The Relationship between Religious Diversity and Personal Income:
A Study of State-Level Economic Outcomes in the United States

by

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A thesis submitted in partial fulfillment
of the requirements for the
Degree of Bachelor of Arts with Honors
in Economics

WILLIAMS COLLEGE

Williamstown, Massachusetts

May 7, 2010

Acknowledgements

I would like to thank Prof. Peter Pedroni,
Prof. Tara Watson, Prof. Quamrul Ashraf,
Gea Hyun Shin, Mike McGuire
and my wonderful sisters for their
support in making this project possible.

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Abstract

This thesis empirically investigates the causal relationship between religious diversity, religious polarization and per capita incomes in the United States from 1929-2000 using a long-run causality test for panels at the state level. I find that religious diversity has had a positive causal impact on income, and vice versa. Furthermore, I find that religious polarization has had a negative impact on income, and vice versa. The analysis overcomes some of the standard econometric pitfalls found in cross-sectional analysis. I propose a number of mechanisms that may account for these causal relationships.

1. Introduction

One of the most widespread questions in the field of economics is what causes economic growth. Hundreds of studies have proposed a wide variety of factors that influence growth rates in regions all across the globe. One field of study has focused on a type of capital called social capital. Social capital is loosely defined as an instantiated informal norm that promotes co-operation between two or more individuals. (Fukayama, 2001) It can also be defined as the bonds of trust, norms of reciprocity, and networks of civic engagement that are created and reinforced in civic organizations. (Putnam, 1993) Like physical and human capital, social capital stimulates economic development by lowering transaction costs and facilitating harmonious and efficient exchanges between parties. Societies with large stocks of social capital form extensive informal social networks that generate the formal public and private institutions that organize and manage modern economies. (Putnam, 1993) One source of social capital is religion. An explicit code of righteous behavior, a key element of most major religious groups, stimulates the creation of trusting, cooperative commercial and industrial relationships at all economic levels.

Adam Smith is often credited with the first recognition of the power of religion on exchange-related market activities. (Anderson, 1988) Max Weber identified religion and religious beliefs specifically as having an effect on economic prosperity in his landmark "Protestant Ethic." A body of scholarly literature has grown up around his thesis that certain ideals, particularly thrift and morally righteous behavior towards all people, inculcated and stressed by the Protestant religious community in particular, enhance economic development and prosperity in Protestant-dominated areas. This occurs by contributing to the regional stock of social capital. However, less research has been conducted on the impact of religious *diversity* on economic growth. Can heterogeneity of identity in market participants be seen as a type of social capital? This study attempts to contribute one small puzzle piece towards answering that question.

Why focus on religious instead of ethnic or linguistic diversity? The primary reason deals with inter-group mobility. In Fukuyama (2001), people that move between social groups are called “weak ties.” These people exist at the periphery of various social networks and can move from group to group bearing new ideas, information and methods. Communities that are highly polarized religiously have fewer of these “weak ties,” since adherents are more isolated and less likely to cross religious boundaries. Such communities may experience lower rates of transmission for innovations, human capital, and other intellectual, and even physical, resources. At the same time, religious affiliation is something that can be changed, unlike ethnic affiliation, so it is possible that more “weak ties” will exist among religious groups. Due to a higher incidence of these weak ties in religious groups as opposed to ethnic ones, the effect of religious diversity on economic growth may be greater than that of ethnic diversity.

Second, religious identity more clearly and explicitly implies a set of values than does linguistic or ethnic identity, as elaborated in Reynal-Querol (2002), Ellickson (1991, p. 237) and Frank (1988, p.250). Since the causal mechanisms will focus on how religious diversity influences economic *behavior*, the more explicit nature of behavioral commandments that are featured in most religious doctrines is important. While there are exceptions the world over, in the United States, the major faiths each have a text that explicitly lays down a set of ethical rules that are to be followed by adherents. To be fair, different subgroups interpret these texts in different ways and the rigor to which the rules are followed varies widely, but this quibble misses the point. The point is that these explicit behavioral and ethical rules *exist* within religious communities.

Not so within ethnic and linguistic groups. There is no codified manual laying out the expected behavior of all French speakers. Since it is *behavior* that we are interested in, specifically economic behavior, religious groups become a qualitatively different object of research than ethnic or linguistic groups. If we wish to uncover how these behavioral codes, social norms and expectations cross cultural lines, we must research levels of diversity, not just the groups that are present. Analyzing the connection between religious diversity, polarization and economic growth can thus provide information on how religious groups create positive externalities in their geographic proximity that foster growth.

It is important to note that religious affiliation forms only one aspect of individual identity. Ethnic and linguistic ties, as well as socioeconomic status, occupational similarities and general engagement in civil society all create groups and sub-groups in a community. Substantial scholarly literature will be introduced that supports the claim that wide variety in these groups may facilitate or restrict economic growth through a number of channels. My primary motivation is to investigate one aspect of heterogeneity of individual and community-wide identity, using both religious diversity and polarization indices, and to determine if that heterogeneity may be a significant input into the growth function.

By design and by necessity, this study is backwards-looking. I do not suggest that past effects will continue into the future, nor that policy should be made based on the conclusions drawn here. Instead, I hope to present this study as one of many perspectives on economic growth in the United States. The rest of this study has the following structure: Section 2 explicitly formulates my hypotheses, Section 3 reviews the existing literature of a related nature, Section 4 describes the data that I will be using, Section 5 proposes a number of mechanisms that may play a causal role between my variables, Section 6 investigates the empirical method that I use. Section 7 presents the results of that analysis. Section 8 discusses those results and Section 9 concludes.

2. Hypothesis

Since my motivations focus on both religious diversity and religious polarization, I have two hypotheses that I will be testing.

- *Hypothesis #1: The relationship between religious diversity and economic growth in the United States has been causal in both directions, in that religious diversity has caused economic growth and economic growth has caused religious diversity.*

As will be discussed in more detail later, I hypothesize that religious diversity creates an atmosphere of tolerance. This tolerance may promote entrepreneurialism, a more optimal resource allocation away from persecution of minorities and complementarities in productivity. The details behind these mechanisms can be found in the Mechanisms section.

- *Hypothesis #2: The relationship between religious polarization and economic growth in the United States has been causal in both directions, in that religious polarization has decreased economic growth and economic growth has decreased religious polarization.*

As will be discussed in more detail later, I hypothesize that religious polarization may increase rent-seeking behavior by market participants. Furthermore, I hypothesize that high levels of polarization may also have a negative affect on levels of toleration. The details behind these mechanisms can be found in the Mechanisms section.

In order to test these hypotheses, I use a pair of indices to measure the extent of religious diversity and religious polarization in a US state. I then verify that these indices demonstrate unit roots and are co-integrated with per capita income. I further test for the sign and direction of long-run causality and verify that these properties are robust for a panel with a small number of observations. The sub-sections that follow will briefly outline the properties of these indices.

Diversity Index

I use a Herfindahl-Hirschman Index (HHI) to measure religious diversity in the United States at the state level. The use of this index is supported by the use of the very same index for the same or similar purpose in Easterly and Levine (1997), Voas et al. (2002), Montalvo and Reynal-Querol (2005), Alesina et al (2003) and many others. Some of the assumptions inherent in the very use of the index are addressed in the Discussion section. The HHI is defined as:

$$HHI = 1 - \sum_{j}^{n} \pi_j^2$$

where π_j is the share of the overall population enjoyed by group j in any given time period. HHI gives the probability that two randomly selected individuals in a population will belong to different groups. It reaches its minimum at 0.00 when all members belong to the same group and its maximum at 1.00 when all members of the population belong to separate groups.

