

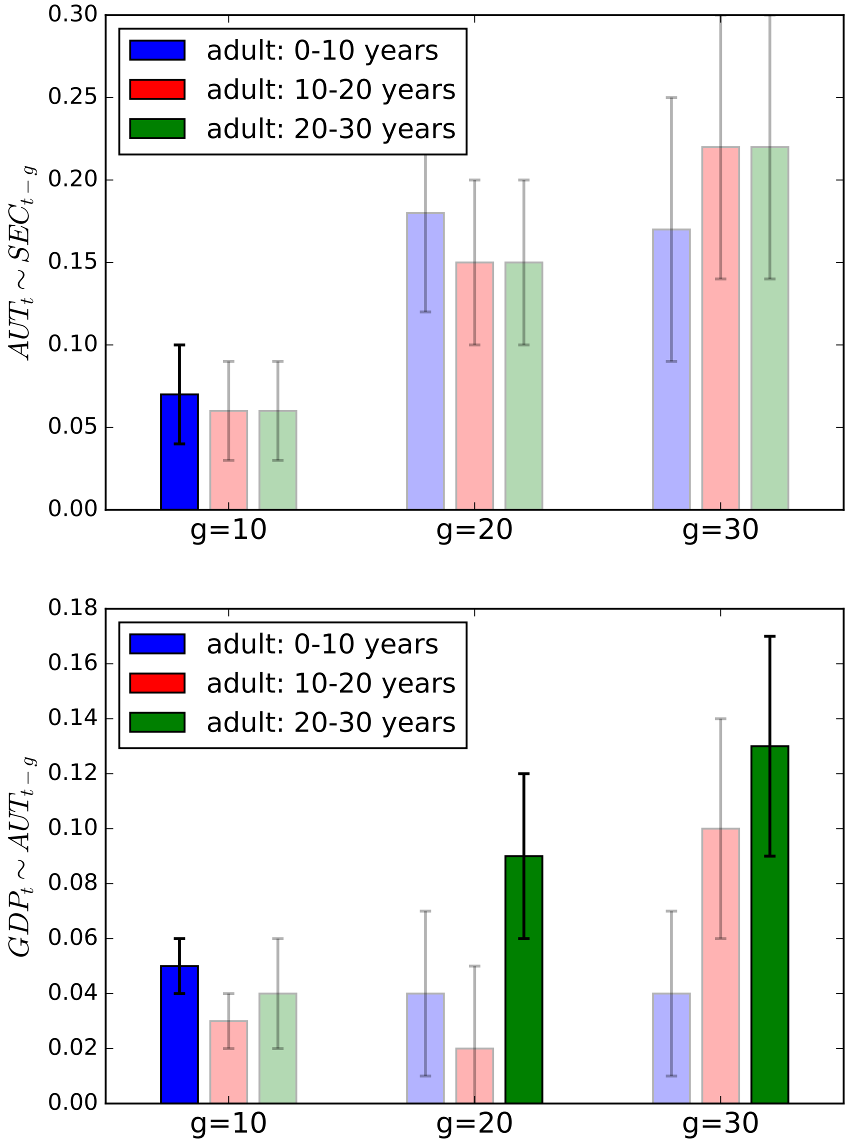


Figure 7.3: The top row: the effect of past generational changes in Secularization SEC on future Autonomy AUT. Bottom Row: similar plot showing the effect of past Autonomy AUT on future Economic Development GDP. In both plots, g is the number of years after a generation has reached adulthood and has become economically active. The blue bar is the effect size if we assume a generation reaches adulthood between 0-10 years, the red bar assumes 10-20 years and the green bar assumes 20-30 years. The bar height is the the effect size and the black error bars are the associated standard errors. The faded bars mean 5% statistical significance was not met (Bonferroni corrected $p < 0.004$).

	SEC (p=5)	SEC (p=10)	SEC (p=15)
N	128	90	73
n	74	67	53
SEC	0.89 (0.02)**	0.86 (0.04)**	0.83 (0.06)**
GDP	0.07 (0.02)**	0.08 (0.02)**	0.08 (0.04)
i	0	0.1	0.12
h	0	0	0.13
R^2	0.94	0.93	0.88

	GDP (p=5)	GDP (p=10)	GDP (p=15)
N	281	223	145
n	105	95	82
SEC	0.02 (0.02)	0.05 (0.03)	0.07 (0.04)
GDP	1.04 (0.01)**	1.08 (0.01)**	1.18 (0.02)**
i	0	0.11	0.21**
h	0.03	0	0.04
R^2	0.99	0.98	0.98

Table 7.1: The time-lagged linear regression results testing the temporal relationship between cross sectional samples of Secularization SEC and Economic Development GDP. The top section shows the effects of past GDP on future SEC after p = 5, 10 and 15 years. The bottom section shows the effects of past SEC on future GDP after p = 5, 10 and 15 years. Abbreviations: N = number of data points, n = number of unique countries, i = variance explained by country-level random effect, h = variance explained by cultural-historic random effect and R^2 = total variance explained. Each entry contains an estimate and, in brackets the standard error. Bonferroni corrected statistical significance: $p < 0.01(**)$; $p < 0.05(*)$.

change results are nearly equivalent. All of the regression results are presented in the tables in the appendix for this chapter.

The effect sizes are much smaller when we use cross-sectional samples compared to generational changes. This is unsurprising given the weak linkages between changes in these cross-sectional samples and economic development (see chapter six). That said, we did find some statistically significant effects that demonstrated the opposite causal pathway seen for generational change: changes in GDP predict those in SEC.

Regressions 7.3 and 7.4 show that SEC does not predict future GDP in any cases —neither after p = 5, 10 or 15 years. Whereas GDP predicts future SEC after both 5 and 10 years (see table 7.1). The effect size after 15 years is substantively equal to the one seen after 10 years, it does not meet statistical significance because of the larger standard error. The reason standard errors are generally high after 15 years is because the sample size N is small. The sample size is small because the cross-sectional time series are only 25 years long at five year intervals. This means we have a maximum of two data points per country, but for most countries it will be fewer because the cross-sectional time series also have a lot of missing values (see chapter four).

Regressions 7.9 to 7.12 include additional cultural value variables — Autonomy AUT and

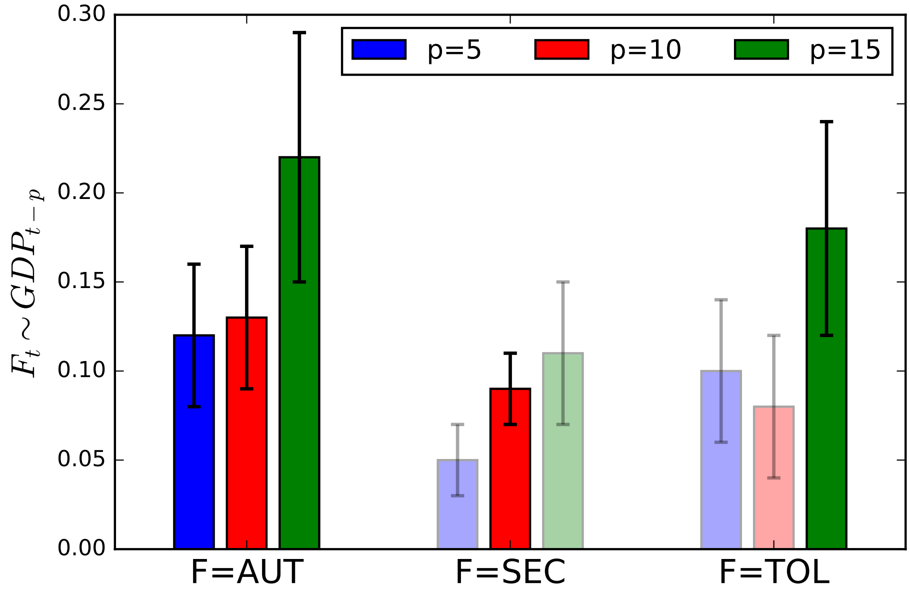


Figure 7.4: The effect of past Economic Development GDP on future levels of the three cultural value variables F measured using the WEVS representative cross sectional samples. The three cultural factors F are Autonomy AUT Secularization SEC and Tolerance of Personal Prohibition Violators TOL. The blue bars show the effect size after $p = 5$ years, the red bars after $p = 10$ years and green bars after $p = 15$ years. The height of the bar is the effect size and the black error bars are standard errors. The faded bars mean the 5% statistical significance level has not been met at the Bonferroni corrected level (p<0.004).

Tolerance of Personal Prohibition Violators TOL. We continue the see changes in GDP preceding those in cultural values, but it turns out that GDP better predicts future AUT, rather than SEC. Figure 7.4 shows larger effect sizes on AUT that increase with time. Also that SEC still has a small effect that increases with time (though statistical significance is only met in one case). It appears that opinion changes in Autonomy track changes in GDP per capita fairly well.

The Cultural-Historic cluster shows no predictive power in any of the cross-sectional regressions. This is not surprising. We saw in chapter five that opinion changes (the driver of cross-sectional trends) are idiosyncratic and culturally similar countries do not experience correlated change; unlike for generational change.

7.3.3 Collinearity

To test for the presence of problematic collinearity, we calculated the Variance Inflation factor VIF for each of the four sets of regressions (see figure 7.5). The first two sets of regressions measure cultural values as generational change. The first set includes only the variables for Secularization SEC and Economic Development GDP — we have called this 'generational minimal' GM — and the second set includes variables for the Tolerance of Personal Prohibition Violators TOL and

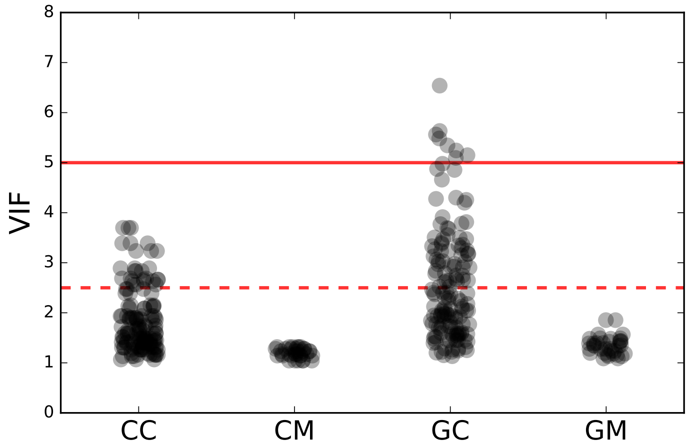


Figure 7.5: The distribution of VIF scores for all parameters estimated using the four sets of regressions: cross-sectional complete CC, cross-sectional minimal CM, generational complete GC and generational minimal GM. Each black circle is the VIF score for a single parameter. In the two complete models (CC and GC) there are four parameters in each of the four regressions and in the two minimal models (CM and GM) there are two parameters in each of the two regressions. In the two cross-sectional models (CC and CM) there are three regressions and in the two generational models (GC and GM) there are nine. This means the total number of parameters for each regression set are $N_{CC} = 48$, $N_{CM} = 12$, $N_{GC} = 144$ and $N_{GM} = 48$. The dotted red line at $VIF = 2.5$ is the level at which collinearity may be a concern and the solid red line at $VIF = 5$ is where collinearity is likely to be a concern.

Autonomy AUT — we have called this 'generational complete' GC. The third and fourth sets of regressions measure cultural values using cross-sectional samples (which is equivalent to using opinion change data). Like the generational changes regressions, the third set only includes variables for SEC and GDP ('cross-sectional minimal' CM) and the fourth includes variables for TOL and AUT ('cross-sectional complete' CC).

When GDP and SEC are the only two variables in the regression (GM and CM), the VIF score never exceeds 2.5 meaning collinearity is not likely to be a problem. A few parameters for the 'cross-sectional complete' set of regressions fall above 2.5, but none above the more troubling threshold of 5. However, the 'generational complete' set has many parameters where $VIF > 2.5$ and even some where $VIF > 5$. The level of collinearity in 'generational complete' GC is a concern and needs further investigation (see figure 7.5).

The main effects we detected in the 'generational complete' regressions were that changes in TOL precede those in GDP and that changes in TOL negatively predict future AUT (see figure 7.2). We found weaker evidence that SEC predicts future AUT and AUT predicts future GDP (see figure 7.3). We test the robustness of the four stated effect sizes by running the 'generational complete' regressions using random re-samples of 50% of the original data. We do this 200 times to create an ensemble parameter estimates and, if collinearity is not an issue, then the estimates should converge on a single value.

The ensembles of parameter estimates converge to a single value in three out of four cases (see figure 7.6). These distributions are unimodal, have the same sign as the original estimates, and are centered around values which increase with time. However, the distribution of effect sizes for past TOL on future GDP is bimodal and thus seems sensitive to choice of data (see figure 7.7). Despite this, the direction of the effect remains positive and the effect size increases with time (as we have come to expect). Therefore, we just need to be wary that the true effect size may be smaller than what we have detected using the entire dataset.

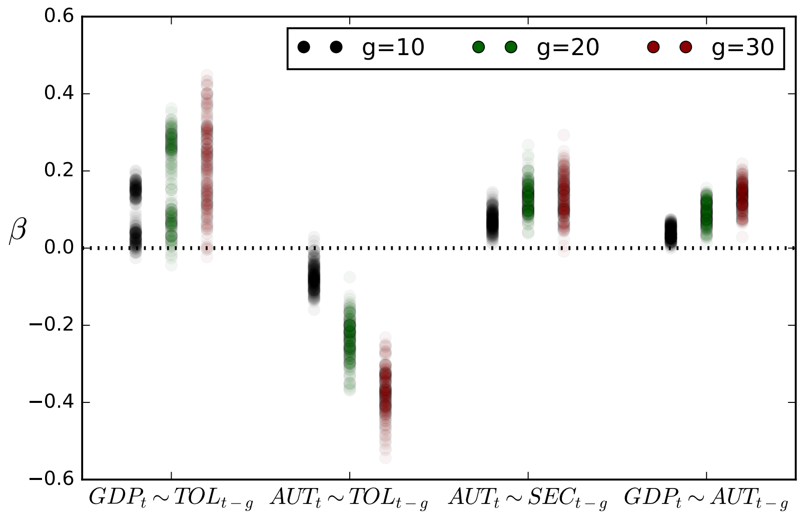


Figure 7.6: The distribution of the ensemble of effect sizes accrued by randomly re-sampling 50% of the generational change cultural value and economic development data. Each of the 200 circles is an estimate arrived at by fitting the time-lagged regression to a version of the resampled data; where, β is the effect size of the lagged predictor on the target ($target \sim predictor$). The four relationships are: lagged Tolerance of Personal Prohibition Violators on Economic Development ($GDP_t \sim TOL_{t-g}$), lagged Tolerance of Personal Prohibition Violators on Autonomy ($AUT_t \sim TOL_{t-g}$), lagged Secularization on Autonomy ($AUT_t \sim SEC_{t-g}$) and lagged Autonomy on Economic Development ($GDP_t \sim AUT_{t-g}$). The black circles represent a lag of $g = 10$ years, green circles of $g = 20$ years and red circles of $g = 30$ years. For this plot, we assume generations reach adulthood in their 20's.

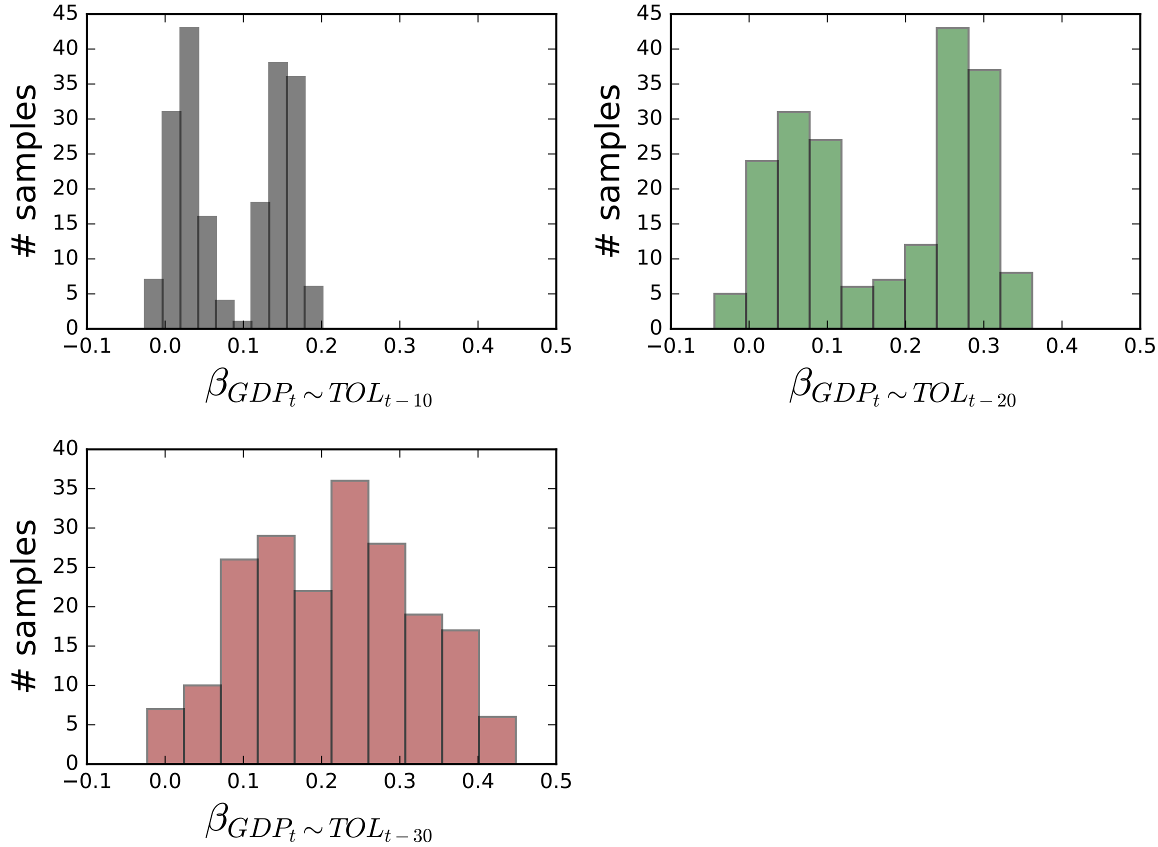


Figure 7.7: Histogram of effect sizes for past Tolerance of Personal Prohibition Violators on Economic Development ($\beta_{GDPt \sim TOLt-g}$). The ensemble of effect sizes are accrued by fitting the time-lagged linear regression to 200 data sets each representing a 50% random resample from the original data. The black histogram is the ensemble of effect sizes after $g = 10$ years, the green is after $g = 20$ years and the red is after $g = 30$ years. For this plot, we assume generations reach adulthood in their 20's.