This index was originally used to measure the level of competition between firms in a marketplace and is still widely used in competition and anti-trust law. Applying this type metric to religious diversity was originally proposed by Adam Smith in his landmark *Wealth of Nations* treatise when he wrote that, “The clergy of every established church constitute a great incorporation.” (Smith, 1799) Competition in this marketplace can thus be measured with an HHI. An HHI of 0.00 corresponds to no regional religious diversity. An HHI of 1.00 would correspond to no religious homogeneity. Using this index we will quantitatively measure religious diversity at the state level for all time periods in our data sample.

<u>Polarization Index</u>

I use a Polarization Index (PI), used in Ratna, Grafton and Kompas (2009), Montalvo and Reynal-Querol (2002), Alesina et al. (2003) and many others, to measure the extent of religious polarization in a society. The Polarization Index is defined as:

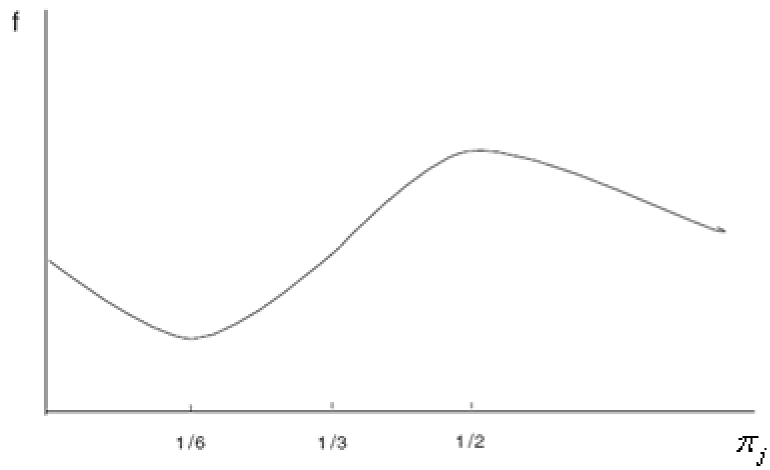
$$PI = 1 - \sum_{j=1}^{\infty} \frac{(.5 - \pi_j)^2 \pi_j}{.25}$$

where π_j is the share of the overall population enjoyed by group j in a given time period. This index is derived from a rent-seeking model in Montalvo and Reynal-Querol (2005). The outline of that derivation in reproduced as Appendix 1. Since this index is probably less familiar, I now proceed to investigate its properties and behavior.

Some simple algebra on the above equation yields a useful re-expression.

$$= \sum_{j=1}^{N} \left(\frac{1}{N} - \pi_j + 4\pi_j^2 - 4\pi_j^3\right) = \sum_{j=1}^{N} f(\pi_j) \qquad (1)$$

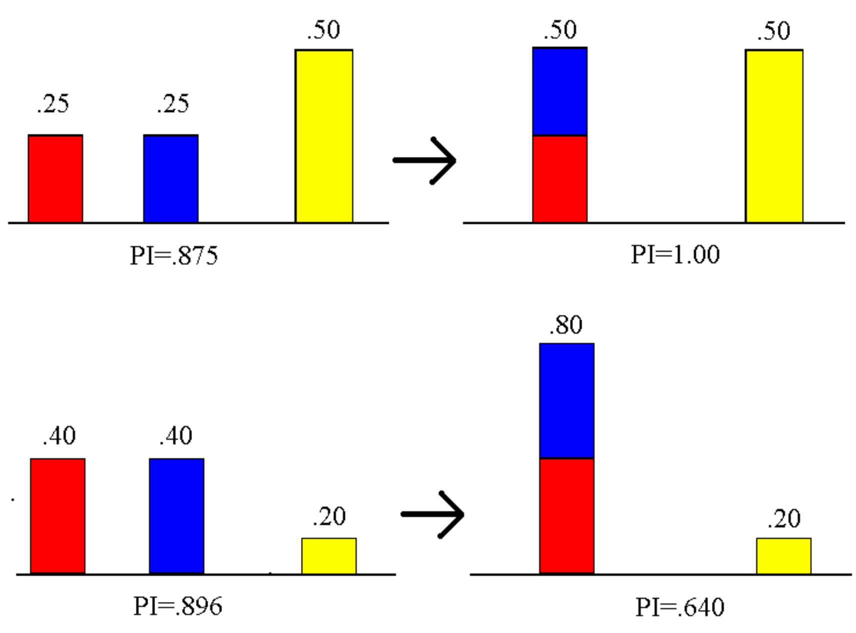
Graphing the function $f(\pi_j)$, we arrive at a graphical representation of how the changing size of a single religious group affects the polarization index.



In this graph, the vertical axis is intentionally left unlabeled. Returning to Equation (1), we see that the absolute number of religious groups in the geographic region influences the amount to which each factor in the summation influences the whole. Thus, this graph of a single group's contribution to the whole irrespective of the number of other groups present cannot possibly have a labeled vertical axis.

From the graph above, it is clear that the maximum PI value of 1.00 is when there are two equally sized groups in the region. Our intuition suggests that religious tension may be higher in such a region than in a region in which one group dominated, or one in which many smaller groups were present. The index is highest at that point, indicating that it may be a good measure of that which it seeks to measure; polarization. At the other extreme, when all members of the population are from the same group, polarization is at it's lowest. We see from the graph that, in this situation, the index would equal 0.00, another good sign for the index. In order to explore some of the interesting features of this index, let us briefly consider an example.

Consider a world with three blocs of countries. The first bloc, Oceania, and the second bloc, Eastasia, have an equal number of countries in their sphere of influence. The third bloc, Eurasia, has all the other countries that are not affiliated with either Eastasia or Oceania. Let us now consider an alliance between Eastasia and Oceania. Effectively, these two blocs now become the same bloc. Without knowing anything about the relative sizes of these two blocs to the Eurasian bloc, we know that geopolitical diversity in the world, as measured by HHI, has decreased. Diversity will have decreased because where there were once three groups, only two remain. However, geopolitical polarization, as measured by a polarization index, may have gone up or down. Let us demonstrate.



In this diagram, the blue and red blocks represent Oceania and Eastasia, and the yellow block represents Eurasia. As we can see, if Oceania and Eastasia are small in comparison to the mighty Eurasia, then this new alliance will boost geopolitical polarization. The world will have become polarized between the Eastasian/Oceanian alliance and the Eurasians. As we can see from the calculations, the index has also risen considerably. If, on the other hand, Oceania and Eastasia are themselves quite large when compared to puny Eurasia, then the world will have become less polarized as most of it is now united. As we can see from the calculations, the index has fallen.

This example demonstrates two characteristics of the PI. The first is that our natural intuition as to how changes to the population distribution change the level of polarization mirrors changes in the index. This suggests that our index may be a good proxy for the true level of religious polarization in a society. The second fact is that we cannot determine how a consolidation of groups, or, equivalently, a movement of people from one group to another, will affect the overall level of polarization in a society without knowing the relative sizes of *all* the groups in the society.

The HHI and the PI describe the religious identity of a geographic region in different and incomplete ways. While they are related, they are not identical. Since the United States is, and always has been, a very diverse place, the variation between the two may yield additional insights. Weaknesses introduced through the inclusion of these indices will be addressed in the Discussion section. Together, the two hypotheses, driven by my primary project motivations, will provide the grounding for my research.

3. Literature Review

My project touches on a number of different research areas, so a quick scan of them is in order. Guiso, Sapienza and Zingales (2003) presents an article that gives a good introduction to the status of existing research on the subject of religion and economic attitudes. Easterly and Levine (1997) uses linguistic fragmentation in a high-profile paper as a causal factor for Africa’s “growth tragedy.” Alesina et al. (2003) finds that, in a cross-country survey of about 190 countries, religious fractionalization and polarization are found to have significant, but minor, negative effects on growth. Montalvo and Reynal-Querol (2003) finds that religious polarization is a better explanatory measure than religious fragmentation internationally and that it has a negative effect on economic growth. Montalvo and Reynal-Querol (2005) continues this comparison between indices and shows that polarization and fractionalization can occasionally be uncorrelated or even negatively correlated, and that heterogeneity, ethnically and religiously, has negative effects on growth. In sum, international evidence suggests that religious diversity and polarization both have negative effects on economic growth, but that those results are derived almost exclusively from cross-sectional studies.

Domestically, Alesina and Ferrara (2005) finds that fractionalization is associated with negative effects on income, but that those effects are smaller, or even positive, at higher levels of income. Ratna, Grafton and Kompas (2009) analyzes religious, ethnic and linguistic polarization and fractionalization at the state level in the United States. Using only data from 1999-2000, it finds that religious diversity is not significantly correlated with economic outcomes using an OLS method, but that ethnic fractionalization has a negative effect on growth. It further finds that linguistic diversity has the opposite effect. Ottoviano and Peri (2004) finds evidence consistent with the positive effects of diversity on incomes through gains to productivity.

Using similar data to that used in my research, Rupasingha and Chilton (2009) finds that higher rates of religious adherence are not beneficial to growth at the county level, but that the results for individual religions are mixed. While this research does not speak directly to religious diversity, it does suggest an over-allocation to religious expression is occurring, a phenomena that will be addressed as a causal mechanism in my research. Heath et al. (1995) uses the ARDA dataset and an OLS regression to conclude that religious fundamentalism has a negative effect on income. In sum, domestic evidence is mixed, with some studies demonstrating no effect and others demonstrating a negative relationship, but that those results are derived exclusively from cross-sectional studies.

Perhaps more important than what we *do* find in the literature is what we *do not* find. First, no surveyed study looks at religious diversity in the United States for an extended time horizon. Second, no studies use a co-integrated panel technique to demonstrate causality in a way that is robust to endogeneity, omitted variables, reverse causality and omitted dynamics. My primary contribution is to use co-integrated panel methods to analyze this dataset in a novel way, adding a few insights on the relationship between religious diversity, religious polarization and personal income not available through traditional cross-sectional approaches.

4. Data Description

My data has two main parts; the religious and the economic; linking them is the goal of my research.

Economic Data

The economic data come exclusively from government sources. The primary measure of economic growth is per capita personal income by state from 1929 – 2000. Personal income is defined as "income received by, or on behalf of, all the residents of that area." (US Dept. of Commerce, 1989) Reliable annual data by state is unavailable for earlier years, and income data by county is only available for post-1969 America, a restriction incompatible with my research aims. The data is compiled and published by the Bureau of Economic Analysis (BEA), a subdivision of the U.S. Department of Commerce. The BEA gathers data from various state and national agencies including, but not limited to, the Department of Labor, the Social Security Administration and the federal tax program of the Department of the Treasury. Because the data are generated at the disbursement level, not at the recipient level, it makes comprehensive annual reporting logistically possible. The data is adjusted before publication to account for "place of residence bias," in which income is disbursed in one state to a resident of a different state.

Were I to use household surveys for personal income estimates, comprehensive annual data series would not be feasible and major methodological discrepancies might arise over time, an issue that does not arise when using those surveys for cross-sectional purposes. A drawback of using administrative data is that it fails to capture the informal economy, which may be an important source of growth stemming directly from social capital changes. However, in order to keep methodological consistency and to take advantage of the preponderance of administrative data, especially for pre-war United States, I have decided to disregard household surveys for the bulk of my research.

The data are provided by the BEA in historic dollars. That is, the income of Massachusetts residents in 1929 is in 1929 dollars. In order to adjust and standardize the currency measurement, I divide all the data points by a national income deflator and multiply by one hundred. The deflator is provided by the BEA National Economic Accounts. While this measure is crude, no state-level income deflators exist going back to the 1920's.

Religion Data

The religion data come from two different sources, the US Census of Religious Bodies and the Association of Religion Data Archives (ARDA). The advantage of state-level data is that it vastly decreases the "random noise" in the measurements, leading to possibly more accurate diversity reporting than at the county level. Digressing briefly, beginning in 1850, US Marshalls, who were the designated Census agents, began asking questions to local clergy about religious institutions and seating capacities as part of the decennial census. However, individuals were not required, nor even asked, to divulge their personal religious affiliation. While the scope of the questions was expanded after the Civil War, the next major change did not occur until 1902, when the US Census was established as a permanent government agency. At that time, the Census of Religious Bodies was created as a stand-alone census to be taken every 10 years, beginning in 1906. (US Religious Landscape Survey, pg. 108)

The first Census of Religious Bodies in 1906, and the subsequent Census' in 1916, 1926 and 1936, were conducted by mailing mandatory questionnaires to religious leaders of all faiths nationwide. However, the 1946 Census was never tabulated due to a cut in funding by Congress, and by 1956, the program had been abolished altogether due to civil rights' and religious liberty leaders' criticism over mandatory religious reporting. While the idea of putting "a religion question" on the Decennial Census was kicked around through the 1970's, it was never implemented and was formally outlawed in 1976. Due to the completeness and reliability of the data, I have included the 1926 and 1936 data into my analysis. (US Religious Landscape Survey, pg. 110)

The religion data for later dates comes from a number of sources, but is compiled and monitored by the Association of Religion Data Archives (ARDA), affiliated with Pennsylvania State University. In 1952, a survey was conducted by the National Council of Churches in much the same way as the earlier Census of Religious Bodies, but was not mandatory. Out of the 251 denominations approached, 114 decided to participate. (Churches and Church…, 1952) While very small groups with no "denomination leader" would be missed, these groups, being very small, would not meaningfully change estimates on levels of diversity.

In 1971, a Lutheran coalition decided to conduct another survey of American religious participation, in much the same way as the 1952 survey, but restricted data collection to Christian churches. The exclusion of Jewish and other faiths is a major shortcoming of this particular data point. It is estimated that 81% of American church membership was represented by this survey. ("Churches and Church…, 1971) In 1980, 1990 and 2000, a wider coalition, including some religiously unaffiliated research organizations, again took surveys. However, this time Jewish congregations, and Muslim congregations in the 2000 survey, were included, representing an estimated 91% of American church membership. (Religious Congregations…, 2000.)

In order to get a better idea of the difference that the omission of certain religious groups makes on the HHI in a given time period, I calculated a "balanced HHI" comprised only of religious groups observed in every time period. Comparing this index to the actual index, I observed significant differences in a number of states over several time periods. This analysis is presented in Appendix 2.

While the data are not perfect, no data ever are. My decision to use them, given the weaknesses, is supported by the use of these data sets in Rupasingha and Chilton (2009), Heath et al (1995), Bainbridge (1989), Hull and Bold (1995) and Lipford and Tollison (2003).

5. Mechanisms

I now turn to how religious diversity and polarization can influence growth and vice versa. While my hypothesis is that diversity enhances growth and polarization restricts growth, causal mechanisms exist in the literature for the opposite effects. These will also be addressed for completeness. Through the next three sub-sections, I outline precise mechanisms, with examples and economic reasoning, for how diversity and polarization may create or restrict economic growth. Which precise mechanisms may be at work, and which dominate others, will be addressed extensively in the Discussion section.

How Diversity and Polarization May Influence Income

Religious diversity and polarization may impact per capita income in many ways, but most of the channels presented here can be grouped under the headings of tolerance and shared values. However, these two categories are, in a sense, opposites. While the first supports my hypothesis and the second does not, this does not mean that one is correct and the other incorrect. The partial resolution of these conflicting mechanisms will be addressed in the Discussion section.