7.4 Discussion

Using a time-lagged linear regression we showed that generational changes in secularization precede those in economic development and not the other way around. This suggests that Max Weber's 'protestant work-ethic' view of secularization, rather than Emile Durkheim's 'functionalist' model, better fits the WEVS data. Although, to believe that the Protestant Reformation is the cause of secularization requires a belief that Protestants were less religious than Catholics, which seems unlikely [Matthews et al., 2013]. That said, secularization could be caused by other non-economic factors, such as state-takeover of the educational system [Franck and Iannaccone, 2014] or other processes of socialization [Ruiter and van Tubergen, 2009]

When we include variables offering competing explanations of economic development —

Tolerance of Personal Prohibition Violators' and Autonomy — we find that tolerance actually offers a better explanation for future levels of economic development than secularization (though the size of this effect is uncertain because the parameter estimates are sensitive to the data sample). This supports the claim that it is actually disagreement about moral issues which best explains the inequality of the wealth of nations [Inglehart and Norris, 2003], rather than a divergence in support for democracy [Huntington, 1996].

Tolerance reflects tolerance of behaviors often morally prohibited on religious grounds such as abortion, divorce and homosexuality (see chapter three). This is why secularization and tolerance are so closely related. That said, they do diverge for Communist-Confucian countries (see chapter five) which are secular but have low tolerance for abortion, divorce and homosexuality, and have fairly bad economic performance. One possible explanation is that the association between religiousness and moral tolerance only emerges in countries where levels of openness are already high [Adamczyk and Pitt, 2009]. In sum, secularization only leads to economic development in as much as it comes with greater tolerance for the rights of individuals.

We found that cultural values precede economic development when we measure cultural values as generational change, but when we measure cultural values using the representative WEVS cross-sectional samples, we actually see weak effects in the opposite direction. We are not the first to run this kind of analysis with cross-sectional samples. Our results are similar to those showing changes in economic development preceding those in secular-rational values [Inglehart and Welzel, 2005] and those in individualism [Hofstede et al., 2010].

The reason for the discrepancy between generational and cross-sectional trends is that cross-sectional samples are dominated by opinion change (as we showed in chapter four) and that the drivers of opinion change are very different to those of generational change; the former is idiosyncratic and only weakly related to changes in human development (see chapters three and five). Most importantly though, opinion changes are transient and don't reflect sustained change. So when previous authors ran regressions that used the standard cross-sectional samples over short periods of time, they are in fact measuring the effect of transient opinion changes.

We see that cultural-historic cluster has far more power to explain generational change compared to opinion change. This supports findings in chapter five showing uncorrelated opinion change within clusters. Cultural factors continue to explain statistically significant proportion of the variance in economic development, supporting the claim that cultural values influence future levels of economic development [Inglehart and Welzel, 2005].

7.5 Conclusion

Using our multi-level time-lagged linear regression we have shown that generational changes in secularization precede those in economic development and not the other way around. However, tolerance of moral norm violators offers a better explanation than secularization. This runs contrary to the findings of Ronald Inglehart and Gert Hofstede who both showed, using cross-sectional samples, that changes in economic development precede those in cultural values. We repeated this analysis using our own cross-sectional samples and found similar results. However, we also show that variance in the cross-sectional samples over short time periods is dominated by transient opinion change. This means analysis using cross-sectional samples is actually capturing transient changes in opinion and not long-term cultural value change.

Chapter 8

Cultural Values and Human Development

We showed in the last chapter that long-term economic development is preceded by secularization and increased tolerance of other moral viewpoints. In this chapter we take a broader perspective and investigate the linkages between general cultural values and human development. We use the same multi-level time-lagged linear regression and include information from all nine cultural factors to investigate cultural value linkages with economic development and the emergence of democratic institutions.

We showed in chapter three that Institutional Confidence and Interest in Politics (along with Prosociality) represent cultural value variation that had not been quantified by the seminal Inglehart-Welzel cultural map [Inglehart and Baker, 2000]. Therefore, our investigation of the Human Development Sequence (described in the literature review) will, for the first time, include variance representing support for institutions. This will hopefully shed light on the mysterious decline in support for democracy and other institutions measured during the last 100 years.

Previous statistical analyses of the HDS have used the representative cross-sectional samples provided by the WEVS [Abdollahian et al., 2012; Inglehart and Welzel, 2005; Spaiser et al., 2014]. We also fit our multi-level time-lagged regressions to the cross-sectional samples, but we know the variance in these samples is driven by transient opinion change (chapters four) and that their dynamics are poorly linked to those in human development (chapter six). Our main focus is on linkages between generational change — which is the cause of cultural value change over long periods of time — and long run human development variables. This is the first attempt to use generational cultural value changes in a formal statistical model of the Human Development Sequence.

8.1 Data

We include human development variables for economic development GDP and democratic institutions DEM. Economic development data was taken from the Madison project which provides historical time series for GDP per Capita (normalized to 1990 US dollars). Democratic institutions were measured using data from the Polity IV project which provide historical assessments of democratic systems. We provide detailed expositions of both these datasets in chapter six.

We want to include the information from all nine of our cultural factors in the analysis; however we are likely to have collinearity problems because of the strong inter-correlation between the cultural factors (see chapter four). For example, consider the mild collinearity problems we had in the last chapter when we included just three cultural value variables (Secularization, Tolerance of Personal Prohibition Violators and Autonomy). For this reason we have to express the cultural factors in a reduced form.

8.1.1 Openness, Secular-Rational and Institutional Support

To minimize collinearity concerns, our cultural value variables will ideally be orthogonal. We use Principal Component Analysis (PCA) to compress our nine cultural factors into a reduced set of orthogonal components. PCA is discussed in chapter three, but fundamentally it attempts to explain some high dimensional variance in a more parsimoniously way.

We rejected the use of PCA in chapter three because our objective then was to uncover factors underlying the WEVS that were, in some sense, real. This meant that we conceptually focused on making the factors interpretable, and so we allowed inter-correlation among factors. PCA is inappropriate for this task because it conceptually focuses on explaining variance using orthogonal components. However, in this chapter, we want to compress our nine cultural factors into a more parsimonious form, a task that PCA was designed for.

Once PCA has been performed, we have to decide how many components to retain. The usual way is to use Kaiser's method, where we retain all of the factors which have an eigenvalue of greater than one [Ledesma and Valero-Mora, 2007] — this means that all retained components explain more variance than the average cultural factor. Kaiser's method tells us to retain three components (see the left hand side of figure 8.1). We have labeled these three cultural value components: Openness $OPEN$, Secular-Rational RAT and Institutional Support $INST$.

The right hand side of figure 8.1 shows the correlations between the original nine cultural factors and the three cultural components. These were used to label the three cultural components. Openness $OPEN$ is positively correlated with Intrinsic Tolerance IT, Xenophilia XEN and Wellbeing WB, and is negatively correlated with the Importance of Personal Prohibitions PP. Secular-Rational RAT is positively correlated with Political Engagement PE and negatively correlated with Religiosity REL, the Importance of Personal Prohibitions PP and Prosociality PRO. Institutional Support $INST$ is positively correlated with Institutional Confidence IC, Interest in Politics IP and Wellbeing WB.

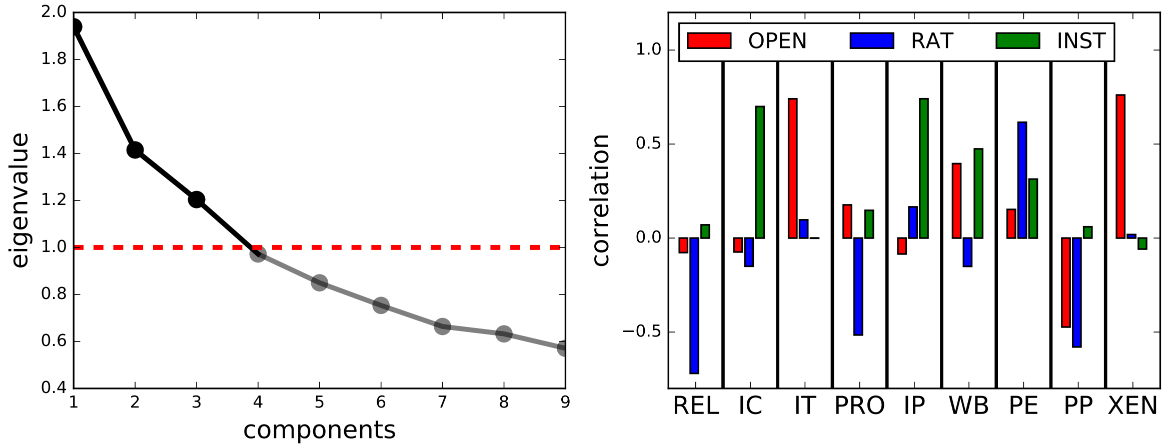


Figure 8.1: Breakdown of the Principal Component Analysis (PCA) used to compress our nine cultural factors into three cultural components. Left hand side: the eigenvalues of the sorted components, where the dotted line indicates the cut-off point for factor retention according to Kaiser's method (eigenvalue=1). Right hand side: the correlations between each of the nine cultural factors and the three cultural components. Cultural factor abbreviations: REL = Religiosity, IC =Institutional Confidence, IT = Intrinsic Tolerance, PRO = Prosociality, IP = Interest in Politics, WB = Wellbeing, PE = Political Engagement, PP = Importance of Personal Prohibitions, XEN = Xenophilia. Cultural component abbreviations: OPEN = Openness, RAT = Secular-Rational and INST = Institutional Support.

Openness $OPEN$ and Secular-Rational RAT are similar to the two dimensions of the Inglehart-Welzel cultural map discussed earlier — 'survival vs self-expression' and 'traditional vs secular-rational' cultural values [Inglehart and Welzel, 2005]. Openness explains 72% of the variation in the 'survival vs self-expression' dimension and Secular-Rational explains 83% of the variance in the 'traditional vs secular/rational' dimension. Conversely and as we expected, Institutional Support $INST$ represents new variation not captured by either of the Inglehart-Welzel dimensions. See table 8.1 for a complete statement of the pairwise relationships between the Inglehart-Welzel cultural dimensions and our three cultural components.

	TRAD-RAT	**SURV-SEF**
RAT	0.83	0.30
OPEN	0.06	0.72
INST	0.04	0.13

Table 8.1: Variance explained (R^2) in the pairwise relationships between the three cultural value components (RAT=Secular-Rational, OPEN=Openness and INST=Institutional Support) and the two dimensions of the Inglehart-Welzel (I-W) cultural map (TRAD-RAT is traditional vs secular-rational values and SURV-SEF is survival vs self-expression values). The correlations are calculated using the 91 countries for which we have I-W dimension data.

8.2 Regressions

Here we present the multi-level time-lagged linear regressions we used to explore the temporal relationships between cultural values and human development (adapted from the general form model documented in chapter six). Cultural values are defined as the three cultural components: Secular-Rational values RAT, Openness $OPEN$ and Institutional Support $INST$. Human development is defined as economic development GDP and democratic institutions DEM. The first set of regressions measure cultural values using generational change data and the second set use cross-section/opinion change data.

All of the regressions contain a universal intercept μ, a random-effect for country γ_i, a random-effect for cultural-historic cluster γ_h and an error term ϵ.

8.2.1 Generational Change

Here we present regressions 8.1 to 8.5, which explore the temporal relationship between generational changes in cultural value components (RAT, $OPEN$ and $INST$) and long run human development (GDP and DEM). The subscripts for country i and cultural-historic cluster h have been dropped from the fixed effect terms for clarity given the length of the equations:

$$\begin{aligned} GDP_t &= \mu + \alpha GDP_{t-g} + \beta_1 DEM_{t-g} + \beta_2 RAT_{t-g} \\ &+ \beta_3 OPEN_{t-g} + \beta_4 INST_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.1}$$

where α is the effect of past GDP on current GDP and the vector β contains the effect sizes of past DEM, RAT, $OPEN$ and $INST$ on current GDP. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

$$\begin{aligned} DEM_t &= \mu + \alpha DEM_{t-g} + \beta_1 GDP_{t-g} + \beta_2 RAT_{t-g} \\ &+ \beta_3 OPEN_{t-g} + \beta_4 INST_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.2}$$

where α is the effect of past DEM on current DEM and the vector β contains the effect sizes of past GDP, RAT, $OPEN$ and $INST$ on current DEM. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$\begin{aligned} RAT_t &= \mu + \alpha RAT_{t-g} + \beta_1 DEM_{t-g} + \beta_2 GDP_{t-g} \\ &+ \beta_3 OPEN_{t-g} + \beta_4 INST_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.3}$$

where α is the effect of past RAT on current RAT and the vector β contains the effect sizes of past GDP, DEM, $OPEN$ and $INST$ on current RAT. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$\begin{aligned} OPEN_t = \mu + \alpha OPEN_{t-g} + \beta_1 DEM_{t-g} + \beta_2 GDP_{t-g} \\ + \beta_3 RAT_{t-g} + \beta_4 INST_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.4}$$

where α is the effect of past $OPEN$ on current $OPEN$ and the vector β contains the effect sizes of past GDP, DEM, RAT and $INST$ on current $OPEN$. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$\begin{aligned} INST_t = \mu + \alpha INST_{t-g} + \beta_1 DEM_{t-g} + \beta_2 GDP_{t-g} \\ + \beta_3 RAT_{t-g} + \beta_4 OPEN_{t-g} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.5}$$

where α is the effect of past $INST$ on current $INST$ and the vector β contains the effect sizes of past GDP, DEM, RAT and $OPEN$ on current $INST$. The subscript g is the generational time lag (we run three regressions for g = 10, 20 and 30 years), i is country and h is cultural-historic cluster and ϵ is the error.

We also run the three age-of-adulthood robustness checks (see chapter six for details). For each regression, we assume that a generation enters adulthood first between 0 and 10 years, then between 10 and 20 years and finally between 20 and 30 years. This means the regressions 8.1 to 8.5 are each fitted nine times.

8.2.2 Cross-Sectional/Opinion Change

Here we present regressions 8.6 to 8.10. They investigate the temporal relationship between the cultural value components (RAT, $OPEN$ and $INST$) — represented using cross-sectional/opinion change data — and recent changes in human development data (GDP and DEM). These regressions are applicable to both cross-sectional and opinion change because both sets of data use time period (since 1990) as their temporal dimension. The equations are quite long so, for clarity, the subscripts for country i and cultural-historic cluster h have been dropped from the fixed effect terms.

$$\begin{aligned} GDP_t = \mu + \alpha GDP_{t-p} + \beta_1 DEM_{t-p} + \beta_2 RAT_{t-p} \\ + \beta_3 OPEN_{t-p} + \beta_4 INST_{t-p} + \gamma_{h|i} + \epsilon \end{aligned} \tag{8.6}$$

where α is the effect of past GDP on current GDP and the vector β contains the effect sizes of past DEM, RAT, $OPEN$ and $INST$ on current GDP. The subscript p is the time period lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster (representing cultural relatedness) and ϵ is the error.

$$DEM_t = \mu + \alpha DEM_{t-p} + \beta_1 GDP_{t-p} + \beta_2 RAT_{t-p} + \beta_3 OPEN_{t-p} + \beta_4 INST_{t-p} + \gamma_{h|i} + \epsilon \tag{8.7}$$

where α is the effect of past DEM on current DEM and the vector β contains the effect sizes of past GDP, RAT, $OPEN$ and $INST$ on current DEM. The subscript p is the time period lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$RAT_t = \mu + \alpha RAT_{t-p} + \beta_1 DEM_{t-p} + \beta_2 GDP_{t-p} + \beta_3 OPEN_{t-p} + \beta_4 INST_{t-p} + \gamma_{h|i} + \epsilon \tag{8.8}$$

where α is the effect of past RAT on current RAT and the vector β contains the effect sizes of past GDP, DEM, $OPEN$ and $INST$ on current RAT. The subscript p is the time period lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$OPEN_t = \mu + \alpha OPEN_{t-p} + \beta_1 DEM_{t-p} + \beta_2 GDP_{t-p} + \beta_3 RAT_{t-p} + \beta_4 INST_{t-p} + \gamma_{h|i} + \epsilon \tag{8.9}$$

where α is the effect of past $OPEN$ on current $OPEN$ and the vector β contains the effect sizes of past GDP, DEM, RAT and $INST$ on current $OPEN$. The subscript p is the time period lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster and ϵ is the error.

$$INST_t = \mu + \alpha INST_{t-p} + \beta_1 DEM_{t-p} + \beta_2 GDP_{t-p} + \beta_3 RAT_{t-p} + \beta_4 OPEN_{t-p} + \gamma_{h|i} + \epsilon \tag{8.10}$$

where α is the effect of past $INST$ on current $INST$ and the vector β contains the effect sizes of past GDP, DEM, RAT and $OPEN$ on current $INST$. The subscript p is the time period lag (we run three regressions for p = 5, 10 and 15 years), i is country and h is cultural-historic cluster and ϵ is the error.

We expect the regression results using cross-sectional and opinion change data to be roughly the same because the variance in the cross-sectional samples is explained almost entirely by opinion change data (see chapter four). We run each of the four regressions three times (where the time period lag is p = 5, 10, and 15 years).

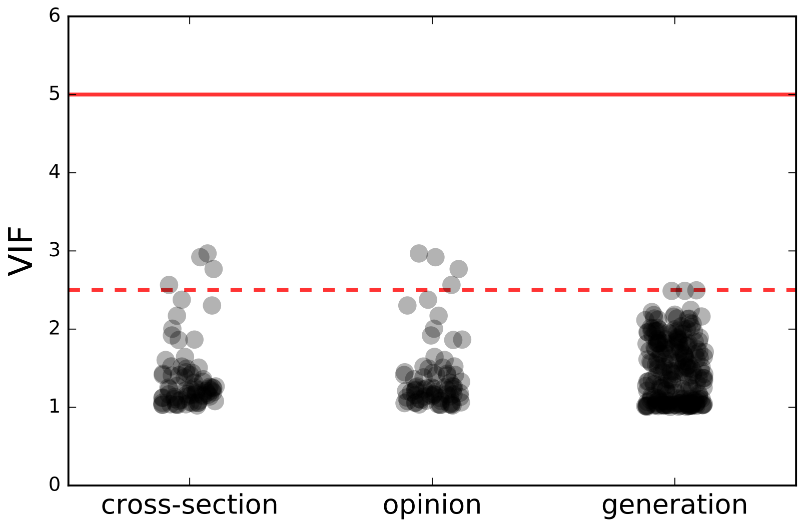


Figure 8.2: The Variance Inflation Factors VIF for parameters in the three sets of regressions. Cross-section — regressions 8.6 to 8.10 — are used to fit the representative cross-sectional data, there are 5 regressions with 5 parameters that are run 3 times, meaning the total number of parameters is 75. Opinion — regressions 8.6 to 8.10 are used to fit the opinion change data, there are 5 regressions with 5 parameters that are run 3 times, meaning the total number of parameters is 75. Generation — regressions (8.1 to 8.5) are used to fit the generational change data; where there are 5 regressions with 5 parameters that are run 9 times, meaning the total number of parameters is 225. Each black circle represents a single parameter. The dotted red line at $VIF = 2.5$ is the threshold where collinearity might be a problem and the solid red line at $VIF = 5$ is the threshold where collinearity is probably a problem.

8.2.3 Collinearity

We expect that by compressing our nine correlated cultural factors into three orthogonal cultural components, we will avoid problems of collinearity. We verify this by calculating the Variance Inflation Factor VIF for each set of regressions. In the last chapter we gave a detailed exposition of collinearity and the VIF. The VIF gives us a indicator for whether collinearity is likely to be a problem, but can not tell us for certain. As a rule of thumb, $VIF > 2.5$ represents a potential problem and $VIF > 5$ a likely problem [Studenmund, 2014].

Figure 8.2 shows, as we thought, that compressing the nine cultural factors into three orthogonal components has avoided the problems associated with collinearity: very few of the parameters have $VIF > 2.5$ and none have $VIF > 5$.

8.3 Results

When we fit regressions 8.1 to 8.5, we see that generational changes in Secular-Rational RAT and Openness $OPEN$ cultural values robustly predict future changes in both economic development

GDP and democratic institutions DEM. Moreover, the mysterious decrease in Institutional Support $INST$ is preceded by a rise in Secular-Rational Values RAT. Although, when we fit the cross-sectional/opinion change regressions 8.6 to 8.10, we see that Institutional Support $INST$ is affected by short term fluctuations in human development: economic development GDP precedes *increases* in Institutional Support $INST$, whereas improvements in democracy DEM precede *decreases* in Institutional Support $INST$.

8.3.1 Generational Change

We fit each of the generational change regressions (8.1 to 8.5) nine times: with generational time lags of $g = 10$, 20 and 30 years and, for each of these, a regression where we consider a generation becoming active in the adult population between the ages of 0 to 10 years, 10 to 20 years and 20 to 30 years. Full regression results in tables in the appendix for this chapter.

Supporting findings from the last chapter, we found robust evidence that changes in cultural values precede those in human development and not the other way around. Changes in RAT precede those in GDP (statistical significance met in nine out of nine regressions) and also precede those in DEM. In the latter case, statistical significance is only met in six out of nine regressions. The three insignificant effects occur at $g = 10$ years, where the effect sizes are small (see the bottom right of figure 8.3). These could be false negatives, given our use of a conservative p value correction (Bonferroni correction). Likewise, changes in $OPEN$ robustly predict future changes in DEM (in all nine of the regressions) and also predict future changes in GDP (in eight of nine regressions). These results are presented in figure 8.3.

The cultural components RAT and $OPEN$ reflect cultural value variance used in past analysis of the human development sequence [Inglehart and Welzel, 2005]. However, we include a third cultural component: Institutional Support $INST$. Regressions 8.1 to 8.10 show that past generational changes in RAT predict future generational change in $INST$. Statistical significance is met in six out of nine cases where, again, the exceptions are after $g = 10$ years. After 10 years the effect sizes are small so, given our conservative p value adjustment, these could be false negatives.

Cultural-historic cluster h explains an average of 33% of the variance in RAT and 34% in SEC, but explains 0% of the variance in $INST$, 8% in GDP and 2% in DEM. It appears as though past cultural values offer a better explanation for human development than cultural relatedness, but that the cultural values themselves diffuse more readily through culturally similar countries. We saw in chapter five that cultural-historic clusters were not separable in the cultural factors which compose $INST$ (Institutional Confidence and Interest in Politics), so it is not surprising that cultural-history offers such a poor explanation for it.

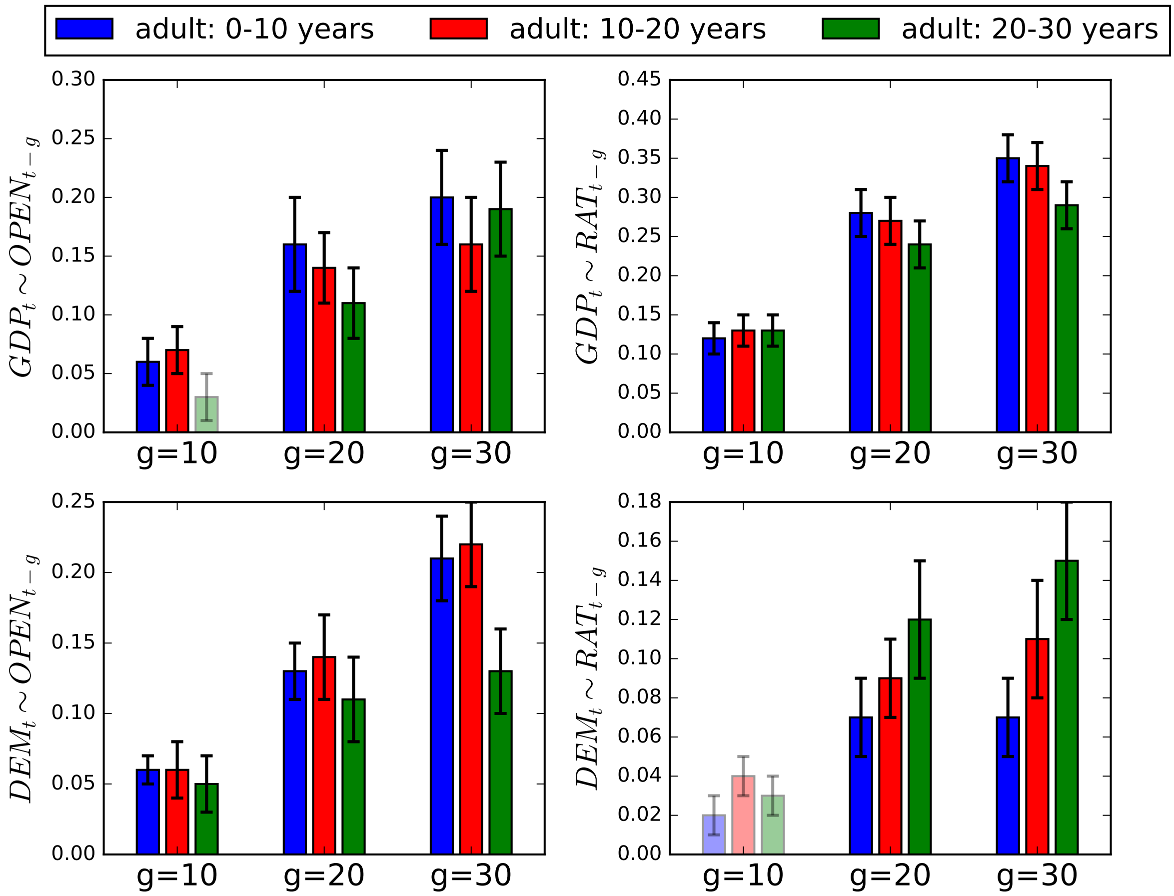


Figure 8.3: The effect sizes of cultural values on future levels of human development. Top left: the effect of Openness $OPEN$ on future economic development GDP. Top right: the effect of Secular-Rationality RAT on future economic development GDP. Bottom left: the effect of past Openness $OPEN$ on future democracy DEM. Bottom right: the effect of past Secular-Rationality RAT on future democracy DEM. The effect sizes are measured with time lags of $g = 10$, $g = 20$ and $g = 30$ years; the blue bar assumes generations reach adulthood between the ages of 0 and 10 years, the red bar between 10 and 20 years and the green bar between 20 and 30 years. The black error bars are standard errors and the faded bars mean that 5% statistical significance was not met (Bonferroni corrected to $p < 0.003$).

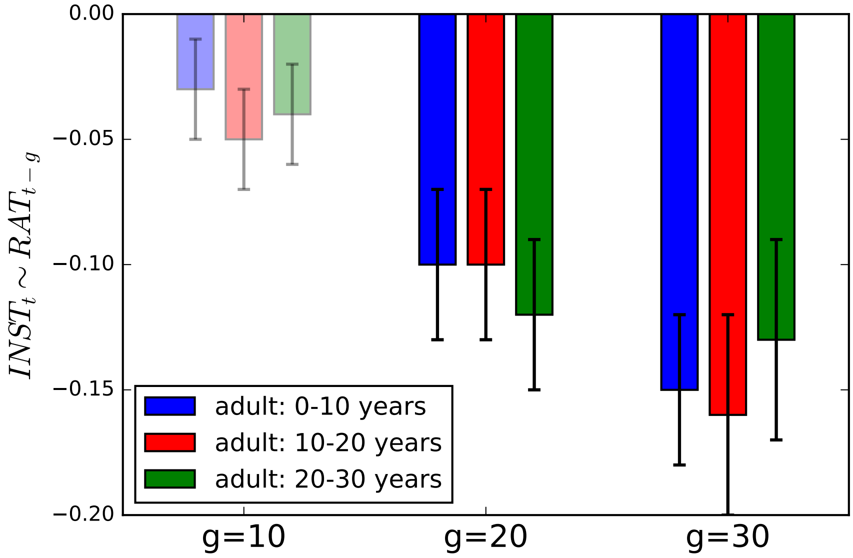


Figure 8.4: the effect of past Secular-Rationality RAT on future Institutional Support $INST$. The effect sizes are measured with a time lag of $g = 10$, $g = 20$ and $g = 30$ years; the blue bar assumes generations reach adulthood between the ages of 0 and 10 years, the red bar between 10 and 20 years and the green bar between 20 and 30 years. The black error bars are standard errors and the faded bars mean that 5% statistical significance was not met (Bonferroni corrected $p < 0.003$).

8.3.2 Cross-Sectional and Opinion Change

We fit regressions 8.6 to 8.10 to investigate the temporal relationship between short tern changes in human development and cross-sectional/opinion changes in cultural values. We found in chapter four that the variation in cross-sectional samples is dominated by opinion change. Therefore, we expect the regression results using the two types of data to be the same; this turns out to be the case. For this reason, we only present in-depth analysis of the cross-sectional results with the knowledge that the opinion change analysis will be nearly identical. The detailed regression results using both cross-sectional and opinion change data are in the appendix for this chapter.

We found limited statistical structure between short term changes in human development and cross-sectional changes in human development, which is similar to the results in the last chapter. Although we did find that GDP predicted future Secularization — an important component of RAT — but this effect disappears once DEM, $OPEN$ and $INST$ are included in the regression. That said, we do see statistically significant effects for both GDP and DEM on future $INST$; but interestingly GDP predicts an increase and DEM predicts a decrease (see figure 8.5).

A major shortcoming of the cross-sectional data is that the time series are stunted. The timespan for the cross-sectional samples is only between 1990 to 2015 at five years intervals.

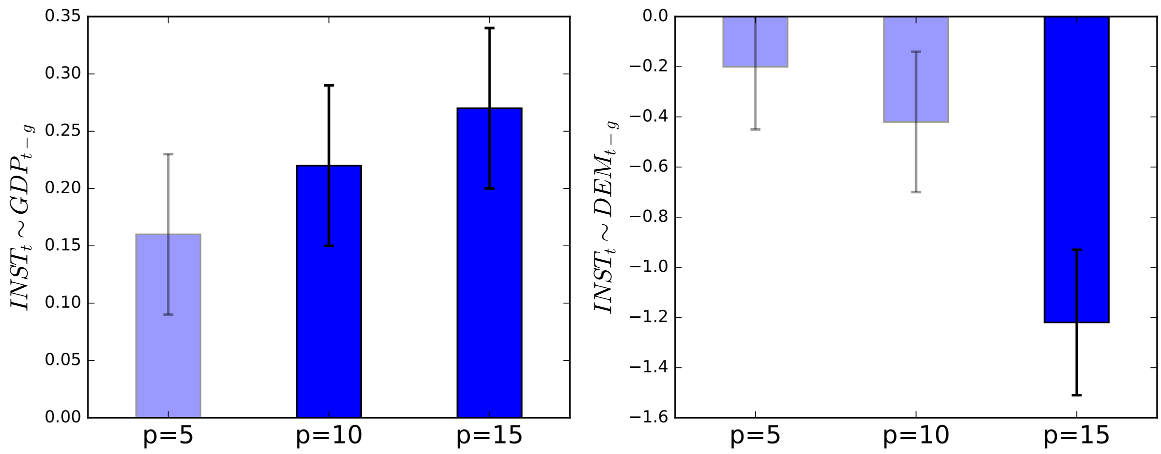


Figure 8.5: The effect of short term changes in human development on opinion changes in Institutional Support $INST$. Left hand side: the effect size of past economic development GDP on future Institutional Support $INST$ Right hand side: the effect size of past democracy DEM on future Institutional Support $INST$. The effect sizes are measured with a time lag of $p = 5$, $p = 10$ and $p = 15$ years. The black error bars are standard errors and the faded colored bars mean that 5% statistical significance was not met (Bonferroni corrected p < 0.003).

This means each country has a maximum of five data points over a 25 year period, so when the regression employs a 15 years time lag, this leaves us with a maximum of two data points per country. The reality is actually worse than this because these time series contain a lot of missing data. This means we lose entire countries as we increase the time lag resulting in the following residual sample sizes: 70 countries with a lag of 5 years, 65 with a lag of 10 years and 49 with a lag of 15 years.

We want to make sure our results are robust to this significant reduction in representative countries. So we rerun the regressions using only the 49 countries which survive when we increase the time lag from $p = 5$ to $p = 15$. Figure 8.6 shows that results are similar: once again only statistically significant effects were seen for GDP and DEM on future $INST$. Tables containing these regression results are in the appendix for this chapter.

8.3.3 Revised Human Development Sequence

These findings give us a new perspective on the Human Development Sequence (HDS). Our version of the HDS contains two modes of cultural value change: generational change which dominates cultural value change over the long-term and opinion change which dominates over the short term. We find that cultural value changes (Secular-Rational and Openness) are primary in the HDS and lead to future changes in human development. This includes an apparent side-effect of a subsequent reduction in Institutional Support. Although, as we see in chapter four, Institutional Support is subject to large opinion changes which are a response to short term

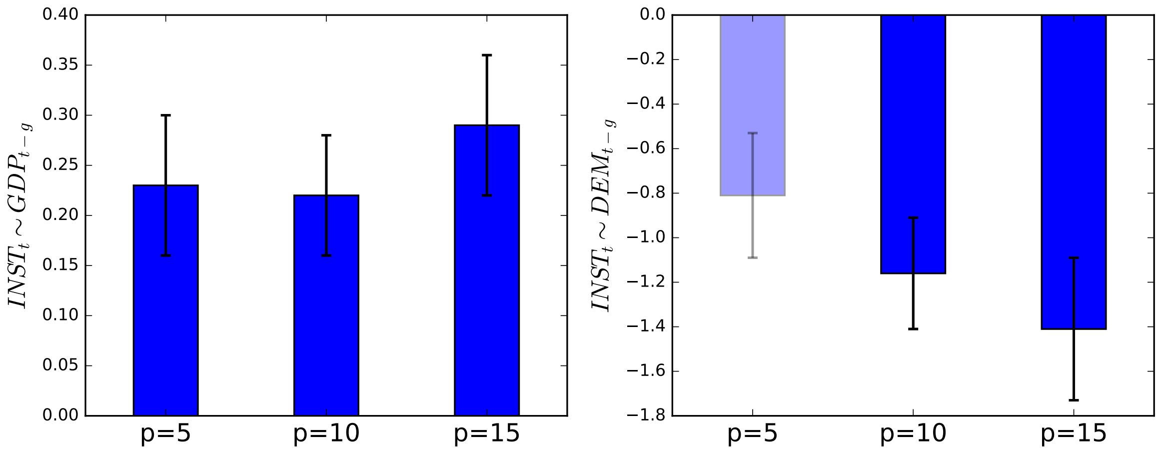


Figure 8.6: A robustness check for the effects of short term changes in human development on opinion changes in Institutional Support $INST$. These plots only use the 49 countries which present data for all time lags ($p = 5$, $p = 10$ and $p = 15$). Left hand side: the effect size of past economic development GDP on future Institutional Support $INST$ Right hand side: the effect size of past democracy DEM on future Institutional Support $INST$. The effect sizes are measured with a time lag of $p = 5$, $p = 10$ and $p = 15$ years. The black error bars are standard errors and the faded colored bars mean that 5% statistical significance was not met (Bonferroni corrected p < 0.003).

fluctuations in human development.

Figure 8.7 illustrates that increases in Secular-Rational and Openness cultural values predict long term future changes in both economic development and the emergence of democratic institutions. It also shows that the mysterious decline in Institutional Support is a symptom of rising Secular-Rational values. Finally, transient opinion changes in Institutional Support are preceded by changes in human development: economic development results in increased Institutional Support, whereas improvements in democracy result in decreased Institutional Support in the short term.

8.3.4 Stability to Component Cultural Factors

As we documented earlier, our three cultural value components are actually orthogonal composites of our nine cultural factors. The nine cultural factors have better defined meanings relating to a small set of correlated WEVS questions. Consequently, we want to make sure our revised human development sequence is robust to the swapping of the cultural value components with its correlated cultural factors (these correlations are illustrated in figure 8.1).