Tolerance

> …in divided societies, ethnic conflict is at the center of politics. Ethnic divisions pose challenges to the cohesion of the state and sometimes to peaceful relations among states. Ethnic conflict strains the bonds that sustain civility… In divided societies, ethnic affiliations are powerful, permeative, passionate and pervasive. (Horowitz, pg 14)

Toleration, that is, respect for ideals and values different from one's own, is a form of social capital. (Corneo, 2009) Toleration may encourage entrepreneurialism both by incentivizing innovation and facilitating the flow of information between social groups. Toleration may also allow for a reallocation of resources away from the persecution of minorities towards more economically productive means. Furthermore, toleration may allow for complementarities to arise. Lastly, toleration may decrease the incidence of rent-seeking behaviors.

While all, none or some of these mechanisms may be present the results of our empirical tests will ultimately provide the perspective needed for a more thorough and sophisticated evaluation. I hypothesize high-diversity and low-polarization communities benefit from higher per-capita incomes due to increased incidence of toleration in those communities.

Toleration may come from formal institutional sources, like the US Constitution, or from informal sources, like a rich mix of identities in a geographic unit. My research focuses on the informal source of toleration, given that formal sources are roughly equivalent across the country.

Individuals desire to be thought of highly. Most individuals would prefer social acceptance to rejection, all else being equal. In areas with low respect for differences, that is, low toleration, there is strong emphasis on the maintenance of the status quo. Doing things differently, that is to say, innovating, may be frowned upon as a radical departure from tradition. This social disapproval of innovation raises the costs of pursuing an entrepreneurial venture. In intolerant communities, where differences are not appreciated, entrepreneurialism may be stifled by these social costs. As innovation and experimentation decline, so does economic growth. Conversely, areas with high levels of toleration will remove those social costs, thus encouraging innovation and growth. In this way, my research builds on the empirical results found in Heath et al (1995), that religious fundamentalism is correlated with lower incomes through decreased toleration, and Bainbridge (1989), that religion deters certain types of individual deviance from social norms.

Toleration may also impact growth through resource allocation. In societies that are low in toleration, significant resources may be allocated to the persecution of minorities instead of more economically beneficial activities like investment. (Florida, 2001) Consider the great surveillance apparatus constructed in the Soviet Union during the Cold War. This was an area in which intellectual, political and religious diversity was not tolerated. The Soviet Union dedicated tremendous resources to ferreting out heterodoxy and removing diversity. What might have happened had all those resources been re-allocated to infrastructure creation, education and science? In tolerant societies, that re-allocation is allowed to occur, spurring growth in the long run. This example also serves another function by highlighting a difference between polarization and diversity with respect to toleration. The Soviet Union was low in toleration, but also in polarization due to the lack of significant expressions of minority identities. So levels of toleration map to diversity as well as polarization, but in different ways.

Toleration also allows for the direct effect of diversity on growth by facilitating complementarities in problem solving. Complementarities arise at the micro level when two or more people approach a problem from different perspectives. Hong and Page (1998) constructs a general model showing how groups with diverse problem-solving skills can arrive at optimal solutions faster than homogenous groups. Prat (2002) analyzes complementarities within a team theory framework and finds that heterogeneity may be optimal in certain situations. Ottoviano and Peri (2004) finds that diversity is associated with gains to productivity. Alesina, Spolaore, and Wacziarg (2000) finds that variety in intermediate inputs, which can be viewed as individual skills, increases output. Lazear (1999a) and Lazear (1999b) both discuss how different skills in a production unit may increase total productivity. They identify an optimal level of diversity that balances gains to productivity through complementarities with harms to productivity from lower levels of communication. These articles show that diversity can have a positive effect on income through complementarities.

As addressed previously and demonstrated in Appendix 1, the Polarization Index can be derived from a rent-seeking model. It is reasonable to expect that in areas of high polarization, rent-seeking behaviors, like trying to capture monopoly privileges or manipulating the economic landscape in one's favor, may become more widespread. Montalvo and Reynal-Querol (2000) supports this view. Consider as an example the highly polarized political environment between Republicans and Democrats in Congress. Considerable resources are allocated by each party towards securing political victories and pursuing gains in zero-sum games. By the same logic, perhaps certain cultural groups dedicate resources towards lobbying for special privileges or rights from local governments at the expense of other groups instead of dedicating those resources towards investment in business expansion or job creation. As the religious environment becomes more polarized, rent-seeking behavior may increase.

In this subsection I have outlined four mechanisms through which toleration, a form of social capital, may create economic growth. My research will help to shed light on which, if any, of these mechanisms are present.

Shared Values

The following shared values mechanisms form causal channels illustrate how religious diversity may *restrict* growth. Since many of them feature prominently in the existing literature, I have included them for completeness. Having a shared set of behavioral, ethical and moral values among members of a population can have powerful effects on economic growth through lowered transaction costs, better decision-making efficiency and higher levels of public goods provisions. I posit that these shared values may partially stem from shared religious beliefs.

Shared values may decrease transaction costs between parties, rendering exchanges more efficient. Let us consider the simple fact that no contract is complete. No document can possibly cover or account for all possible events with such a level of specificity that no wiggle room is possible. Attempting to do so imposes significant costs in negotiating contracts, enforcing them, monitoring them and, in some circumstances, litigating them. In this vein, Lipford and Yandle (1997) finds that in areas of low diversity, rates of litigation are also lower.

Etzioni (1988) and Wilson (1993) argue that individual morality is as important, or more important, than formally dictated law in protecting property rights and thus reducing transactions costs. Ellickson (1991, p. 237), Frank (1988, p.250) and Hull and Bold (1989) recognize that churches and religious groups are particularly good at enforcing these property-protecting behaviors through the invocation of an all-knowing and all-powerful god as well as the low-cost enforcement mechanisms of heaven and hell. The less trust and good faith that exist between different contractual parties, the more specific, more detailed and more expensive these contracts become. Thus, having shared sets of values, which partially arise from shared religion, between members of a population may enhance growth by lowering transaction costs.

Shared values may influence growth through the reduction of bureaucratic costs of many layers of management as well. (Fukuyama, 2001) Consider a factory that produces cars. The person with the most knowledge of brake installation is probably the person installing the brakes, not the CEO. If something goes wrong on the assembly-line floor with the brake installation, if the expert does not have the authority to shut down the assembly line, considerable resources may be wasted in installing faulty brakes while the request to shut down production is passed up the chain of command and then permission is passed back down. However, if the CEO, or management in general, believes that the assembly-line workers will act in good faith, that is, they are trusted, then the authority to shut down can be given to them and considerable time and resources can be saved in the event of an emergency. This will be called the anti-Taylorism argument.

While this mechanism may seem farfetched and implausible, consider the tragedy of the Piper Alpha Oil Rig disaster on July 6th, 1988. While the oil rig burned, the rig management, who had the authority to shut down the rig or order an evacuation, could not be found, costing precious minutes of time. 167 people were killed and insured damages exceeded $3.4 billion, in addition to the loss of oil production capabilities, which counted for over 10% of total North Sea production at the time. (The Public Inquiry…, 1990) Were the engineer in the pump room to have had the authority to shut down the pumps immediately when something went wrong, the worst oil rig disaster in history may have been avoided.

Obviously, a flatter decision-making process can be advantageous in less extreme circumstances. Many decisions from picking the highest-quality provider of goods and services to re-ordering parts, scheduling deliveries and implementing innovations to productivity may be more easily and more efficiently done by the people with the most intimate knowledge of the processes involved. These people rarely see the inside of a corporate boardroom. In order for an anti-Taylorist structure to be efficient, however, there must exist a level of respect and trust between Management and Labor. Shared values contribute to that level of respect and trust.