We suspect that the long term generational change parts of the revised HDS will survive, but not the cross-sectional/opinion change parts. This is because the set of cultural factors which correlate with a given component also show correlated generation change, but not correlated

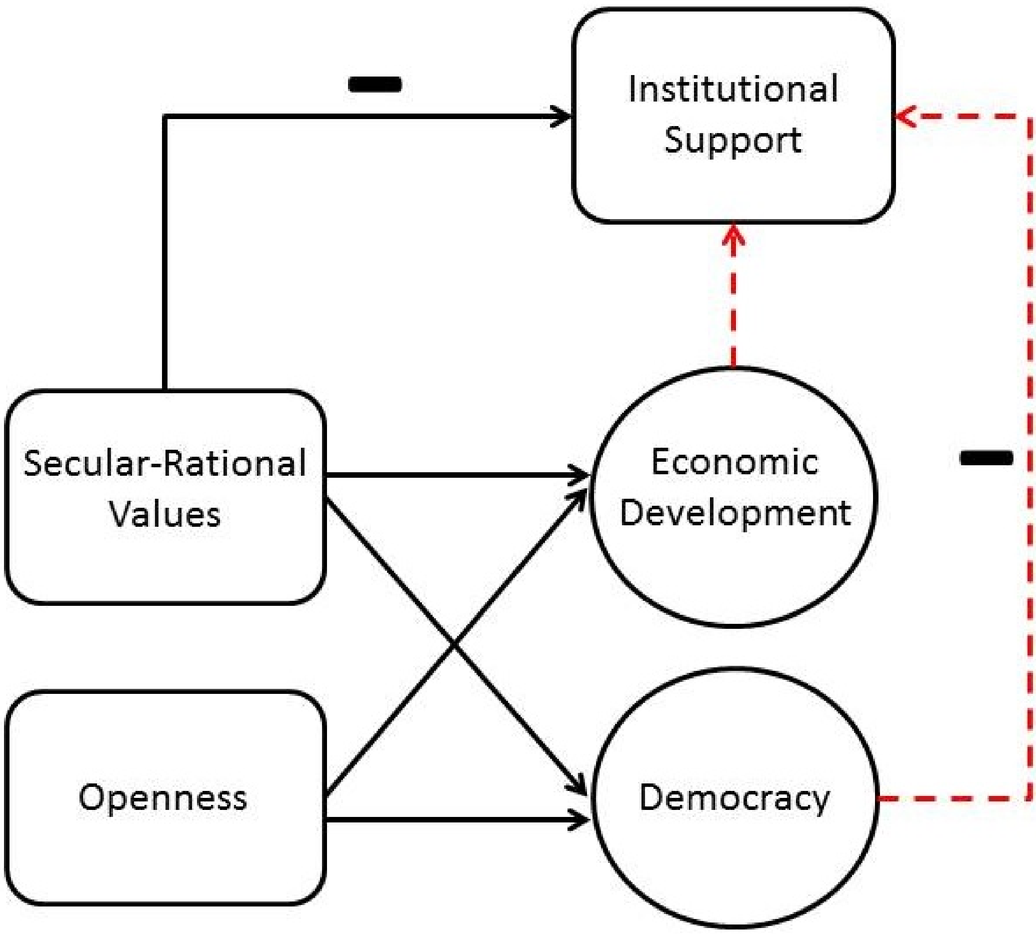


Figure 8.7: A schematic illustrating the linkages between the human development variables — economic development and democracy — and cultural value variables — Secular-Rationality, Openness and Institutional Support. The human development variables are represented by rectangles and the cultural value variables by circles. The black arrows indicate a pathway between long term generational changes and human development variables. The dotted red arrows indicate a pathway from short run changes in human development variables to opinion changes in Institutional Support. A minus sign (-) indicates a negative relationship. The cultural value variables are the three cultural components derived in this chapter, the economic development data is taken from the Madison project [Bolt et al., 2014] and the democracy data is taken from the Polity IV project [Marshall et al., 2017].

opinion change. For example, the Secular-Rational component is correlated with Religiosity REL, the Importance of Personal Prohibitions PP and Political Engagement PE and chapter four showed that generational changes among these cultural factors were correlated, yet their opinion changes were not.

We run each set of regressions another two times, substituting the cultural components with

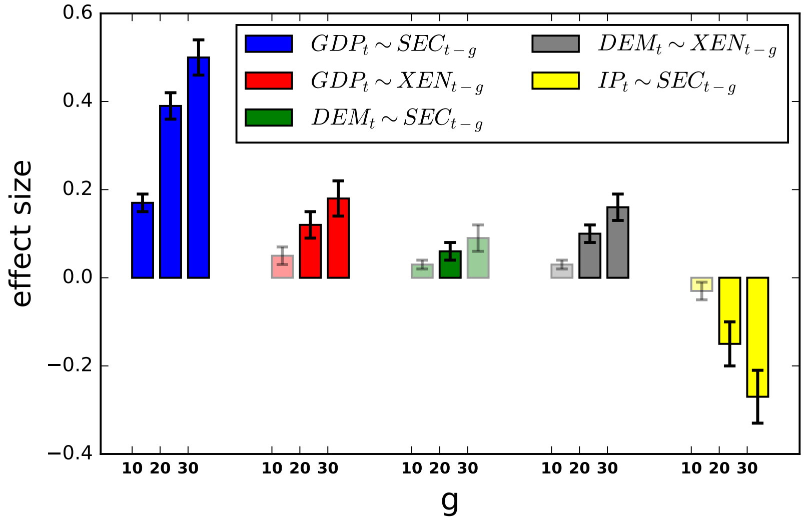


Figure 8.8: Robustness test for the five significant effects of cultural component generational change on long term human development and Institutional Support ($GDP_t \sim RAT_{t-g}$, $GDP_t \sim OPEN_{t-g}$, $DEM_t \sim RAT_{t-g}$, $DEM_t \sim OPEN_{t-g}$ and $INST_t \sim RAT_{t-g}$). We substitute each cultural component with its most correlated cultural factor: $RAT = SEC$, $OPEN = XEN$ and $INST = IP$; where SEC is Secularization, XEN is Xenophilia and IP is Interest in Politics. The effect sizes are measured $g = 10$, $g = 20$ and $g = 30$ years after the generation enters adulthood, which occurs between the ages of 20 and 30 years. The black error bars are standard errors and the faded colored bars mean 5% statistical significance was not met (Bonferroni corrected $p < 0.003$).

the two cultural factors most strongly correlated with it. In the first new regression we make the following substitutions: RAT=Secularization (inverse of Religiosity), $OPEN$=Xenophilia and $INST$=Interest in Politics . The second the following substitutions: RAT=Political Engagement, $OPEN$=Intrinsic tolerance and $INST$=Institutional Confidence.

8.3.4.1 Generational Change

As we predicted, the HDS structure associated with long-term generational changes is robust to the substitution of highly correlated cultural factors (see figure 8.8 and 8.9). When we substitute in the most correlated cultural factors (RAT=religiosity, $OPEN$=Xenophilia and $INST$=Interest in Politics) the five causal arrows in figure 8.7 remain intact. The one minor difference is that Secularization SEC has a much weaker effect on future DEM than RAT does. This means statical significance is not met in two out of three regressions, but this could be a false negative due to our use of the conservative Bonferroni p value adjustment.

As figure 8.9 shows, when we substitute in the second most correlated cultural factors (RAT=Political Engagement, $OPEN$=Intrinsic Tolerance and $INST$=Institutional Confidence) the HDS structure is largely preserved again. The one small difference is that the effect of

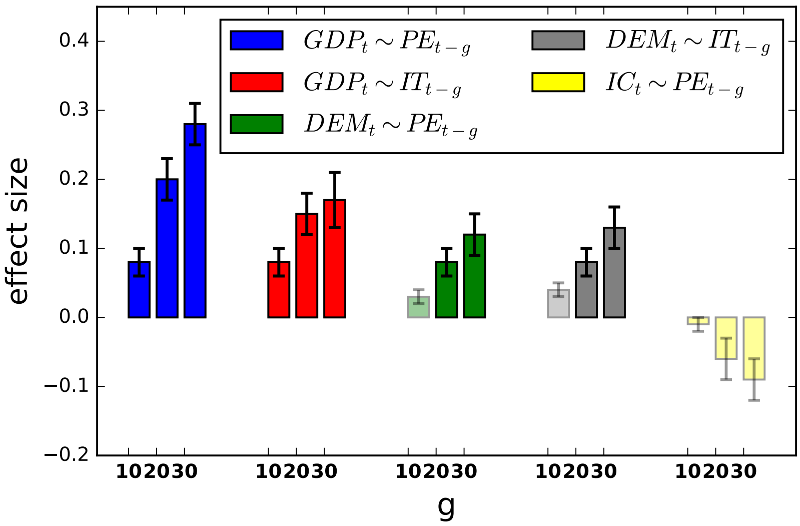


Figure 8.9: Robustness test for the five significant effects of cultural component generational change on long term human development and Institutional Support ($GDP_t \sim RAT_{t-g}$, $GDP_t \sim OPEN_{t-g}$, $DEM_t \sim RAT_{t-g}$, $DEM_t \sim OPEN_{t-g}$ and $INST_t \sim RAT_{t-g}$). We substitute each cultural component with its second most correlated cultural factor: $RAT = PE$, $OPEN = IT$ and $INST = IC$; where PE is Political Engagement, IT is Intrinsic Tolerance and IC is Institutional Confidence. The effect sizes are measured with time lags of $g = 10$, $g = 20$ and $g = 30$ years, with age of adulthood occurring between the ages of 20 and 30 years. The black error bars are standard errors and the faded colored bars mean 5% statistical significance was not met (Bonferroni corrected $p < 0.003$).

Political Engagement PE on future Institutional Confidence IC is small and does not reach statistical significance; unlike the cultural component effect of RAT on future $INST$. That said, the effect is still in the same direction and increases with time, which leads us to think that the absence of statistical significance is a false negative.

8.3.4.2 Cross-Sectional Samples

As expected, when we substitute cultural components using the cross-sectional samples, our revised HDS is modified. The first set of substitutions (RAT=Secularization, $OPEN$=Xenophilia and $INST$=Interest in Politics) show the expected positive effect of GDP on Interest in Politics IP, but not the negative effect of DEM on Interest in Politics. Whereas, when we substitute the second set of cultural factors (RAT=Political Engagement, $OPEN$=Intrinsic Tolerance and $INST$=Institutional Confidence), we see no evidence for the expected effect of GDP on Institutional Confidence and only limited evidence for the expected effect of DEM on Institutional Confidence. These effect sizes are illustrated in figure 8.10.

This suggests that short term changes in human development result in different trajectories of opinion change for cultural factors that are inter-correlated. In other words, GDP and DEM

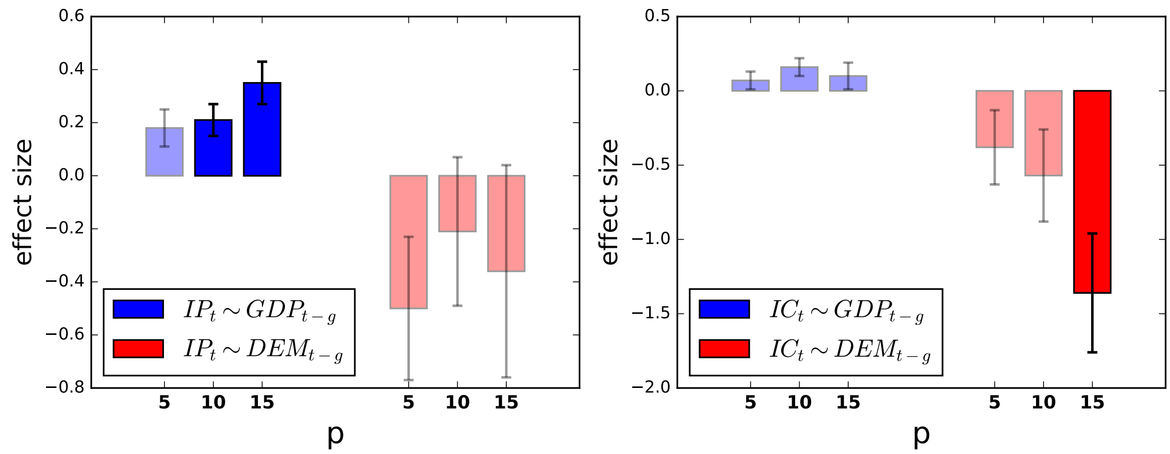


Figure 8.10: Robustness tests of the two significant effects for short term changes in human development and opinion change in Institutional Support ($INST_t \sim GDP_{t-p}$ and $INST_t \sim DEM_{t-p}$). Left hand side: we substitute each cultural component with its most correlated cultural factor — $RAT = SEC$, $OPEN = XEN$ and $INST = IP$; where SEC is Secularization, XEN is Xenophilia and IP is Interest in Politics. Right hand side: we substitute each cultural component with its second most correlated cultural factor — $RAT = PE$, $OPEN = IT$ and $INST = IC$; where PE is Political Engagement, IT is Intrinsic Tolerance and IC is Institutional Confidence. The effect sizes are measured with lags of $p = 5$, $p = 10$ and $p = 15$ years. The black error bars are standard errors and the faded colored bars mean 5% statistical significance was not met (Bonferroni corrected p < 0.003).

both affect the cultural component $INST$ because GDP affects Interest in Politics and DEM affects Institutional Confidence, whereas the generational change in inter-correlated sets of cultural factors is synchronous and they affect human development in the same way. For example, RAT affects GDP because Secularization and Political Engagement both affect GDP.

8.4 Discussion

The Human Development Sequence (HDS) was devised by Ronald Inglehart and Christian Welzel to explain the role of cultural value change in the broader context of economic development and emergent democratic institutions [Inglehart and Welzel, 2005]. They propose a causal structure in which economic development facilitates cultural value change, which in turn facilitates the rise of democracy. Although this sequence of events has been questioned [Spaiser et al., 2014]. We contribute to this debate by using time-lagged linear regressions to investigate the order in which human development and cultural value variables emerged. Unlike previous studies, we separate the two modes of cultural value change (generational and opinion) because these two modes interact with human development in different ways.

Long term generational cultural values are primary in the HDS. Secular-Rationality and

Openness precede changes in both economic development and democracy. This is contrary to the mainstream view that economic development is primary [Inglehart and Welzel, 2005]. Unlike previous versions of the HDS, we include a variable for Institutional Support, which has been declining in a way similar to 'support for democracy' [Foa et al., 2016]. It turns out that the long term decline in Institutional Support is usually preceded by an increase in Secular-Rationality. This supports the view that an increasingly informed and skeptical public become critical of their governing institutions [Norris and Inglehart, 2009]. Therefore, it looks like the decline of Institutional Support may just be an inevitable consequence of human development.

Institutional Support is also subject to large opinion fluctuations (as we saw in chapter four). These changes are predicted by short term changes in democracy and economic development. An increase in democracy can result in a transient *reduction* in future Institutional Support. Conversely, an increase in economic development predicts a *rise* in Institutional Support. Given that institutional confidence is linked to perceived government performance [Newton and Norris, 2000], this suggests that people might see economic prosperity as a responsibility of government.

Enrico Spolaore uses the idea of 'cultural barriers' to explain why cultural-history has such a big influence on economic development [Spolaore and Wacziarg, 2016]. Elaborating, the means of economic development (i.e. the knowledge, knowhow and technology associated with the industrial revolution) will diffuse more readily between countries with similar cultures. However, we found that past cultural values offer a better explanation for economic development than cultural-history. That said, cultural-history still has a big influence on the global distribution of cultural values themselves — cultural values being the primal variable in our revised HDS.

The cultural barriers model should therefore be applied to the spread of cultural values. Possible barriers to the spread of cultural values include an incompatibility of stable cultural features like language and religion [Inglehart and Welzel, 2005; Spolaore and Wacziarg, 2016] or information restrictions resulting from a non-free press and bad communication infrastructure [Norris and Inglehart, 2009]. It is possible that some other variable explains the global distribution of cultural values. These include education [Murtin and Wacziarg, 2014]. However, a recent study shows that increased tertiary education enrollment does not predict future cultural values [Ruck et al., 2019].

Generational cultural value change occurs at a deeper level than opinion change. Each of our cultural value components are highly correlated with a few of our nine cultural factors. When we substitute a cultural component with one of its correlated cultural factors, the long-term HDS structure associated with generational change remains the same. On the other hand, when we make the same cultural factor substitutions for short term opinion changes, the linkages to human development differ depending on which correlated cultural factor was substituted in. If we imagine a cultural value hierarchy in which deep cultural values affect those at the superficial level, then generational changes occur at a deep level, causing correlated changes among the superficial cultural factors (as we saw in chapter four). This is unlike opinion changes which are actioned at the superficial level.

Economic development is driven by technological innovation [Arthur, 2014], which scales in complexity and diversity when knowledge and know-how accumulates in large and densely connected networks [Hidalgo, 2015; Muthukrishna and Henrich, 2016]. Cultural values are an important part of the social software that directs human collective behavior [Morris, 2015; Ruck et al., 2018, 2019]. Cultural values of secular-rationality — a greater concern for worldly issues — means the productive capacity each person (the size of a person byte [Hidalgo, 2015]) goes up. Openness values — openness to cooperation with traditional norm violators and out-groups (see figure 8.1)— will increase the size and density of cooperative networks, possibly driving the expansion of cities [West, 2017].

Figure 8.1 shows that secular-rationality and cosmopolitanism are both correlated with low importance of personal prohibitions, which is indicative of the primacy of individual rights in western cultures [Schulz et al., 2018]. Therefore, these societies have preferences for racial, gender and economic equality [Inglehart and Welzel, 2005; Nikolaev et al., 2017] that makes democracy an attractive administrative arrangement. Furthermore, the economic power these cultural values bring (see figure 8.3) means that urban innovators can challenge the extractive rule of hereditary elites [Flannery and Marcus, 2012].

We ran a number of regressions in this chapter, which raises concerns about the validity of statistical significance levels; some even propose that the conventional statistical significance level of 5% is too liberal and a 0.5% level should be employed instead [Benjamin et al., 2018]. However, applied statisticians place too much emphasis on p values which, in reality, are just a continuous measure of certainty regarding the direction of an effect. This makes it a useful heuristic when comparing many effects, but any cutoff — be it 5% or 0.5% — is arbitrary. In Bayesian Statistics p-values are not employed because parameters are described by distributions, therefore credible intervals — the proportion of the probability mass that is positive (or negative) — are used instead [McElreath, 2015].

That said, many of our regressions include similar variables and many are just robustness checks, which means they are not independent tests. Nonetheless, we still use a conservative Bonferroni correction (which assumes independent tests) to adjust our p value threshold.

When using birth cohort differences to measure generational changes, we get the added bonus of extending our time series to 100 years. However, our opinion change time series, like the cross-sectional samples, only cover the last 25 years. This makes comparisons of generational and opinion changes uncertain. That said, it is clear from chapters four and five that opinion changes are very different in character from generational changes. Moreover, evidence from west European countries allows us to extend opinion change time series back 40 years and we still see that opinion changes are highly variable [Inglehart, 2008]. These trends still do not match the largely increasing trends in both economic development and democracy seen by the world over the same time period. Therefore, its probable that opinion changes will still be badly correlated with long-term human development, even if we had access to longer time series.