Lastly, we turn briefly to public goods. While the vast majority of public goods are provided by formal federal, state and local governments, religious groups also provide public goods, like education, to take the most obvious example. Studies like Lipford and Yandle (1997) suggest that in areas with high levels of diversity, public goods, like policing, may be under-provided and public harms, like extensive litigating, may be over-provided. In Montalvo and Reynal-Querol (2003), the authors empirically demonstrate that "religious polarization has a negative effect on the investment ratio and enrollment in secondary education." Montalvo and Reynal-Querol (2000) show that the transmission of technology is slower in highly polarized societies. Since my indices of religious diversity and polarization are just different ways of capturing the underlying diversity of identity, I may also find a negative effect of religious diversity and polarization on growth.

These three shared values mechanisms, created by low levels of religious diversity, may each influence economic growth positively. My research will help to shed light on which, if any, of these mechanisms are present in my data.

In this sub-section I have shown two general ways in which the religious composition of an area's population may influence economic growth. Toleration may contribute to higher levels of entrepreneurialism, a set of resource allocation decisions that approach optimality, complementarities to innovation and a lower incidence of rent-seeking behavior. Shared values may contribute to lower transactions costs, anti-Taylorist gains to efficiency and higher provision of public goods. However, note the apparent contradiction. The "tolerance" story is about gains to growth when people are different. The "shared values" story is about gains to growth when people are similar. Can these both be true? If so, will we be able to tell if religious diversity has any impact on growth at all? These questions will be addressed in the shadow of the empirical results.

How Income May Influence Diversity and Polarization

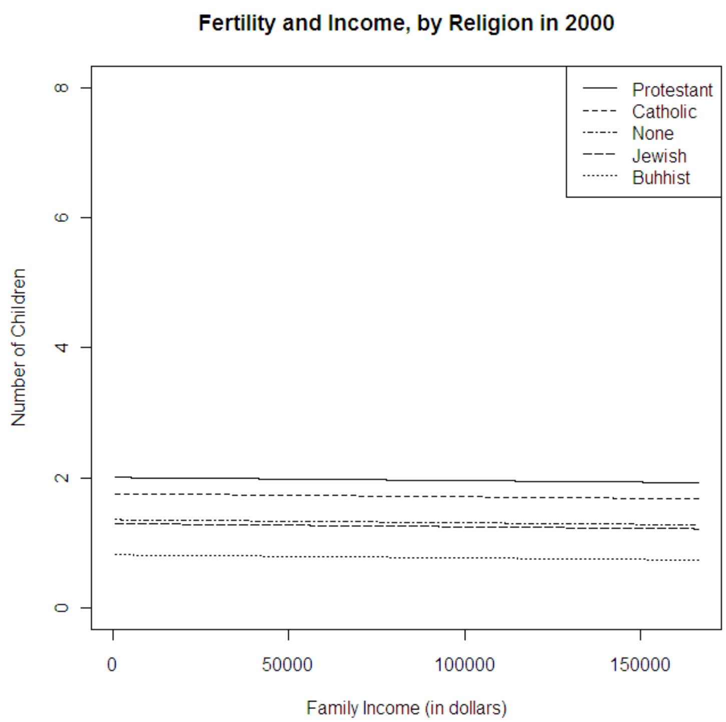
This sub-section deals with the reverse direction of causality from the previous section. Here, we discuss potential channels through which increased economic growth may affect levels of religious diversity and polarization. Support for the existence of this direction of causality can be found empirically and theoretically in Azzi and Ehrenberg (1975) and Lipford and Tollison (2003). The two primary channels addressed here are migration and fertility; the two primary ways in which levels of diversity can change. How these channels are impacted by economic growth could be the subject of many theses. Here, I will just introduce a few general concepts, leaving the interested reader with other sources with which to delve into more detail.

Migration

Areas of high economic growth are likely to attract influxes of people. In areas of high growth, opportunities for employment and higher standards of living abound. These characteristics will entice people to move to an area. Blanchard and Katz (1992) demonstrated that migration within the United States responds strongly and relatively quickly to income opportunities. This migration could affect diversity and polarization differently depending on the demographic distribution of the influx. Zaiceva and Zimmermann (2008) find that net migration has increased diversity in the European Union, but it is theoretically possible for diversity to remain unchanged or even decrease due to migration. Either way, migration is likely to increase towards high-growth areas, having an effect on diversity.

Fertility

It is also possible for changing income levels to change levels of diversity through disparate effects on fertility. If rising incomes change the fertility choices of members of different religious groups in different ways, it may cause diversity to change in the long-run. In order to check for this, I analyze data on income, number of children and religion for a sample of 2386 US families from the General Social Survey data in 2000.



It appears as though changing income levels do not affect fertility choices made by US women from different religions in different ways. To confirm this, I tested for parallel slopes and concluded that I cannot reject the null hypothesis that there is no difference in the changes in fertility choices made by women of different religions as income levels change. Thus, the causal mechanism from income level to religious diversity through fertility does not appear to exist in the United States. While the data suggest that fertility patterns will change the religious diversity of a region (assuming children adopt their parents' religion), that change does not appear to be caused by changes in income level.

In this sub-section we have seen a few potential ways in which economic growth can influence the level of religious diversity.

6. Methodology

My methodology follows the approach outlined in Canning and Pedroni (2008) for long-run causality in co-integrated panels. The benefit of using this method is that it enables me to disentangle the bidirectional causality issues using panel data and isolate the long-run effect of religious diversity on growth, and vice versa, in a way that is robust to endogeneity, omitted variables and other empirical weaknesses inherent in other methods. However, the use of this method pre-supposes that my data exhibits characteristics of bivariate co-integration. Underlying that characteristic is the need for each one of my variables to display unit root properties. Only if both unit roots and co-integration are present can we proceed with the long-run causality for co-integrated panels method. What now follows is a discussion of unit roots and co-integration, and how we test for their presence.

Unit Roots

A series has a unit root when the largest root of the stochastic difference equation lies outside of the unit circle. A stochastic process can be written as an autoregressive (AR) process of order k:

$$y_t = a_1 y_{t-1} + a_2 y_{t-2} + \ldots + a_k y_{t-k} + \varepsilon_t$$

where ε_t is i.i.d white noise. If m=1 is a solution to the characteristic equation of this process,

$$m^k - a_1 m^{k-1} - a_2 m^{k-2} - \ldots - a_{k-1} m^1 \;\; a_k = 0$$

then y_t has a unit root. That is to say, y_t is integrated of order 1, I(1). I will use both sets of notation for the remainder of this paper.

The presence of a unit root implies that the series is non-stationary. As a demonstration and proof of this fact, consider the first order condition of the above stochastic process for y_t:

$$y_t = y_{t-1} + \varepsilon_t$$

By repeated substitution,

$$y_t = \sum_{i=1}^{t} \varepsilon_i$$

The variance of y_t is given by:

$$\mathrm{Var}(y_t) = \sum_{i=1}^{t} Var(\varepsilon_i) = \sum_{i=1}^{t} \sigma^2 = t\sigma^2$$

As we can see, the variance positively depends on the time. That means that as t continues to infinity, the variance of y_t diverges to infinity. This implies that y_t is a non-stationary series.

The implication of a non-stationary series is that the series is not mean-reverting. Intuitively, we see that if a sequence fluctuated above and below its long-run mean value, then the variance of that series would approach some finite value in the limit. Since the variance diverges to infinity, the series cannot be mean-reverting. This implies that the effects of a shock to y_t will not die out over time, but will persist in perpetuity.

Returning to our first order stochastic process:

$$y_t = y_{t-1} + \varepsilon_t$$

we see that it can be written as:

$$\Delta y_t = \varepsilon_t$$

where ε_t is random white noise. However, we can treat ε_t more generally as some stationary process e_t, of which random white noise, ε_t , is a special case. Since e_t is a stationary process, we can represent it using an infinite AR process using matrix notation as:

$$e_t = c + y_{t-1} + \sum_{j=1}^{\infty} R_j \Delta y_{t-j} + \mu_t$$

where μ_t is i.i.d random white noise. We can approximate this process using a finite AR process with an appropriate number of lags, P.

$$e_t = c + \varphi y_{t-1} + \sum_{i=1}^{P} R_i \Delta y_{t-i} + \mu_t$$

where $\varphi = 1$ only when y_t is integrated order 1. As one final re-writing of the above equation, we see that:

$$\Delta y_t = c + \rho y_{t-1} + \sum_{i=1}^{P} R_i \Delta y_{t-i} + \mu_t$$

where $\rho = (\varphi - 1) = 0$ only when y_t is integrated order 1. That is to say, when y_t has a unit root. We now have the basis of our test for the presence of unit roots in time series data, called the "Augmented Dickey-Fuller Test," or ADF test, outlined in Dickey, Hasza and Fuller (1984).

The ADF test estimates the above equation for each value of t, then uses a t-test for the significance of $\rho \neq 0$. Since the test is one-sided, large negative values indicate a rejection of the null hypothesis and verification that the series is stationary. We compare the value of the t-statistic to the critical values from the distribution of the test, found in widely-available tables since the test distribution is non-standard, based on Wiener processes of Brownian motion.

There are a number of other tests for unit roots in time series data as well. Im, Pesaran and Shin (2003) outlines an alternative unit-root test for panel data. The hypothesis for this test is:

$H_0 : \rho_i = 0$ (presence of a unit root) for all i

$H_A : \rho_i < 0$ (no unit root present) for all i

This test allows for heterogeneous time dynamics and the reduction of cross-sectional dependence. Cross sectional dependence is reduced by subtracting out common time effects (that is, de-meaning the series) in the calculation of Δy_t (although in this case, it would be Δy_{ti} since parameters are indexed by i in a panel) before estimating the ADF regressions. Heterogeneous time dynamics are introduced by estimating the ADF regression for each member of the panel individually and weighting the ρ coefficients from each regression based on the variance of the residuals from that regression in the final calculation of the test statistic. It is this test that I use in my research.

Co-integration

In order to use the long-run causality test outlined in Pedroni and Canning (2008), the data series must also be co-integrated. Two variables are said to be co-integrated if independently they have unit roots, but a linear combination of them is stationary. That is, if y_{it}, for t = 1, … T has a unit root for each panel member i = 1, … N, and x_{it}, for t = 1, … T has a unit root for each panel member i = 1, … N, then y_{it} and x_{it} form a co-integrated pair if a linear combination $e_{it} = y_{it} - \beta_i x_{it} - \alpha_{it}$ is stationary. This implies that $e_{it} \sim I(0)$ for every i.

Combined with the concept of the unit root, the fact that a linear combination of variables is stationary in the long run is very useful econometrically. First, it implies that a linear combination of non-mean-reverting variables is mean-reverting. Since we know that the effects of a shock to a non-stationary variable do not dissipate, and the relationship between the co-integrating variables is mean-reverting in the long-run, we know that a shock to one must influence the level of the other in the long-run. This fact is crucial towards the validity of our methodology.

Second, it is robust to endogeneity. A conventional assumption for the use of OLS estimators is that the independent variable, x, in uncorrelated with the error term, ε. Stated differently,

$$E(x_t\ \varepsilon_t) = 0$$

The reason for this is that in order to show that the estimated co-efficient, $\hat{\beta}_0$, is unbiased, we need to show that

$$E(\hat{\beta}_0 - \beta_0) = \frac{E(x_t e_t)}{E(x_t^2)} = 0$$

However, when dealing with economic data, the error terms are almost always correlated with the regressor. One reason is that x_{t-1} influences x_t, but others include, but are not limited to, omitted dynamics, endogeneity and omitted variables. With co-integration, we can still use OLS and get unbiased estimators, even with correlation between the independent variable and the error terms. Consider the ratio in the above equation. Since e_t is stationary by construction and x_t is non-stationary, then the statistic in the numerator will have a unit root and grow at some rate L. The statistic in the denominator is the product of two unit root processes and will grow at some rate vastly exceeding L. Thus, the expectation is zero for large T values and our estimator is unbiased, even with endogeneity or omitted variables.

Co-integration also has the property of separating out the short-run dynamics from the long-run dynamics. Being able to econometrically determine how two variables interact in the steady-state, independent from short-run seasonal or business-cycle fluctuations, is very valuable.

Panel co-integration has many advantages over traditional time-series co-integration as well. First, variation between members, in the cross-sectional direction, can substitute for variation across time. This allows strong tests for co-integration with much shorter time spans. Second, panel co-integration tests have standard distributions, not the rather complex Weiner process distributions often found with time series tests.

A common test for panel co-integration is developed in both Pedroni (2004) and Pedroni (1999). Begin by estimating by OLS the equation:

$$y_{it} = \alpha_{it} + \beta_i x_{it} + e_{it}$$

for each member of the panel i. Then, using the estimated residuals, estimate by OLS regression the AR equation:

$$\Delta e_{it} = \rho_i e_{i,t-1} + \sum_{j=1}^{P} R_{i,j} \Delta e_{i,t-j} + \mu_{i,t}$$

for each member of the panel i. This will yield a set of N ρ_i's where N is the number of members of the panel. Testing each ρ_i individually, we obtain a set of N test statistics t_i. We can take the mean of this set, scale it appropriately, and test it against the standard normal distribution for:

$$H_0 : Ŧ = 0 \text{ (no co-integration)}$$

$$H_A : Ŧ < 0 \text{ (co-integration present)}$$

where Ŧ is the scaled mean test statistic. This is simply an ADF test for unit roots on the residuals to determine whether they are stationary or non-stationary, adopted to a panel setting and taking advantage of the central limit theorem. If the residuals are non-stationary ($\rho = 0$), then the variables cannot be co-integrated as they would diverge over time.

The intuition behind the use of OLS in test is simple. The variance of the stationary linear combination of variables will be less than the variance of any other possible combination of those variables, since they would all be non-stationary. The OLS estimation will find that combination since it works by minimizing the variation in the residuals. To test for co-integration in a panel, we use a parametric pooled t-statistic.

Bootstrapping

Because my panel dataset is rather short in the T dimension, I bootstrap the results of the unit root, co-integration and long-run causality sign tests in order to account for some of the finite sample size distortion. What follows is a description of bootstrapping theory and practice.

Bootstrapping is a re-sampling algorithm that allows one to simulate additional data and thus create a large number of test statistics under the null hypothesis of the test in order to determine what test distribution and critical values are appropriate. This comes from the fact that the simulated data is consistent with the nuisance features of the observed data. It is important to note that this process just reduces the size distortion from a limited amount of data. The lack of power inherent in a test that relies on so few data points will be addressed in the Discussion section.

For the multivariate case, I start by estimating the VAR process:

$$R(L)_i \Delta y_{ti} = c_i + u_{ti}$$

where u_{ti} is a realization of a random white noise process with standard normal distribution. I then hold R_i and c_i fixed, and sample from the standard normal distribution T times to generate a new set of u_{ti}, where T is the time dimension of the panel dataset.

There is a more sophisticated sampling process that avoids any distributional assumptions and uses the actual set of u_{ti} as a population from which to sample. Due to the complexity of the vector multiplication in this method, I do not use it in my research. These new realizations of the random white noise process force new values for Δy_{ti} by the above equation. Repeating this across the N dimension, where N is the number of members in the panel, I generate a complete simulated dataset. I then re-accumulate the new Δy_{ti} vectors to obtain y_{ti}*, vectors that mimic, in terms of nuisance parameters that may be present, our original vectors y_{ti}. With the new dataset, I can apply any appropriate empirical test, generating a test statistic. Repeating this process a large number of times, I generate 10,000 new test statistics. Plotting a distribution of these statistics yields the desired critical values. If my observed test statistic is outside the critical values I reject the null hypothesis. However, if my observed statistic is within the body of the distribution, I fail to reject the null hypothesis. I will perform this process for the *HHI* and *PI* variables individually for unit root testing, both co-integrating pairs for the co-integration tests and the sign test for long-run causality.