Controlling for the non-independence of countries is essential to avoid Galton's problem [Mesoudi, 2011] and Simpson's paradox [McElreath, 2015]. We have done this using a hierarchical model that treats countries as members of discrete language categories, but this ignores the fact that languages are actually continuously related according to a phylogenetic tree [Pagel et al., 2007]. Data from Glottolog [Hammarström et al., 2018] and Ethnologue [Lewis, 2009] could be used to construct a network of linguistic similarity among nations and, if this network were sufficiently clustered, it would justify the use of discrete language categories to control for cultural-history. Otherwise a full phylogenetic control must be developed [Matthews et al., 2016].

8.5 Conclusion

We used our time-lagged linear regression to evaluate the temporal relationships between human development (economic development and democratic institutions) and cultural values (Secular-Rational, Openness and Institutional Support). We used the results to recommend a revised version of the human developmental sequence which distinguishes between generational and opinion cultural value change. The revised HDS shows that Secular-Rationality and Openness are primary and predict future levels of human development. Our HDS includes a new variable — Institutional Support — whose decline is partly explained by the rise of Secular-Rationality. Institutional Support also shows volatile opinion changes that are preceded by short term fluctuations in human development. However, opinion changes occur superficially in the cultural value hierarchy, whereas generational changes occur at deeper level. The result being that cultural factors which compose Secular-Rational, Openness and Institutional Support will exhibit correlated generational change, but uncorrelated opinion change.

Chapter 9

Discussion

In the previous six chapters, we summarized the WEVS data and arrived at a parsimonious description of cultural values. We have quantified their long and short term dynamics and have shown that cultural values are primary in the sequence of human development. To promote economic development and democracy around the world, we must reduce the barriers that prevent the spread of beneficial cultural values by facilitating a free press, free trade and better communication infrastructure [Norris and Inglehart, 2009].

In chapters two to four, we used unsupervised statistical methods to summarize the World and European Values Surveys (WEVS) data. We view the WEVS responses as the visible emergent property of a set of underlying cultural values. In chapter three, we discovered nine interpretable cultural factors that explained the WEVS data. In chapter four, we used a two stage Bayesian linear regression to measure cultural value dynamics, identifying two modes of change. First, steady and persistent generational change that determine cultural values over the long term. Second, rapid and transient opinion change that dominates cultural value change in the short term. We showed in chapter five that countries cluster into four cultural value clusters that reflect both cultural-history (language, religion and colonial history) and economic development.

Chapters five to seven place dynamic cultural values within the broader framework of human development (economic development and democracy). Chapter six introduces our multi-level time-lagged linear regression which we used to determine whether changes in cultural values preceded those in human development or vice versa. We expand our time horizon by treating birth cohorts as representative of historic time periods because cultural values are formed during the first decades of life [House et al., 2013; Sears and Funk, 1999]. In chapter seven, we show that secularization precedes economic development, contradicting certain theories [Durkheim, 1912; Norenzayan, 2013], but also that respect for individual rights is a more likely driver of economic development. In chapter eight, we showed that changes in cultural values precede those in human development, demonstrating the primacy of cultural values. We also showed the concerning decline in support for national institutions may just be an inevitable consequence of human development.

9.1 Cultural Value Dynamics and Human Development

Our nine cultural factors were Religiosity, Political Engagement, the Importance of Personal Prohibitions, Xenophilia, Tolerance of Intrinsic Differences, Wellbeing, Prosociality, Institutional Confidence and Interest in Politics. We used Principal Component Analysis to compress these nine cultural factors into three orthogonal cultural components: Secular-Rationality (correlated with Secularization and Political Engagement), Openness (correlated with Xenophilia and Intrinsic Tolerance) and Institutional Support (correlated with Institutional Confidence and Interest In Politics). Secular-Rationality and Openness correspond to the two dimensions of the seminal Inglehart-Welzel cultural map [Inglehart and Baker, 2000; Inglehart and Welzel, 2005], but Institutional Support represents new variance.

The generational and opinion modes of cultural value change have distinctive characters. Opinion changes are rapid and transient [Inglehart, 2008], often as a response to fluctuations in short term economic variables [Inglehart and Welzel, 2005]. For instance, changes in inflation and unemployment track the mood in English language literature [Acerbi et al., 2013] and that opinion change in Institutional Support is a response to fluctuations in human development (see chapter eight). Opinion change dominates the variance in the WEVS's representative cross-sectional samples, so when previous work used these cross-sectional samples to show that changes in economic development preceded those in cultural values [Hofstede et al., 2010; Inglehart and Welzel, 2005], they were in fact showing that short term changes in the economy cause transient opinion changes in cultural values. A view supported by findings in chapter seven.

On the other hand, generational changes are gradual and persistent and explain the distribution of cultural values we see in the world today (see chapter four). Furthermore, unlike opinion changes, they track changes in human development and cultural-history (see chapter six). The strong and long-term linkages of generational change with human development suggest it is the important mode of cultural value change required to understand sustained improvements in economic development and democracy. We show that changes in cultural values precede improvements in both economic development and democracy (see chapter eight), in addition to changes in tertiary education enrollment [Ruck et al., 2018]. Chapter five showed that generational changes in African-Islamic countries are small to non-existent and are largest in Western countries. The cultural values of rich and poor countries are continuing to diverge [Norris and Inglehart, 2009].

Our Prosociality cultural factor is a measure of moral behavior; where 'moral behavior' means following the established rules of your society without coercion — like paying for taxes and public transport when it is possible to avoid it. Prosociality is a particularly volatile cultural factor because it is subject to large opinion changes (see chapter four). This might be because of the complex way our innate moral behavior interacts with economic incentives [Bowles, 2016]. In a democratic country, a government's influence is often constrained to around a decade due to time-limited periods in office, whereas generational change can be on the order of a century. Therefore, governments necessarily respond to the transient opinion changes of the public as opposed to the more slowly evolving generational changes. Therefore, it is possible the extreme variability in Prosociality are responses to the different short-termist incentive structures laid down by successive governments.

Wellbeing has a fairly typical global profile when compared to other cultural factors. We see that Western countries have greater Wellbeing than African-Islamic countries (the separability of these two cultural-historic clusters is a standard feature of most cultural factors). However, Wellbeing is unusual because the last 100 years of generational change does not explain the modern day distribution of countries. For instance, we see that Western counties have the highest Wellbeing and Communist-Confucian countries have the lowest, yet Communist-Confucian countries have seen the strongest generational increase in Wellbeing in the last 100 years (see chapter five). This suggests that an even larger inequality of Wellbeing existed in the time before the 20th century.

The Importance of Personal Prohibitions is the cultural factor which acts as the best 'cultural value barometer' for external conditions. It reflects cultural-history (see chapter five), it provides the best explanation for future levels of economic development (see chapter seven) and is correlated with Openness and Secular-Rationality which are the primal cultural values in the human development sequence (see chapter eight). The WEVS questions used to define the Importance of Personal Prohibitions ask about the justifiability of homosexuality, abortion, divorce and euthanasia. These questions represent a respect for individuals to make their own choices. This supports previous work showing that 'individualism' is important for explaining human development [Gorodnichenko and Roland, 2011; Hofstede et al., 2010; Inglehart and Norris, 2003].

The Openness cultural component is highly correlated with Xenophilia and Intrinsic Tolerance. Intrinsic Tolerance means a person is open to interactions with norm violating in-group members, such as drug users, alcoholics and homosexuals and Xenophilia means being open to interactions with out-group members, like immigrants and those of other races. Evidence from chapters three, four, five and seven show that Openness to in-group norm violators is often accompanied by Openness to out-group members, but this is not always the case. In an extreme example, the population of Lebanon have very high Openness towards in-group norm violators (particularly when compared to other countries in the region), yet they are deeply suspicious of out-group members (see chapter five). This might be a result of the interference of foreign countries during their civil war [Totten, 2013].

In the standard version of the Human Development Sequence (HDS), economic development leads to Openness because development brings material security and less of a focus on basic survival, meaning there is no reason to suspect the 'other' [Inglehart and Welzel, 2005]. However, we showed in chapter eight that Openness emerges before economic development, which brings this standard version of the HDS into question. We also show that democratic institutions do not predict economic development, contradicting the view that 'inclusive institutions' are the key to understanding economic development [Acemoglu et al., 2001]. However, democracy is just one type of institution and there are many others that could still affect economic development, such as rule of law [Fukuyama, 2001] and property rights [Besley and Ghatak, 2010].

Chapters seven and eight show clearly that cultural values of Secular-Rationalism and Openness are primal in the Human Development Sequence and that democracy and economic development are terminal outcomes. Economic development is the product of technological innovation and trade [Arthur, 2014], which becomes more numerous and complex as the size of the economic network increases [Hidalgo et al., 2007; Muthukrishna and Henrich, 2016]. More precisely, economic development scales super-linearly ($N^{1.2}$) with population size [Bettencourt et al., 2007]. Openness cultural values act to remove barriers to cooperation by including people with different ethnic markers in economic networks.

The second cultural value, Secular-Rationalism, represents an increased concern with improving the real world, rather than being concerned with salvation in the supernatural realm [Pinker, 2018; Weber, 1930]. This is conducive to economic development because it increases the society's motivation and capacity for technological innovation [Hidalgo, 2015], an effect that is multiplied by universal education [Ruck et al., 2019].

Democracy emerges in the wake of Secular-Rational, and in particular the Openness, cultural values (chapter eight). Openness to people from different cultures necessitates a more egalitarian world view [Morris, 2015], extending the boundaries of the in-group [Pettigrew and Tropp, 2006] and the associated sense of fairness. Mass-participation democracy is the institutionalization of the norms of fairness and equality [Inglehart and Welzel, 2005]. However, democracy is also diffusive [Brinks and Coppedge, 2006] and readily spreads from recently democratized countries to undemocratic neighbors who are culturally similar [Matthews et al., 2016]. If the recipient country does not have the appropriate levels of Openness then democracy will be unstable. This might explain why many countries in the 20th century have experienced democratic recession following democratization [Marshall et al., 2017].

The standard HDS states that Secular-Rationality is a prerequisite for both economic development and democracy [Inglehart and Welzel, 2005]. Our analysis supports this claim, but we also showed that Secular-Rationality predicts the surprising decline in Institutional Support we observed in chapter four (a generational decline similar to the one seen for 'support for democracy' [Foa et al., 2016]). This could be because Secular-Rational societies are more skeptical and critical of their ruling hierarchies [Norris and Inglehart, 2009]. Therefore the decline in Institutional

Support, though concerning, may just be a side-effect of human development.

9.2 Deep Generational vs. Superficial Opinion Change

Opinion changes occur at high frequency and are highly transient (chapter four). Evidence suggests that these occur in response to some environmental changes, such as terrorist attacks [Best et al., 2006], or economic crises [Bentley et al., 2014] (also see chapters seven and eight). These shifts in cultural values are similar to survival strategy changes seen in other primates [Dunbar et al., 2009; Hockings et al., 2015]. During times of crisis humans revert to more conservative values that are more rigorously implemented [Gelfand et al., 2011], whereas, when security is assured, cultural values like Secular-Rationalism and Openness support innovation and economic development [Harrington and Gelfand, 2014; Ruck et al., 2018].

Generational cultural value change, on the other hand, is more gradual and directional (chapter four). Differences between birth cohorts are a result of the different conditions of socialization they experienced during formative years [Inglehart and Welzel, 2005; Ryder, 1965]. Converging evidence from neuroscience [Petanjek et al., 2011; Sowell et al., 1999] and developmental psychology [House et al., 2013; Sutter and Kocher, 2007] suggest this age is between adolescence and 30 years, which is reflected in our simulation models (see chapter six).

Generational changes represent internalized cultural values that are acquired from many sources, including parents, one-to-many sources (media and education) and peer groups [Mesoudi, 2011]. However, evidence suggests that individualistic cultural values (related to Secular-Rationalism and Openness values [Inglehart and Oyserman, 2004]) are acquired from peers and one-to-many sources, whereas collectivist values come from parents [Mesoudi et al., 2016]. We have seen that richer nations have higher Openness and Secular-Rationalism than poorer ones (chapters six to eight) because mass-media and formal education have existed for longer in these rich countries [Norris and Inglehart, 2009]. Also large urban areas are more common in rich countries, which has the effect of expanding the size of peer networks and accelerating cultural change [Bettencourt et al., 2007]. Nonetheless, parental influence is important, particularly in the early years [Grusec and Kuczynski, 1997], so new generations are still anchored to the cultural values of previous ones, hence the gradual nature of generational change (chapter four).

In chapter eight we used Enrico Spolaore's 'cultural barriers' model [Spolaore and Wacziarg, 2016] to explain the influence of deep culture on the spread of cultural values. Cultural values spread more readily between similar cultures because differences in stable cultural features — like language and religion — act as a barrier to the spread of information (something similar is observed for political and economic shocks [Matthews et al., 2016]). Non-cultural barriers also prevent the spread of cultural values, these include the absence of a free press, economic isolationism and poor communication infrastructure [Norris and Inglehart, 2009]. The origin of the cultural values conducive to human development is probably Western Europe and, given the centrality afforded to individual rights, they could be Enlightenment values [Pinker, 2018].

9.2.1 Frequentist vs Bayesian Statistics

Statistical models are the engine of data analysis and causal inference, but there are two ways of approaching this modelling: Bayesian and Frequentist. Though in practice Bayesian and Frequentist methods often converge, or at least yield the same result, they are different philosophically. Our analysis in this thesis employs a combination Frequentist and Bayesian methods and so here we discuss the differences between them and why we employed both.

From a purely practical standpoint, Frequentist statistics are more accessible for non-statisticians. Frequentist statistics was the overwhelmingly dominant paradigm in the 20th century because it was computationally inexpensive. Frequentist inference uses only the likelihood, whereas Bayesian statistics must infer a posterior distribution by multiplying a likelihood by a prior distribution. The posterior distribution is analytically intractable in all but a few cases where the prior distribution is 'conjugate'. This means inferring Bayesian models requires a combination of efficient sampling engines, like Markov Chain Monte Carlo, and plentiful computational power [Gelman et al., 2013], which has only become available in the last few decades.

The headstart enjoyed by Frequentist statistics means that black-box software packages like Stata and SPSS largely implement these approaches. Therefore, non-statisticians who use statistics in their scientific work tend to be Frequentist. Though in this thesis we exploit Bayesian statistics where possible, we are non-statisticians and so employ Frequentist approaches when our statistical knowledge is not sufficient to correctly formulate a model.

As an aside, the status quo may be changing as new packages become available which bridge this knowledge gap, making Bayesian methods available for non-statisticians, such as Richard McElreath's statistical package in R called 'Statistical Rethinking' [McElreath, 2015].

Calculating a Bayesian posterior distribution may be computationally expensive, but it overcomes a series of conceptual and practical problems that are baked into Frequentist statistics. Frequentist approaches perform inference using only the likelihood, which assumes that the model parameters are fixed and that the data are variable. This means that a genuine probability distribution over the unknown parameters cannot be defined. This limitation is overcome using the conceptually convoluted confidence interval on parameter estimates. A 95% confidence interval is the range of parameter values that will explain 95% of data sampled from the same hypothetical infinite dataset as the observed data [Van der Plas, 2014]. The centrality of the likelihood also makes parameters distinct from data, which makes missing data mitigation complicated [Marshall et al., 2009].

On the other hand, a Bayesian posterior expresses a joint probability distribution over all parameters conditional on data. This frames probability as uncertainty about parameters that can be reduced by introducing new data. The Bayesian framework also makes data and parameters interchangeable (data are just known parameters), so if data are missing then we can simply assign them as parameters and infer them using the model [Gelman et al., 2013]. Moreover, Bayesian statistics allow you to flexibly formulate known prior information about the model in the form of a prior distribution, whereas Frequentist statistics implicitly assume an infinite flat prior [McElreath, 2015].

9.3 Conclusions

We used the World and European Values Surveys (WEVS) to investigate the dynamics of global cultural values and their role in human development. We showed that cultural values are primal in the human development sequence: Secular-Rationality and Openness are prerequisites for economic development and democracy. Cultural-history affects the spread of Secular-Rationality and Openness by putting up cultural barriers between countries because stable cultural features like language and religion prevent information being transmitted between dissimilar societies [Spolaore and Wacziarg, 2016]. But these barriers can be reduced should a country adopt a free press, free trade and modern communication infrastructure [Norris and Inglehart, 2009].

We identified nine cultural factors which underlie the WEVS data and these can be summarized as three orthogonal cultural components: Secular-Rationality, Openness and Institutional Support. Secular-Rationality and Openness correspond with the two dimensions of the seminal Inglehart-Welzel cultural map [Inglehart and Welzel, 2005], whereas Institutional Support represents a new cultural component. We see a surprising generational decline in Institution Support, similar to the one seen in 'support for democracy' [Foa et al., 2016], that corresponds to a rise in Secular-Rationality. Therefore, the decline in Institutional Support may just be a side-effect of human development.

We separated two independent modes of cultural value change from the representative cross-sectional samples provided by the WEVS: generational and opinion changes. Generational changes are persistent, steady and reflect socialized cultural values acquired during formative years. Opinion changes are rapid, transient and affect the entire population during a particular time period. Generational changes show strong linkages with human development and explain the long term changes in cultural values, economic development and democracy.

Opinion changes respond to fluctuations in development variables. Moreover, the variance in the representative cross-sectional samples is dominated by opinion changes. Therefore, when previous authors found that economic development caused changes in cultural values [Hofstede et al., 2010; Inglehart and Welzel, 2005], they were actually detecting transient opinion changes and not generational changes linked with long run human development.

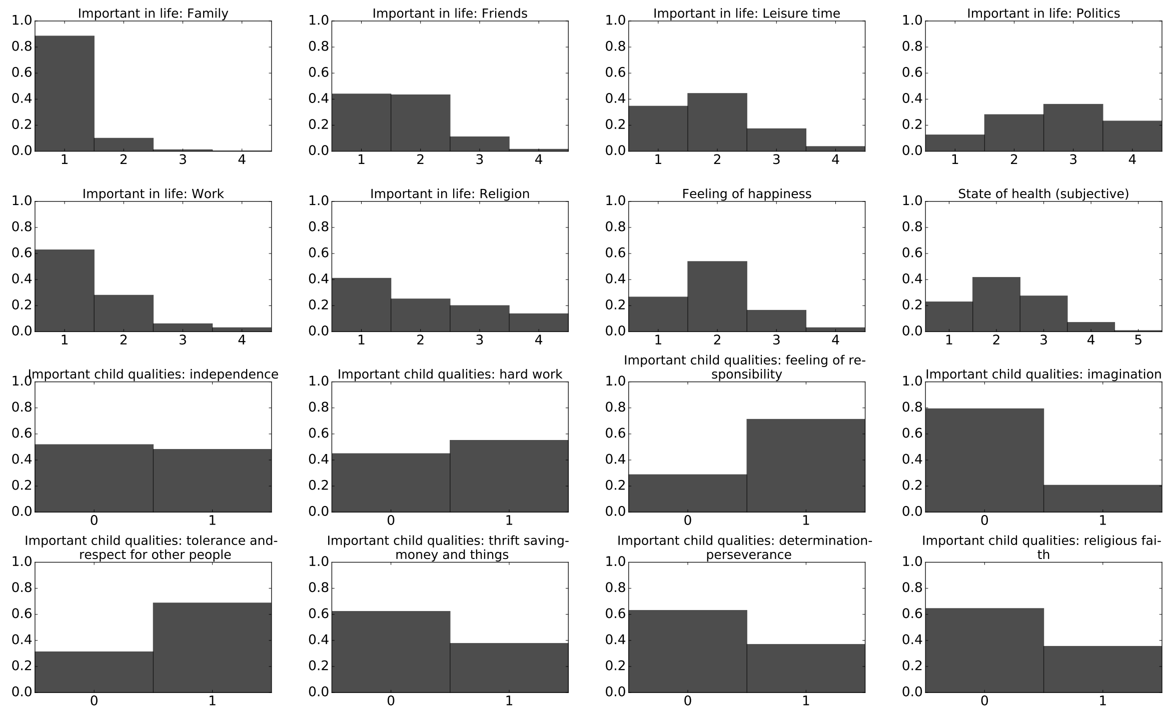
There are some limitations to our analysis which present opportunities for future work. We have entirely focused on comparing the *average* person from each country. Future work might focus on the importance of *variation* within populations. There are reasons to believe that the causes of within-population variation are different to between-population variation. Take the example of political orientation, where the within population distribution is Gaussian [Tuschman, 2013]. This Gaussian has a larger variance in countries with political and economic uncertainty [Tuschman, 2013] and those with rigid hierarchical social structures [Hofstede et al., 2010]. Whereas the mean of the Gaussian depends on factors like economic development and cultural-history [Inglehart and Baker, 2000].

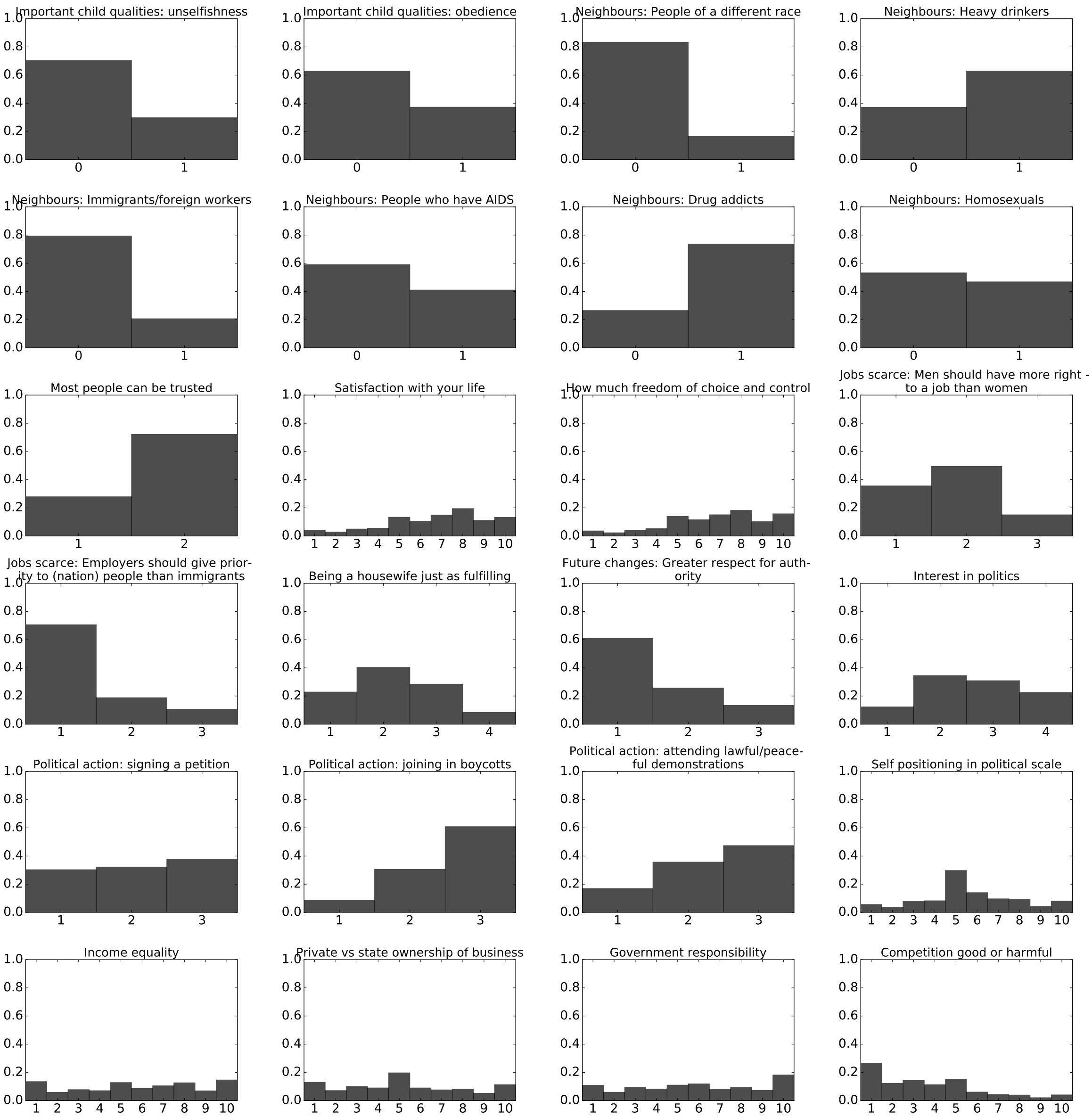
From a methodological stand point, we were faced with missing data problems throughout. In chapters five to seven, when we employed our multi-level time-lagged linear regression, we decided to omit missing data. Omitting data can bias inference and, because the use of different time lags results in different missingness structure, comparing the models is difficult. We ran many checks to ensure that our findings were robust in a number of different scenarios, but this was not parsimonious. A Bayesian framework offers the opportunity to build data imputation into the statistical model.

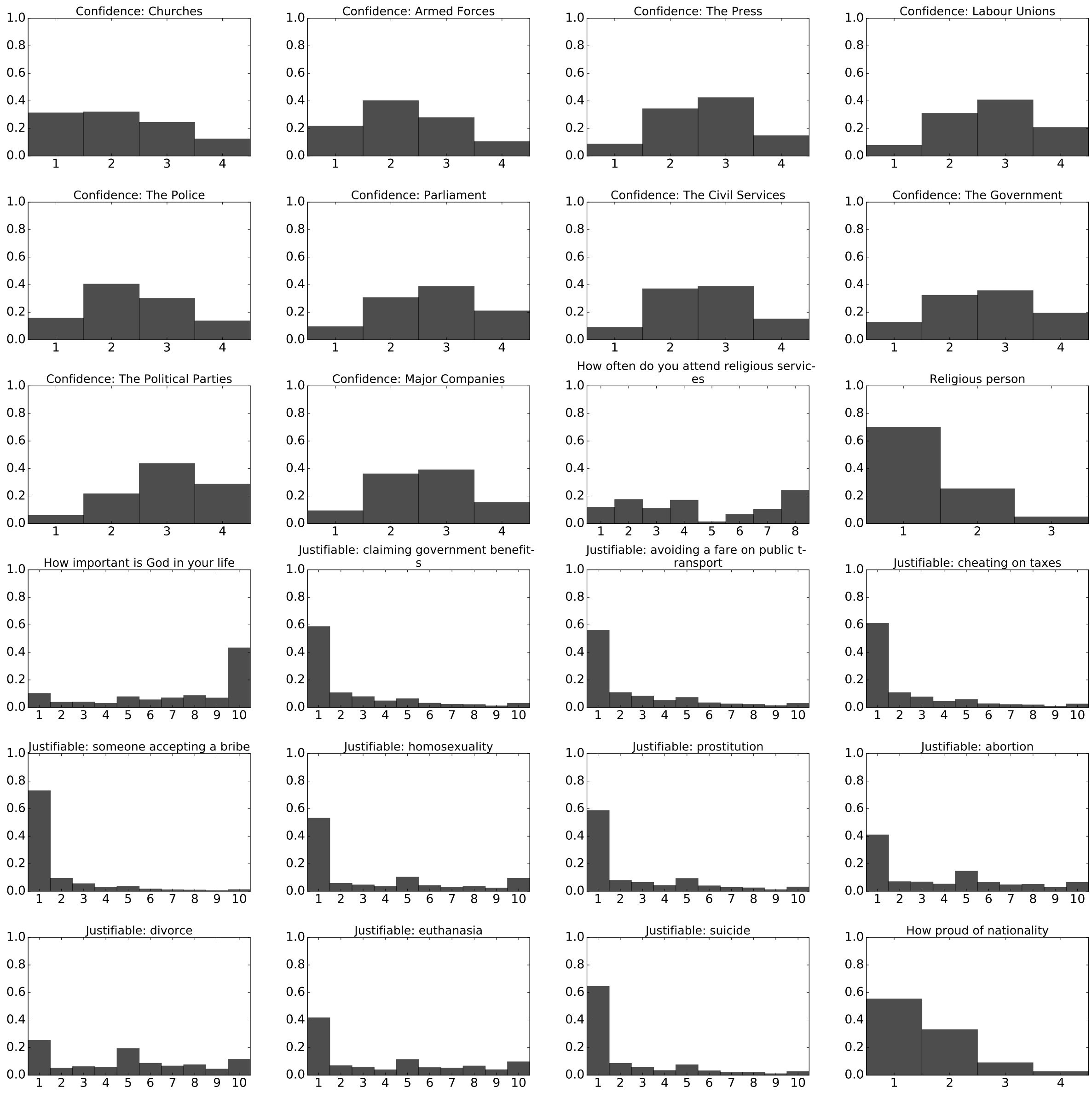
Appendix A

Chapter Three

This appendix contains histograms of responses for each the 64 World and European Value Survey questions we utilized. All of the questions are on ordinal or Likert scales of varying lengths and the frequencies at each level are expressed as a fraction of the 476,583 responders (minus non-responses).




Important child qualities: unselfishness
Important child qualities: obedience
Neighbours: People of a different race
Neighbours: Heavy drinkers
Neighbours: Immigrants/foreign workers
Neighbours: People who have AIDS
Neighbours: Drug addicts
Neighbours: Homosexuals
Most people can be trusted
Satisfaction with your life
How much freedom of choice and control
Jobs scarce: Men should have more right - to a job than women
Jobs scarce: Employers should give prior- ity to (nation) people than immigrants
Being a housewife just as fulfilling
Future changes: Greater respect for auth- ority
Interest in politics
Political action: signing a petition
Political action: joining in boycotts
Political action: attending lawful/peace- ful demonstrations
Self positioning in political scale
Income equality
Private vs state ownership of business
Government responsibility
Competition good or harmful


Confidence: Churches
Confidence: Armed Forces
Confidence: The Press
Confidence: Labour Unions
Confidence: The Police
Confidence: Parliament
Confidence: The Civil Services
Confidence: The Government
Confidence: The Political Parties
Confidence: Major Companies
How often do you attend religious servic-es
Religious person
How important is God in your life
Justifiable: claiming government benefit-s
Justifiable: avoiding a fare on public t-ransport
Justifiable: cheating on taxes
Justifiable: someone accepting a bribe
Justifiable: homosexuality
Justifiable: prostitution
Justifiable: abortion
Justifiable: divorce
Justifiable: euthanasia
Justifiable: suicide
How proud of nationality

Appendix B

Chapter Six

The generational time series' for Religiosity REL in each country. It shows that older people are more religious than younger people (particularly in Western countries). The table continues on the next two pages.

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990
Albania				-0.15	0.01	0.15	0.18	0.28	0.38	
Algeria					-0.88	-0.81	-0.74	-0.71	-0.67	-0.59
Andorra					0.50	0.75	0.97	1.12	1.06	
Argentina			-0.36	-0.30	-0.14	-0.06	0.05	0.16	0.30	0.41
Armenia				-0.27	-0.20	-0.17	-0.24	-0.23	-0.27	
Australia			0.21	0.29	0.45	0.63	0.68	0.80	0.83	
Austria			-0.08	0.08	0.26	0.36	0.46	0.64	0.76	
Azerbaijan				-0.08	-0.05	-0.02	-0.04	-0.09	-0.16	-0.11
Bahrain						-0.37	-0.40	-0.35	-0.37	-0.34
Bangladesh					-1.04	-0.99	-0.92	-0.90		
Belarus			0.17	0.27	0.36	0.51	0.55	0.60	0.74	0.82
Belgium		0.07	0.18	0.26	0.53	0.73	0.78	0.79	1.00	
Bosnia				0.01	-0.04	-0.03	-0.08	-0.11	-0.12	
Brazil				-0.72	-0.62	-0.55	-0.54	-0.48	-0.41	-0.37
Bulgaria			0.48	0.58	0.71	0.74	0.75	0.82	0.89	
Burkina Faso						-0.85	-0.83	-0.77	-0.80	
Canada		-0.51	-0.37	-0.24	0.00	0.15	0.19	0.38	0.55	
Chile			-0.66	-0.51	-0.42	-0.28	-0.19	-0.06	0.07	
China				1.22	1.21	1.22	1.20	1.26	1.24	1.25
Colombia				-0.81	-0.73	-0.66	-0.68	-0.60	-0.51	-0.44
Croatia				-0.14	0.09	0.10	0.07	0.21	0.24	

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990
Cyprus (G)				-0.72	-0.58	-0.38	-0.24	-0.13	-0.07	
Cyprus (T)								-0.18	-0.09	
Czech Rep.		0.44	0.56	0.70	1.00	1.20	1.27	1.27	1.48	
Denmark				0.55	0.73	0.80	0.98	1.03	1.16	
Dominican Rep.							-0.48	-0.49		
Ecuador						-0.81	-0.64	-0.64	-0.54	-0.45
Egypt				-0.89	-0.87	-0.88	-0.85	-0.83	-0.82	-0.81
El Salvador				-0.86	-0.81	-0.72	-0.72	-0.68		
Estonia			0.47	0.68	0.84	0.85	0.92	1.00	1.16	1.28
Ethiopia							-0.70	-0.58	-0.52	
Finland				0.27	0.47	0.59	0.75	0.88	1.04	
France			0.36	0.48	0.79	0.88	0.94	1.06	1.20	
Georgia			-0.35	-0.39	-0.46	-0.55	-0.58	-0.65	-0.67	-0.74
Germany		0.39	0.48	0.66	0.84	1.00	1.04	1.09	1.29	1.40
Ghana						-0.97	-0.98	-1.01	-1.00	-1.02
Great Britain		0.08	0.19	0.31	0.48	0.64	0.81	0.88	0.94	
Greece				-0.43	-0.26	-0.19	0.00	0.08	0.20	
Guatemala						-0.91	-0.87	-0.82	-0.79	
Hong Kong				0.77	0.80	0.88	0.86	0.88	0.93	0.95
Hungary			-0.01	0.16	0.52	0.75	0.78	0.94	1.14	
Iceland					0.10	0.30	0.45	0.58	0.81	
India			-0.32	-0.31	-0.30	-0.29	-0.25	-0.18	-0.19	-0.18
Indonesia					-0.97	-0.94	-0.94	-0.91	-0.89	
Iran				-0.89	-0.80	-0.82	-0.74	-0.69	-0.67	
Iraq					-0.82	-0.80	-0.80	-0.79	-0.74	-0.73
Ireland			-0.80	-0.61	-0.40	-0.20	-0.03	0.21	0.36	
Israel				0.07	0.19	0.03	0.00	0.00	-0.03	
Italy			-0.41	-0.38	-0.13	0.01	0.03	0.06	0.22	
Japan				0.76	0.90	1.03	1.10	1.26	1.36	
Jordan					-1.00	-0.96	-0.93	-0.91	-0.90	-0.87
Kazakhstan					0.12	0.18	0.21	0.18	0.23	0.23
Kosovo					-0.55	-0.56	-0.55	-0.57	-0.59	
Kuwait							-0.76	-0.74	-0.65	-0.78
Kyrgyzstan						-0.06	-0.14	-0.10	-0.12	-0.11
Latvia			0.34	0.43	0.50	0.61	0.64	0.64	0.76	
Lebanon						-0.15	-0.27	-0.22	-0.12	-0.13
Libya						-0.83	-0.77	-0.76	-0.76	-0.72
Lithuania			-0.20	-0.05	0.19	0.42	0.52	0.54	0.78	
Luxembourg				0.34	0.44	0.59	0.63	0.73	0.83	
Macedonia				-0.07	-0.01	-0.03	-0.04	-0.04	0.01	
Malaysia						-0.69	-0.69	-0.66	-0.60	-0.62
Mali					-0.93	-0.92	-0.89	-0.89	-0.85	
Malta				-0.92	-0.76	-0.65	-0.54	-0.42	-0.28	
Mexico				-0.68	-0.58	-0.49	-0.41	-0.40	-0.26	-0.18
Moldova				-0.32	-0.14	-0.10	-0.13	0.02	0.05	
Morocco					-1.05	-0.99	-1.00	-0.94	-0.89	
Netherlands			0.38	0.49	0.70	0.86	0.94	0.99	1.14	

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990
New Zealand			0.40	0.45	0.57	0.72	0.72	0.75		
Nigeria					-0.99	-0.99	-0.98	-0.97	-0.97	-0.96
North Ireland				-0.23	-0.13	0.26	0.38	0.36		
Norway			0.35	0.40	0.70	0.81	0.89	1.01	1.19	
Pakistan					-0.91	-0.90	-0.90	-0.86	-0.84	-0.84
Palestine							-0.70	-0.73	-0.67	-0.60
Peru					-0.66	-0.58	-0.52	-0.43	-0.34	-0.25
Philippines					-0.85	-0.85	-0.84	-0.84	-0.82	
Poland			-0.68	-0.61	-0.44	-0.32	-0.35	-0.24	-0.12	
Portugal			-0.38	-0.31	-0.12	0.07	0.12	0.28	0.43	
Puerto Rico			-0.98	-0.93	-0.86	-0.81	-0.71	-0.64		
Qatar						-0.98	-0.97	-0.97	-0.98	
Romania			-0.68	-0.56	-0.49	-0.31	-0.24	-0.22	-0.06	
Russia		0.22	0.30	0.37	0.56	0.57	0.59	0.62	0.73	0.83
Rwanda						-0.53	-0.52	-0.51	-0.50	-0.47
Saudi Arabia						-0.81	-0.82	-0.75	-0.78	
Serbia and Montenegro			0.12	0.16	0.25	0.30	0.27	0.34	0.41	
Singapore					-0.32	-0.32	-0.25	-0.12	-0.12	-0.03
Slovakia			-0.33	-0.17	0.16	0.32	0.33	0.54	0.67	
Slovenia			0.24	0.29	0.50	0.66	0.71	0.71	0.90	
South Africa			-0.68	-0.68	-0.63	-0.61	-0.58	-0.56	-0.51	-0.50
South Korea				0.23	0.32	0.36	0.50	0.60	0.67	
Spain		-0.31	-0.11	-0.04	0.26	0.54	0.71	0.83	1.01	
Sweden			0.65	0.72	0.94	1.08	1.07	1.15	1.30	1.41
Switzerland		-0.03	0.08	0.19	0.38	0.52	0.60	0.72	0.84	
Taiwan					0.30	0.45	0.45	0.61	0.78	0.85
Tanzania					-0.96	-0.90	-0.92	-0.95	-0.93	
Thailand				-0.24	-0.20	-0.13	-0.09	-0.07	-0.02	
Trinidad and Tobago					-0.71	-0.74	-0.72	-0.63	-0.58	
Tunisia					-0.89	-0.79	-0.77	-0.66	-0.61	-0.54
Turkey				-0.75	-0.68	-0.52	-0.45	-0.44	-0.33	-0.24
Uganda							-0.86	-0.79	-0.82	
Ukraine			-0.01	0.06	0.16	0.15	0.15	0.20	0.27	
United States		-0.52	-0.49	-0.43	-0.31	-0.20	-0.16	-0.10	-0.02	0.05
Uruguay			0.00	0.12	0.22	0.41	0.47	0.56	0.73	
Uzbekistan						-0.17	-0.18	-0.18	-0.12	-0.04
Venezuela					-0.67	-0.60	-0.57	-0.52	-0.50	
Viet Nam				0.58	0.65	0.62	0.68	0.64	0.69	
Yemen							-0.90	-0.80	-0.87	-0.86
Zambia							-0.79	-0.76	-0.72	-0.75
Zimbabwe						-0.93	-0.87	-0.85	-0.85	-0.83

Table B.1: Religiosity REL generational time series.