Long-Run Causality

The long-run causality test used in Pedroni and Canning (2008) rests on the assumptions of unit roots and co-integration. Co-integration shows that my variables have a long-run, causal relationship. However, it does not specify which direction causality flows, or what sign it has. This test can estimate the sign and direction of causality in panel data where the time dimension is not nearly as extensive as would be required for tests of reasonable power in time series data. Before testing directly, I must delve into three implications of panel co-integration.

First, the fact that y_t and x_t are co-integrated unit root processes implies that a stationary vector moving average (MA) representation exists as:

$$\Delta y_t = F(L)\varepsilon_{1,t} \qquad \Delta x_t = F(L)\varepsilon_{2,t} \quad \text{where F(L)} = \sum_{j=0}^{\infty} F_j L^j \tag{1}$$

in matrix notation as an MA polynomial and $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are the white noise shocks to y_t and x_t, respectively, as outlined in Poskitt (2003). Setting L, the lag operator, equal to 1 gives the long-run response of the change in the level of y_t and x_t to the shock. F(1) is then the causality matrix:

$$\text{F(1)} = \begin{vmatrix} F(1)_{11} & F(1)_{12} \\ F(1)_{21} & F(1)_{22} \end{vmatrix} \quad \text{where } F(1)_{ij} = \sum_{j=0}^{Q_i} F_{ij}$$

This implies that:

$F(1)_{11}$ = the cumulative effect on y from a shock ε^y
$F(1)_{12}$ = the cumulative effect on y from a shock ε^x
$F(1)_{21}$ = the cumulative effect on x from a shock ε^y
$F(1)_{22}$ = the cumulative effect on x from a shock ε^x

Second, co-integration also implies that an error correction representation for each member of the panel, i, exists:

$$\Delta y_{it} = \lambda_{1,i}\hat{e}_{it-1} + \sum_{j=1}^{K_i} R_{ij,11}\Delta y_{it-j} + \sum_{j=1}^{K_i} R_{ij,12}\Delta y_{it-j} + \varepsilon_{1,it} \tag{2a}$$

$$\Delta x_{it} = \lambda_{2,i}\hat{e}_{it-1} + \sum_{j=1}^{K_i} R_{ij,21}\Delta y_{it-j} + \sum_{j=1}^{K_i} R_{ij,22}\Delta y_{it-j} + \varepsilon_{2,it} \tag{2b}$$

were λ_1 and λ_2 are the steady-state adjustment values for the co-integrating relationship, ε_1 and ε_2 are the white noise innovations and the summations are the transitory dynamics.

For greater background on error correction representations, consult Engle and Granger (1987). Notice that all parameters are indexed by i, allowing the heterogeneous effects between members that makes this method so useful.

Third, the validity of the Granger Representation Theorem, proven in Granger and Lee (1989), which also flows from co-integration, implies that a connection exists between F(1) from the moving average representation and λ from the error correction model. Specifically, it claims that

$$F(1)\lambda = 0 \tag{3}$$

follows from the minimized variances of the estimates for λ from OLS regression on the error correction models.

These three implications of co-integration can be used directly to prove the direction and sign of causality. From equation (3):

$$F(1)_{21}\lambda_1 + F(1)_{22}\lambda_2 = 0 \tag{4}$$

We know that $F(1)_{22} \neq 0$. This flows from the fact that x_t has a unit root and unit roots imply that a shock to x_t changes the level of x_t in the long-run. In addition, from equations (2) we know that both λ_1 and λ_2 cannot equal zero. Otherwise, the error correction model would not exist. Thus;

$$F(1)_{21} = 0 \quad \text{if and only if} \quad \lambda_2 = 0$$

Now we have a test for long-run causality where:

$$H_0 : \lambda_2 = 0 \text{ (no long-run causality } y_{it} \rightarrow x_{it}\text{)}$$

$$H_A : \lambda_2 \neq 0 \text{ (long-run causality } y_{it} \rightarrow x_{it} \text{ exists)}$$

However, this test tells us nothing about the sign of the direction. We know nothing about whether shocks to y_{it} influence x_{it} positively or negatively. What we do know is that:

$$F(1)_{22} > 0$$

by the assumption of unit roots. By simply re-arranging equation (4), we can say that:

$$\text{if} \quad F(1)_{21} \neq 0, \quad \text{then} \quad \mathit{sign}[F(1)_{21}] = \mathit{sign}[-\lambda_2 / \lambda_1]$$

Thus, the sign of the long-run causality will be the same as the sign of the negative ratio of λ_2 to λ_1. It is important to note that the actual values of λ_2 and λ_1 are meaningless. While we can make inferences about their signs, their magnitudes contain no useful information as to quantitatively estimating the effect of one variable on the other.

Now we have all the econometric tools for constructing tests for the direction of long-run causality and the sign of that effect in panel data. Moreover, these tests will be robust to heterogeneous short- and long-run effects, as well as heterogeneous effects between panel members. Furthermore, they will have standard distributions and can be used with short time span data sets.

First, estimate the equation:

$$y_{it} = \alpha_{it} + \beta_i x_{it} + e_{it}$$

for each member i of the panel. It is important not to use OLS in this step, since that method may yield an inconsistent distribution on the parameter $\hat{\beta}_i$. I use a method from Pedroni (2000) based on fully modified OLS principles to ensure that the estimated variance for the distribution, $\hat{\sigma}^2_\beta$, approaches the true variance σ^2_β, given the data.

Next, use the residuals, $\hat{e}_{it}$, to estimate the error correction representation equations, (2a) and (2b), by OLS for the steady-state adjustment values, λ_{1i} and λ_{2i}. Since the long-run relationship is stationary by co-integration, we know that λ_{1i} and λ_{2i} are stationary as well. Thus,

$$\hat{\lambda}_i - \lambda_i \sim N(0, \sigma_{\lambda i})$$

Using our estimates, $\hat{\lambda}_i$, we construct a pair of panel-based tests: a group mean test and a Lambda-Pearson (Fisher) test. Each will provide useful information in their own right, and together they will help to disentangle heterogeneous long-run effects between panel members.

Starting with the group mean test, we know that the individual $\hat{\lambda}_{2i}$'s are distributed normally. Thus, each one has an associated t-statistic for the test:

$$H_0 : \lambda_2 = 0 \text{ (no long-run causality } y_{it} \rightarrow x_{it} \text{ on average)}$$

$$H_A : \lambda_2 \neq 0 \text{ (long-run causality } y_{it} \rightarrow x_{it} \text{ exists on average)}$$

We can compare the mean t-statistic,

$$\bar{t}_{\lambda 2} = \frac{1}{n}\sum_{i=1}^{n} t_{\lambda 2i} \quad \sim \quad \text{N}(0,1)$$

to the critical values for the normal distribution and either accept or reject our null hypothesis. By exactly the same procedure, simply switching $\hat{\lambda}_{1i}$ in, we can evaluate the opposite direction of causality. This test will tell us, on average, whether x_{it} and y_{it} are causally connected across members in the panel and in which direction that causality flows.