Appendix C

Chapter Seven

This appendix contains the complete set of regressions results from chapter seven, where we look at the relationship between secularization and economic development. In all tables the column headings are the dependent variables and the rows represent lagged predictor variables.

C.1 Generational Changes

C.1.1 Secularization and Economic Development Regressions

Regression results investigating the temporal relationship between long term economic development GDP and generational changes in Secularization SEC.

	SEC	GDP
N	420	501
n	102	97
SEC	0.99 (0.01)***	0.11 (0.01)***
GDP	-0.01 (0.01)	0.98 (0.02)***
i	0.05***	0.08***
h	0.07***	0.04
R2	0.99	0.92

Table C.1: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	453	498
n	102	102
SEC	0.99 (0.01)***	0.13 (0.02)***
GDP	-0.02 (0.01)	0.98 (0.02)***
i	0.05***	0.08***
h	0.07***	0.04
R2	0.99	0.93

Table C.2: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	480	429
n	102	102
SEC	1 (0.01)***	0.14 (0.02)***
GDP	-0.02 (0.01)	0.95 (0.02)***
i	0.05***	0.12***
h	0.07***	0.05
R2	0.99	0.94

Table C.3: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	326	473
n	96	102
SEC	0.91 (0.02)***	0.34 (0.03)***
GDP	-0.01 (0.03)	0.85 (0.04)***
i	0.13***	0.22***
h	0.2***	0.21***
R2	0.99	0.91

Table C.4: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	356	415
n	101	102
SEC	0.9 (0.02)***	0.36 (0.03)***
GDP	-0.01 (0.02)	0.8 (0.04)***
i	0.13***	0.24***
h	0.2***	0.22***
R2	0.99	0.93

Table C.5: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	378	340
n	101	102
SEC	0.92 (0.02)***	0.24 (0.04)***
GDP	-0.04 (0.02)	0.83 (0.04)***
i	0.13***	0.23***
h	0.19***	0.19***
R2	0.99	0.91

Table C.6: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	230	390
n	84	102
SEC	0.76 (0.02)***	0.55 (0.04)***
GDP	0 (0.05)	0.81 (0.05)***
i	0.22***	0.36***
h	0.37***	0.31***
R2	0.99	0.96

Table C.7: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	263	326
n	94	102
SEC	0.76 (0.02)***	0.43 (0.04)***
GDP	0 (0.04)	0.82 (0.05)***
i	0.23***	0.34***
h	0.37***	0.23***
R2	0.99	0.94

Table C.8: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	282	251
n	99	95
SEC	0.78 (0.03)***	0.31 (0.05)***
GDP	-0.04 (0.03)	0.8 (0.06)***
i	0.22***	0.34***
h	0.35***	0.24***
R2	0.99	0.93

Table C.9: Generational change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

C.1.2 Secularization, Tolerance, Autonomy and Economic Development

Regression results investigating the temporal relationship between long term economic development GDP and generational changes in Secularization SEC, Autonomy AUT and Tolerance of Personal Prohibition Violators TOL.

10	AUT	SEC	TOL	GDP
N	441	420	420	501
n	102	102	102	97
AUT	0.95 (0.02)***	-0.01 (0.01)	-0.01 (0.01)	0.05 (0.01)**
SEC	0.07 (0.03)	1.01 (0.02)***	0.02 (0.02)	0.01 (0.02)
TOL	-0.09 (0.03)	-0.01 (0.02)	0.93 (0.02)***	0.1 (0.02)***
GDP	-0.03 (0.03)	0 (0.01)	-0.01 (0.02)	0.94 (0.02)***
i	0.04	0.05***	0.06***	0.07***
h	0.1**	0.07***	0.12***	0.05
R2	0.95	0.99	0.99	0.93

Table C.10: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	476	453	453	498
n	102	102	102	102
AUT	0.95 (0.02)***	-0.01 (0.01)	-0.01 (0.01)	0.03 (0.01)
SEC	0.06 (0.03)	1 (0.02)***	0.02 (0.02)	0.04 (0.02)
TOL	-0.07 (0.03)	0 (0.02)	0.94 (0.02)***	0.12 (0.02)***
GDP	-0.04 (0.03)	-0.01 (0.01)	-0.03 (0.02)	0.93 (0.02)***
i	0.05	0.05***	0.06***	0.08***
h	0.1*	0.07***	0.12***	0.06
R2	0.95	0.99	0.99	0.94

Table C.11: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	503	480	480	429
n	102	102	102	102
AUT	0.95 (0.02)***	-0.01 (0.01)	-0.01 (0.01)	0.04 (0.02)
SEC	0.06 (0.03)	1 (0.01)***	0.03 (0.02)	0.04 (0.03)
TOL	-0.1 (0.03)*	0 (0.02)	0.94 (0.02)***	0.12 (0.03)***
GDP	0.01 (0.03)	-0.02 (0.01)	-0.03 (0.02)	0.88 (0.03)***
i	0.05	0.05***	0.06***	0.11***
h	0.11***	0.07***	0.12***	0.04
R2	0.95	0.99	0.99	0.95

Table C.12: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	349	326	326	473
n	98	96	96	102
AUT	0.8 (0.03)***	-0.03 (0.02)	-0.02 (0.02)	0.04 (0.03)
SEC	0.18 (0.06)**	0.97 (0.03)***	0.01 (0.04)	0.06 (0.04)
TOL	-0.3 (0.06)***	-0.04 (0.03)	0.8 (0.04)***	0.3 (0.04)***
GDP	-0.04 (0.06)	0 (0.03)	-0.02 (0.04)	0.76 (0.04)***
i	0.22***	0.12***	0.16***	0.18***
h	0.31***	0.2***	0.33***	0.17***
R2	0.93	0.99	0.98	0.92

Table C.13: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	377	356	356	415
n	101	101	101	102
AUT	0.81 (0.03)***	-0.03 (0.02)	-0.01 (0.02)	0.02 (0.03)
SEC	0.15 (0.05)	0.95 (0.03)***	0.02 (0.04)	0.09 (0.05)
TOL	-0.26 (0.06)***	-0.04 (0.03)	0.79 (0.04)***	0.32 (0.05)***
GDP	-0.08 (0.05)	0.01 (0.03)	-0.03 (0.03)	0.68 (0.04)***
i	0.21***	0.13***	0.15***	0.21***
h	0.3***	0.2***	0.31***	0.16*
R2	0.93	0.99	0.98	0.94

Table C.14: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	401	378	378	340
n	101	101	101	102
AUT	0.81 (0.03)***	-0.02 (0.02)	-0.02 (0.02)	0.09 (0.03)*
SEC	0.15 (0.05)	0.95 (0.03)***	0.02 (0.03)	0.01 (0.05)
TOL	-0.27 (0.06)***	-0.01 (0.03)	0.82 (0.04)***	0.24 (0.05)***
GDP	-0.04 (0.05)	-0.03 (0.03)	-0.06 (0.03)	0.69 (0.05)***
i	0.21***	0.13***	0.15***	0.21***
h	0.31***	0.19***	0.31***	0.12
R2	0.93	0.99	0.98	0.92

Table C.15: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	251	230	230	390
n	86	84	84	102
AUT	0.71 (0.05)***	-0.06 (0.03)	-0.05 (0.03)	0.04 (0.03)
SEC	0.17 (0.08)	0.9 (0.05)***	0.04 (0.06)	0.14 (0.06)
TOL	-0.39 (0.08)***	-0.06 (0.04)	0.62 (0.05)***	0.42 (0.05)***
GDP	-0.16 (0.08)	0.02 (0.05)	0.02 (0.05)	0.67 (0.05)***
i	0.32***	0.21***	0.25***	0.29***
h	0.48***	0.35***	0.51***	0.23***
R2	0.94	0.99	0.99	0.95

Table C.16: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	286	263	263	326
n	97	94	94	102
AUT	0.7 (0.04)***	-0.05 (0.02)	-0.06 (0.03)	0.1 (0.04)
SEC	0.22 (0.08)	0.89 (0.04)***	0.06 (0.05)	0.07 (0.06)
TOL	-0.37 (0.07)***	-0.07 (0.04)	0.65 (0.05)***	0.34 (0.06)***
GDP	-0.15 (0.07)	0.03 (0.04)	-0.04 (0.05)	0.64 (0.05)***
i	0.33***	0.22***	0.25***	0.28***
h	0.42***	0.35***	0.5***	0.13
R2	0.94	0.99	0.99	0.94

Table C.17: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

10	AUT	SEC	TOL	GDP
N	303	282	282	251
n	100	99	99	95
AUT	0.69 (0.04)***	-0.04 (0.02)	-0.05 (0.03)	0.13 (0.04)*
SEC	0.22 (0.08)	0.87 (0.04)***	0.06 (0.05)	0.02 (0.07)
TOL	-0.4 (0.08)***	-0.05 (0.04)	0.68 (0.05)***	0.27 (0.07)***
GDP	-0.06 (0.07)	-0.01 (0.03)	-0.08 (0.04)	0.6 (0.07)***
i	0.33***	0.22***	0.23***	0.3***
h	0.45***	0.35***	0.48***	0.17
R2	0.94	0.99	0.99	0.93

Table C.18: Generational change regressions to establish the temporal relationships between SEC, TOL, AUT and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

C.2 Cross-Sectional Changes

C.2.1 Secularization and Economic Development Regressions

Regression results investigating the temporal relationship between short term economic development GDP and cross-sectional changes in Secularization SEC.

	SEC	GDP
N	128	281
n	74	105
SEC	0.89 (0.02)***	0.02 (0.02)
GDP	0.07 (0.02)**	1.04 (0.01)***
i	0	0
h	0	0.03
R2	0.94	0.99

Table C.19: Cross-sectional change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	90	223
n	67	95
SEC	0.86 (0.04)***	0.05 (0.03)
GDP	0.08 (0.02)**	1.08 (0.01)***
i	0.1	0.11
h	0	0
R2	0.93	0.98

Table C.20: Cross-sectional change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	73	145
n	53	82
SEC	0.83 (0.06)***	0.07 (0.04)
GDP	0.08 (0.04)	1.18 (0.02)***
i	0.12	0.21***
h	0.13	0.04
R2	0.88	0.98

Table C.21: Cross-sectional change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

C.2.2 Secularization, Tolerance, Autonomy and Economic Development

Regression results investigating the temporal relationship between short term economic development GDP and cross-sectional changes in Secularization SEC, Autonomy AUT and Tolerance of Personal Prohibition Violators TOL.

	AUT	SEC	TOL	GDP
N	128	128	128	281
n	74	74	74	105
AUT	0.72 (0.06)***	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)
SEC	0.11 (0.07)	0.88 (0.04)***	0.15 (0.06)	0.02 (0.02)
TOL	-0.09 (0.09)	0.06 (0.04)	0.74 (0.07)***	-0.05 (0.03)
GDP	0.12 (0.04)*	0.05 (0.02)	0.1 (0.04)	1.03 (0.01)***
i	0	0	0.1	0
h	0.05	0	0.18	0.07
R2	0.77	0.94	0.89	0.99

Table C.22: Cross-sectional change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	AUT	SEC	TOL	GDP
N	90	90	90	223
n	67	67	67	95
AUT	0.67 (0.07)***	-0.07 (0.04)	0.01 (0.06)	0.01 (0.03)
SEC	0.13 (0.1)	0.92 (0.06)***	0.05 (0.09)	0.07 (0.05)
TOL	-0.22 (0.1)	0 (0.06)	0.54 (0.1)***	-0.1 (0.05)
GDP	0.13 (0.04)**	0.09 (0.02)**	0.08 (0.04)	1.09 (0.02)***
i	0.27	0.1	0.21	0.12
h	0.09	0	0.33	0.1
R2	0.84	0.93	0.85	0.98

Table C.23: Cross-sectional change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	AUT	SEC	TOL	GDP
N	73	73	73	145
n	53	53	53	82
AUT	0.5 (0.1)***	-0.09 (0.06)	-0.19 (0.08)	-0.02 (0.04)
SEC	0.05 (0.13)	0.84 (0.07)***	0.17 (0.11)	0.12 (0.06)
TOL	-0.1 (0.14)	0.1 (0.09)	0.51 (0.12)***	-0.1 (0.06)
GDP	0.22 (0.07)**	0.11 (0.04)	0.18 (0.06)*	1.2 (0.03)***
i	0.42	0.15	0.33	0.21***
h	0.21	0	0.35	0.07
R2	0.85	0.89	0.89	0.98

Table C.24: Cross-sectional change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

C.3 Opinion Changes

C.3.1 Secularization and Economic Development

Regression results investigating the temporal relationship between short term economic development GDP and opinion changes in Secularization SEC.

	SEC	GDP
N	127	280
n	74	105
SEC	0.88 (0.02)***	0.02 (0.01)
GDP	0.06 (0.02)*	1.04 (0.01)***
i	0	0
h	0.01	0.02
R2	0.94	0.99

Table C.25: Opinion change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	89	222
n	66	95
SEC	0.88 (0.04)***	0.05 (0.03)
GDP	0.06 (0.02)*	1.08 (0.01)***
i	0.11	0.11
h	0.05	0
R2	0.94	0.98

Table C.26: Opinion change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	SEC	GDP
N	73	144
n	53	82
SEC	0.85 (0.06)***	0.08 (0.04)
GDP	0.04 (0.04)	1.18 (0.02)***
i	0.13	0.21***
h	0.15	0.03
R2	0.91	0.98

Table C.27: Opinion change regressions to establish the temporal relationships between SEC and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

C.3.2 Secularization, Tolerance, Autonomy and Economic Development

Regression results investigating the temporal relationship between short term economic development GDP and opinion changes in Secularization SEC, Autonomy AUT and Tolerance of Personal Prohibition Violators TOL.

	AUT	SEC	TOL	GDP
N	127	127	127	280
n	74	74	74	105
AUT	0.72 (0.06)***	-0.01 (0.03)	-0.03 (0.05)	0.01 (0.02)
SEC	0.1 (0.07)	0.88 (0.03)***	0.17 (0.06)	0.02 (0.02)
TOL	-0.09 (0.09)	0.02 (0.05)	0.65 (0.07)***	-0.03 (0.02)
GDP	0.13 (0.04)*	0.05 (0.02)	0.11 (0.04)	1.03 (0.01)***
i	0	0	0.16	0
h	0.05	0.02	0.2	0.05
R2	0.76	0.93	0.86	0.99

Table C.28: Opinion change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	AUT	SEC	TOL	GDP
N	89	89	89	222
n	66	66	66	95
AUT	0.7 (0.07)***	-0.03 (0.04)	0.03 (0.07)	0.01 (0.03)
SEC	0.09 (0.1)	0.93 (0.05)***	0.08 (0.09)	0.05 (0.04)
TOL	-0.23 (0.1)	-0.05 (0.05)	0.46 (0.1)***	-0.02 (0.05)
GDP	0.13 (0.04)*	0.07 (0.02)*	0.08 (0.04)	1.08 (0.02)***
i	0.28	0.09	0.22	0.11
h	0.12	0.07	0.35	0.02
R2	0.84	0.94	0.82	0.98

Table C.29: Opinion change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	AUT	SEC	TOL	GDP
N	73	73	73	144
n	53	53	53	82
AUT	0.46 (0.09)***	-0.04 (0.05)	-0.15 (0.08)	-0.01 (0.04)
SEC	0.02 (0.12)	0.86 (0.07)***	0.21 (0.11)	0.09 (0.05)
TOL	-0.07 (0.13)	0.01 (0.08)	0.44 (0.12)***	-0.02 (0.06)
GDP	0.2 (0.07)*	0.05 (0.04)	0.2 (0.06)**	1.18 (0.03)***
i	0.48**	0.14	0.38**	0.21**
h	0.23	0.13	0.32	0.04
R2	0.88	0.9	0.9	0.98

Table C.30: Opinion change regressions to establish the temporal relationships between SEC, AUT, TOL and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

APPENDIX D

CHAPTER EIGHT

This appendix contains the complete set of regressions results from chapter eight, where we examine the temporal relationships between human development and cultural values. In all tables the column headings are the dependent variables and the rows represent lagged predictor variables.

D.1 Generational Changes

Regression results investigating the temporal relationship of long term changes in economic development GDP and democracy DEM with generational changes in Secular-Rationality RAT, Openness $OPEN$ and Institutional Support $INST$.

	RAT	OPN	INS	GDP	DEM
N	437	437	437	514	529
n	98	98	98	95	98
RAT	0.93 (0.02)***	0.02 (0.02)	-0.03 (0.02)	0.12 (0.02)***	0.02 (0.01)
OPN	0.04 (0.02)	0.94 (0.02)***	0 (0.02)	0.06 (0.02)*	0.06 (0.01)***
INS	0 (0.01)	-0.01 (0.01)	0.93 (0.01)***	-0.03 (0.01)	0.01 (0.01)
GDP	0.02 (0.03)	-0.02 (0.03)	-0.04 (0.04)	0.87 (0.02)***	0.01 (0.02)
DEM	0.02 (0.04)	0 (0.04)	0.05 (0.05)	0.09 (0.03)	0.73 (0.03)***
i	0.04	0.03	0.03	0.1***	0
h	0.11***	0.08	0	0.06	0
R2	0.96	0.96	0.92	0.93	0.74

Table D.1: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	484	484	484	507	520
n	98	98	98	98	98
RAT	0.94 (0.02)***	0.03 (0.02)	-0.05 (0.02)	0.13 (0.02)***	0.04 (0.01)
OPN	0.05 (0.02)	0.9 (0.02)***	-0.02 (0.02)	0.07 (0.02)*	0.06 (0.02)***
INS	0 (0.01)	-0.01 (0.01)	0.92 (0.01)***	-0.02 (0.01)	0.01 (0.01)
GDP	-0.04 (0.03)	-0.04 (0.03)	0.05 (0.04)	0.88 (0.02)***	-0.01 (0.02)
DEM	0.01 (0.04)	0.01 (0.04)	0.05 (0.05)	0.08 (0.03)	0.74 (0.03)***
i	0.05	0.05	0.05	0.1***	0
h	0.1***	0.11***	0	0.05	0.03
R2	0.96	0.96	0.92	0.94	0.75

Table D.2: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	526	526	526	453	465
n	98	98	98	98	98
RAT	0.92 (0.02)***	0.04 (0.02)	-0.04 (0.02)	0.13 (0.02)***	0.03 (0.01)
OPN	0.05 (0.02)	0.88 (0.02)***	-0.02 (0.02)	0.03 (0.02)	0.05 (0.02)***
INS	0 (0.01)	-0.01 (0.01)	0.92 (0.01)***	0 (0.01)	0 (0.01)
GDP	0 (0.03)	-0.03 (0.02)	0.01 (0.03)	0.87 (0.03)***	-0.02 (0.02)
DEM	0 (0.04)	0.04 (0.03)	0.05 (0.05)	0.12 (0.03)**	0.75 (0.03)***
i	0.05	0.05	0.01	0.09***	0
h	0.12***	0.12***	0	0.01	0.02
R2	0.96	0.95	0.91	0.93	0.75

Table D.3: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 10 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	350	350	350	469	469
n	94	94	94	98	98
RAT	0.77 (0.03)***	0.02 (0.03)	-0.1 (0.03)***	0.28 (0.03)***	0.07 (0.02)***
OPN	0.04 (0.04)	0.73 (0.04)***	0.01 (0.03)	0.16 (0.04)***	0.13 (0.02)***
INS	0 (0.03)	0.01 (0.02)	0.84 (0.02)***	-0.08 (0.02)**	0.01 (0.02)
GDP	0.04 (0.05)	-0.03 (0.04)	0 (0.06)	0.7 (0.04)***	0.02 (0.04)
DEM	-0.03 (0.06)	-0.13 (0.05)	0.1 (0.06)	0.13 (0.05)	0.26 (0.05)***
i	0.18***	0.18***	0.19***	0.21***	0.12***
h	0.31***	0.33***	0	0.17***	0
R2	0.93	0.96	0.92	0.93	0.62

Table D.4: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	390	390	390	425	423
n	98	98	98	98	98
RAT	0.75 (0.03)***	0.08 (0.03)*	-0.1 (0.03)***	0.27 (0.03)***	0.09 (0.02)***
OPN	0.09 (0.04)	0.66 (0.03)***	0 (0.03)	0.14 (0.03)***	0.14 (0.03)***
INS	0 (0.02)	0.01 (0.02)	0.82 (0.02)***	-0.01 (0.02)	0.01 (0.02)
GDP	-0.02 (0.05)	-0.08 (0.04)	0.03 (0.05)	0.65 (0.04)***	0 (0.04)
DEM	-0.01 (0.06)	-0.14 (0.05)	0.11 (0.07)	0.12 (0.05)	0.21 (0.05)**
i	0.18***	0.2***	0.2***	0.19***	0.14***
h	0.3***	0.38***	0	0.11	0.03
R2	0.94	0.96	0.91	0.91	0.64

Table D.5: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	428	428	428	370	367
n	98	98	98	98	98
RAT	0.76 (0.03)***	0.11 (0.03)***	-0.12 (0.03)***	0.24 (0.03)***	0.12 (0.03)***
OPN	0.1 (0.04)	0.62 (0.03)***	0 (0.03)	0.11 (0.03)**	0.11 (0.03)**
INS	-0.01 (0.02)	0.01 (0.02)	0.82 (0.02)***	0 (0.02)	0.01 (0.02)
GDP	-0.06 (0.04)	-0.07 (0.04)	0.04 (0.05)	0.65 (0.05)***	-0.01 (0.04)
DEM	0.01 (0.05)	0.02 (0.04)	0.11 (0.06)	0.17 (0.06)*	0.28 (0.06)**
i	0.19***	0.2***	0.2***	0.18***	0.12
h	0.3***	0.37***	0	0.07	0.06
R2	0.94	0.96	0.91	0.9	0.62

Table D.6: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 20 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	257	257	257	388	385
n	77	77	77	98	98
RAT	0.63 (0.04)***	0.04 (0.04)	-0.15 (0.03)***	0.35 (0.03)***	0.07 (0.02)*
OPN	0.03 (0.05)	0.53 (0.05)***	-0.03 (0.04)	0.2 (0.04)***	0.21 (0.03)***
INS	-0.01 (0.04)	0 (0.03)	0.74 (0.03)***	-0.07 (0.03)	0.03 (0.02)
GDP	0.03 (0.1)	-0.02 (0.09)	0.1 (0.1)	0.7 (0.05)***	-0.02 (0.05)
DEM	-0.01 (0.07)	-0.14 (0.06)	0.18 (0.07)	0.14 (0.06)	-0.05 (0.05)
i	0.28***	0.29***	0.29***	0.28***	0.19***
h	0.49***	0.5***	0	0.16	0
R2	0.95	0.96	0.94	0.94	0.68

Table D.7: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 0 and 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	303	303	303	342	338
n	93	93	93	98	98
RAT	0.61 (0.04)***	0.09 (0.03)	-0.16 (0.04)***	0.34 (0.03)***	0.11 (0.03)***
OPN	0.09 (0.05)	0.48 (0.04)***	-0.05 (0.04)	0.16 (0.04)***	0.22 (0.03)***
INS	-0.02 (0.03)	0 (0.03)	0.69 (0.03)***	-0.01 (0.03)	0.04 (0.02)
GDP	-0.03 (0.07)	-0.07 (0.06)	0.13 (0.07)	0.6 (0.05)***	-0.07 (0.05)
DEM	-0.08 (0.07)	-0.19 (0.06)**	0.15 (0.07)	0.13 (0.06)	-0.12 (0.06)
i	0.32***	0.29***	0.37***	0.27***	0.21***
h	0.48***	0.56***	0	0.08	0.02
R2	0.95	0.96	0.93	0.92	0.7

Table D.8: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 10 and 20 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	334	334	334	286	283
n	97	97	97	98	97
RAT	0.6 (0.03)***	0.13 (0.03)***	-0.13 (0.04)**	0.29 (0.03)***	0.15 (0.03)***
OPN	0.1 (0.05)	0.48 (0.04)***	0.02 (0.05)	0.19 (0.04)***	0.13 (0.03)***
INS	-0.01 (0.03)	0.01 (0.03)	0.58 (0.03)***	-0.01 (0.03)	0.02 (0.02)
GDP	-0.03 (0.05)	-0.13 (0.05)	-0.09 (0.06)	0.55 (0.06)***	-0.07 (0.05)
DEM	0 (0.07)	-0.1 (0.06)	0.05 (0.08)	0.2 (0.07)	0.12 (0.07)
i	0.29***	0.28***	0.42***	0.27***	0.14
h	0.46***	0.55***	0.11	0	0.07
R2	0.95	0.96	0.93	0.92	0.61

Table D.9: Generational change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes 30 years after a generation reaches adulthood which happens between the ages of 20 and 30 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

D.2 Opinion Changes

Regression results investigating the temporal relationship of short term changes in economic development GDP and democracy DEM with opinion changes in Secular-Rationality RAT, Openness $OPEN$ and Institutional Support $INST$.

	RAT	OPN	INS	GDP	DEM
N	122	122	122	266	264
n	70	70	70	99	99
RAT	0.84 (0.05)***	0.13 (0.07)	-0.01 (0.08)	0.04 (0.01)	0.01 (0.01)
OPN	0.06 (0.06)	0.41 (0.08)***	0.06 (0.09)	0.03 (0.02)	0 (0.01)
INS	0 (0.05)	0.04 (0.06)	0.75 (0.07)***	0.02 (0.01)	-0.02 (0.01)*
GDP	0.07 (0.04)	-0.03 (0.06)	0.16 (0.07)	1.02 (0.01)***	0 (0.01)
DEM	0.01 (0.18)	0.17 (0.21)	-0.3 (0.24)	0.05 (0.05)	0.79 (0.03)***
i	0	0.26	0	0	0.05*
h	0	0.59***	0.21	0	0.02
R2	0.82	0.81	0.69	0.99	0.88

Table D.10: Opinion change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	87	87	87	210	207
n	64	64	64	90	89
RAT	0.63 (0.06)***	-0.15 (0.07)	0.05 (0.08)	0.08 (0.03)	0.01 (0.01)
OPN	0.07 (0.08)	0.28 (0.08)	-0.07 (0.1)	0.05 (0.04)	0.01 (0.01)
INS	0.07 (0.07)	0.02 (0.06)	0.63 (0.08)***	0.02 (0.03)	-0.01 (0.01)
GDP	0.06 (0.05)	0.06 (0.05)	0.21 (0.06)**	1.05 (0.02)***	0 (0.01)
DEM	0.22 (0.23)	0.14 (0.19)	-0.66 (0.28)	0.01 (0.12)	0.08 (0.04)
i	0.2	0.36***	0.37	0.12	0.2***
h	0	0.65**	0	0	0.13***
R2	0.77	0.93	0.77	0.98	0.97

Table D.11: Opinion change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	71	71	71	139	137
n	51	51	51	79	77
RAT	0.62 (0.09)***	0.06 (0.11)	0.01 (0.1)	0.07 (0.04)	0.01 (0.02)
OPN	0.19 (0.11)	0.45 (0.11)***	0.28 (0.1)	-0.01 (0.05)	0.03 (0.02)
INS	0.11 (0.09)	-0.03 (0.08)	0.64 (0.07)***	0.02 (0.04)	-0.01 (0.02)
GDP	0.06 (0.08)	0.03 (0.07)	0.29 (0.07)***	1.18 (0.03)***	0 (0.02)
DEM	0.46 (0.38)	0.53 (0.31)	-1.33 (0.3)***	0.04 (0.14)	0.3 (0.06)***
i	0.32	0.37**	0.17	0.2**	0.17***
h	0	0.54	0.58**	0.07	0.07
R2	0.78	0.91	0.9	0.98	0.93

Table D.12: Opinion change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

D.3 Cross-Sectional Changes

Regression results investigating the temporal relationship of short term changes in economic development GDP and democracy DEM with cross-sectional changes in Secular-Rationality RAT, Openness $OPEN$ and Institutional Support $INST$.

	RAT	OPN	INS	GDP	DEM
N	123	123	123	267	265
n	70	70	70	99	100
RAT	0.85 (0.05)***	-0.06 (0.07)	0 (0.09)	-0.02 (0.02)	-0.01 (0.01)
OPN	-0.08 (0.06)	0.43 (0.08)***	0.05 (0.09)	0.02 (0.02)	0 (0.01)
INS	-0.01 (0.05)	0.01 (0.06)	0.73 (0.07)***	0.01 (0.01)	-0.02 (0.01)
GDP	-0.08 (0.04)	-0.01 (0.06)	0.16 (0.07)	1.03 (0.01)***	-0.01 (0.01)
DEM	-0.05 (0.18)	0.13 (0.2)	-0.2 (0.25)	0.06 (0.05)	0.63 (0.04)***
i	0	0.24	0	0	0.09***
h	0.04	0.58***	0.25	0.01	0.07
R2	0.82	0.81	0.67	0.99	0.89

Table D.13: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	88	88	88	211	207
n	65	65	65	90	89
RAT	0.57 (0.08)***	0.16 (0.08)	0 (0.08)	-0.04 (0.03)	-0.01 (0.01)
OPN	-0.13 (0.09)	0.33 (0.08)	-0.07 (0.1)	0.02 (0.04)	0 (0.01)
INS	-0.05 (0.07)	-0.02 (0.06)	0.58 (0.09)***	0.01 (0.03)	-0.01 (0.01)
GDP	-0.07 (0.05)	0.07 (0.05)	0.22 (0.07)**	1.07 (0.02)***	0 (0.01)
DEM	-0.32 (0.23)	0.1 (0.19)	-0.42 (0.28)	0.04 (0.12)	0.09 (0.04)
i	0.23	0.33**	0.42	0.1	0.19***
h	0.12	0.63**	0	0.02	0.15***
R2	0.79	0.91	0.78	0.98	0.97

Table D.14: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	71	71	71	140	137
n	51	51	51	79	77
RAT	0.54 (0.1)***	0.04 (0.1)	-0.04 (0.1)	-0.02 (0.05)	-0.01 (0.02)
OPN	-0.2 (0.11)	0.43 (0.1)**	0.28 (0.1)	-0.04 (0.05)	0.02 (0.02)
INS	-0.06 (0.09)	-0.08 (0.07)	0.66 (0.07)***	0.03 (0.04)	-0.01 (0.02)
GDP	-0.1 (0.08)	0.06 (0.07)	0.27 (0.07)***	1.2 (0.03)***	0 (0.02)
DEM	-0.61 (0.39)	0.59 (0.3)	-1.22 (0.29)***	0.07 (0.14)	0.3 (0.06)***
i	0.35	0.33	0.16	0.2*	0.17***
h	0.11	0.54	0.58*	0.1	0.08
R2	0.79	0.9	0.91	0.98	0.93

Table D.15: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP. They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

D.4 Robustness Check for Cross-Sectional Regressions

Robustness test for the results in the previous section (Cross-Sectional Changes). The regressions are rerun, but using a reduced sample consisting of 42 countries. These countries always yield data points whether we set the time lag to $p = 5$ years, $p = 10$ years or $p = 15$ years. This makes it easier to compare effect sizes across regressions with different time lags.

	RAT	OPN	INS	GDP	DEM
N	94	94	94	180	180
n	49	49	49	49	49
RAT	0.86 (0.07)***	-0.09 (0.07)	0.01 (0.09)	0 (0.02)	0.01 (0.01)
OPN	-0.04 (0.07)	0.67 (0.07)***	0.01 (0.1)	0.01 (0.02)	0 (0.01)
INS	-0.05 (0.06)	-0.05 (0.06)	0.73 (0.07)***	0.04 (0.02)	-0.02 (0.01)
GDP	-0.06 (0.05)	-0.01 (0.05)	0.23 (0.07)**	1.03 (0.02)***	0.01 (0.01)
DEM	-0.27 (0.24)	0.29 (0.22)	-0.81 (0.28)	0.1 (0.08)	0.51 (0.05)***
i	0	0.13	0	0.02	0.08***
h	0	0.33	0.29	0.03	0.04
R2	0.78	0.85	0.76	0.99	0.85

Table D.16: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP, but using only the 49 countries that yield data for all time lags ($p = 5$, $p = 10$ and $p = 15$ years). They measure the effect sizes after 5 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	72	72	72	149	149
n	49	49	49	49	49
RAT	0.61 (0.09)***	0.16 (0.09)	-0.05 (0.09)	-0.03 (0.05)	0 (0.01)
OPN	-0.2 (0.1)	0.3 (0.09)	-0.07 (0.09)	0.03 (0.05)	0.01 (0.01)
INS	-0.05 (0.08)	-0.07 (0.07)	0.71 (0.06)***	0.06 (0.04)	-0.01 (0.01)
GDP	-0.02 (0.07)	0.14 (0.06)	0.22 (0.06)***	1.02 (0.03)***	0 (0.01)
DEM	-0.54 (0.31)	0.13 (0.24)	-1.16 (0.25)***	0.25 (0.19)	0.03 (0.04)
i	0.24	0.32	0	0.18	0.15***
h	0.14	0.6	0.3	0***	0.09
R2	0.77	0.91	0.83	0.98	0.94

Table D.17: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP, but using only the 49 countries that yield data for all time lags ($p = 5$, $p = 10$ and $p = 15$ years). They measure the effect sizes after 10 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

	RAT	OPN	INS	GDP	DEM
N	69	69	69	104	104
n	49	49	49	49	49
RAT	0.57 (0.1)***	0.03 (0.1)	-0.06 (0.1)	-0.01 (0.06)	0.02 (0.02)
OPN	-0.19 (0.11)	0.42 (0.11)**	0.25 (0.1)	0 (0.07)	0.01 (0.02)
INS	-0.06 (0.09)	-0.08 (0.07)	0.65 (0.07)***	0.06 (0.05)	0.01 (0.01)
GDP	-0.12 (0.08)	0.07 (0.07)	0.29 (0.07)***	1.12 (0.05)***	0.02 (0.01)
DEM	-0.5 (0.42)	0.46 (0.33)	-1.41 (0.32)***	0.23 (0.22)	0.2 (0.05)**
i	0.36	0.34	0.13	0.23	0.13***
h	0	0.54	0.61**	0.12***	0.04
R2	0.78	0.9	0.91	0.98	0.91

Table D.18: Cross-sectional change regressions to establish the temporal relationships between RAT, OPEN, INST, DEM and GDP, but using only the 49 countries that yield data for all time lags ($p = 5$, $p = 10$ and $p = 15$ years). They measure the effect sizes after 15 years. Each entry is an effect size with the standard error in brackets. Bonferroni corrected statistical significance: $p < 0.1(*)$; $p < 0.05(**)$; $p < 0.01(***)$.

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