The Lambda-Pearson (Fisher) test, "LPF", can be used to determine whether heterogeneous long-run effects between members of the panel are cancelling each other out in the group mean tests. For the test, we find the p-value for the t-stat from each of the $\hat{\lambda}_{2i}$'s. From these p-values, we calculate:

$$P_{\lambda} = -2\sum_{i=1}^{n} \ln(p_i) \quad \sim \quad \chi^2_{2n}$$

Testing P_{λ} against the chi-squared distribution critical values allows us to evaluate:

$H_0 : \lambda_2 = 0$ (no long-run causality $y_{it} \rightarrow x_{it}$ pervasively throughout panel)

$H_A : \lambda_2 \neq 0$ (long-run causality $y_{it} \rightarrow x_{it}$ exists pervasively throughout panel)

Switching $\hat{\lambda}_{1i}$ into the equation allows us to evaluate causality in the other direction. Keeping these two tests together allows us to tell which direction causality flows in most cases, and how the causality is distributed across the sample.

The test for the sign of causality is slightly more complex. The problem with using either the group mean or LPF tests is that the ratio of two normally distributed variables is a Cauchy distribution, for which the mean and variance do not exist. However, the median estimator for the Cauchy distribution does have a well-defined variance. Bootstrapping from our sample of $\hat{\lambda}_{2i}$'s yields a sample of median estimators and we can calculate the variance of that sample. Using the median estimator and its simulated variance, we can test the reliability of our sign for long run causality.

What I have shown here are the theoretical and practical underpinnings for the test for the sign and direction of long-run causality in co-integrated panels. The application of these tests follows.

7. Results

In order to establish the validity of my econometric method, I first demonstrate that my data series have unit roots and are co-integrated. Furthermore, I conduct the long-run causality test outlined in Canning and Pedroni (2008). The results of all three levels of testing are reported here. For conducting the tests, I use the "Regression Analysis of Time Series" (RATS) statistical computing software. All tests are conducted using a time variable to subtract out common time effects that affect all members of the panel equally and thus create cross-member correlation in our panel. Subtracting the common time effects significantly lowers this correlation.

Unit Roots

I use the Im, Pesaran and Shin (IPS) test for unit roots in panel data for all three of my variables; economic growth (as measured by average per capita *log(Income)*), religious diversity (as measured by *HHI*) and religious diversity (as measured by *PI*).

The test statistics for each variable with one lag are reported below.

Variable	IPS test
Log(Income)	-2.017
HHI	-5.746
PI	-11.656

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.

In order to correct for the small sample size distortion, I perform a bootstrap procedure for the IPS test on both the HHI and the PI. Summary results and critical values of the bootstrap tests are included in Appendix 3. These results indicate that we cannot reject the null hypothesis that, on average, unit roots are present for *HHI*, *PI* and *log(Income)*.

Intuitively, these results make sense. Since *HHI* and *PI* are measures of the level of religious diversity present in a population, there is no reason we should think that these measures would be mean-reverting. High levels of diversity do not create pressures to homogenize, nor do low levels of diversity create incentives to leave the majority. High levels of polarization would not incentivize minority groups to migrate to an area, quite the contrary. Since lack of mean-reversion is part of the definition of a non-stationary process, of which unit roots are merely a symptom, we can safely conclude, on the basis of both the empirical tests and the economic reasoning, that our diversity index, *HHI*, and our polarization index, *PI*, are non-stationary.

The same reasoning goes for our economic indicator, *log(Income)*. Higher incomes do not create pressures for incomes to drop, nor vice-versa. It is well accepted by mainstream macroeconomists that per capita incomes are not mean-reverting. Instead, they increase in the long-run, though are subject to the short-run winds of the business cycle. Since we are concerned primarily with long-run equilibrium levels, we can assume that our economic indicator is not mean-reverting. Even though relative growth rates should be greater in poorer states, this does not create downward pressure or mean-reversion on incomes in the long run. This economic reasoning confirms our empirical result, giving support to our claim that *log(Income)* is a non-stationary series.

Now that we have demonstrated that our series are non-stationary, we can proceed with tests for co-integration.

Co-Integration

I must also demonstrate that *HHI* and *PI* are co-integrated with *log(Income)* in order to demonstrate that the long-run relationship between these variables is stable. I do this using a parametric pooled t-statistic outlined in Pedroni (1999) and Pedroni (2004). Like the unit root test, I bootstrap the co-integration test to correct for the small sample size in the T dimension. The results of the bootstrap, with the associated critical values, are presented in Appendix 4. The results of the co-integration tests are reproduced below.

Co-integrating Pair	Pooled t-stat
Log(Income) and *HHI*	-14.155***
Log(Income) and *PI*	-11.556*

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level

Recall that:

$$H_0 : \rho = 0 \text{ (no co-integration)}$$

$$H_A : \rho < 0 \text{ (co-integration present)}$$

We can see that we reject the null hypothesis of no co-integration at far beyond the 1% level for our first co-integrating pair. There is little doubt that *HHI* is co-integrated with *log(Income).*

The story is slightly more complex for the second co-integrating pair. The parametric pooled t-test rejects the null of no co-integration at the 10% level, but not at the 5% level. For this reason, we will continue to include *PI* as a metric, but keeping reservations as to the validity of any conclusions drawn from it.

Now that we have demonstrated that our series are co-integrated, we can proceed with tests for long-run causality.

Long-Run Causality

The test for long-run causality between *HHI* and *log(Income)* and *PI* and *log(Income)* with one lag, used in Canning and Pedroni (2008), was conducted using the RATS software.

		λ_2	λ_1
HHI	Group Mean Test	6.67***	-1.64*
	Lambda-Pearson (Fisher)	4336.21***	242.41***
PI	Group Mean Test	1.03***	-1.90***
	Lambda-Pearson (Fisher)	1142.66***	951.58***

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.

The results in the third column indicate that *HHI* and *PI* have a strong, causal effect on *log(Income),* both pervasively and on average, indicating the lack of heterogeneous effects between members of the panel. Recall that for the Lambda-Pearson (Fisher) test, the distribution is X^2 with 96 degrees of freedom.

The results in the fourth column indicate that that *log(Income)* has a strong causal effect on *HHI*, but there is a possibility of heterogeneous effects as we are unable to reject the null hypothesis of no causality at the 5% level for the group mean test. Since we reject the null convincingly in the Lambda-Pearson (Fisher) test, this indicates that while causality is pervasive, in some members it may have a positive sign and in others it may have a negative sign. The results in the fourth column also indicate that *log(Income)* has a strong, causal effect on *PI*, both pervasively and on average, indicating the lack of heterogeneous effects between members of the panel.

We now proceed to the sign test with one lag.

	$-\lambda_2 / \lambda_1$	
	HHI	PI
Sign Ratio	3.33***	-.72*
Standard Error	(.94)	(.54)

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.

The results indicate that the sign of causality for *HHI* is likely positive and the sign of causality for *PI* is negative, although we are not as confident in that determination.

8. Discussion

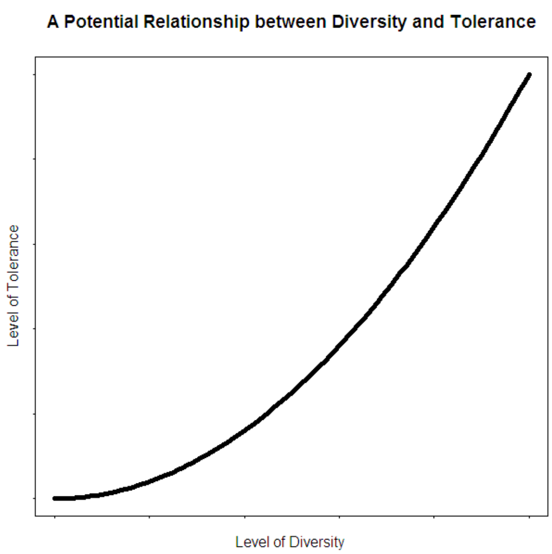
This section will be comprised of five sub-sections, each analyzing a facet of my results. The first four will deal with integrating the empirical results of the long-run causality tests with the economic reasoning and analysis provided in the Mechanisms section. The final sub-section will address weaknesses in my analysis and how each can be confronted.

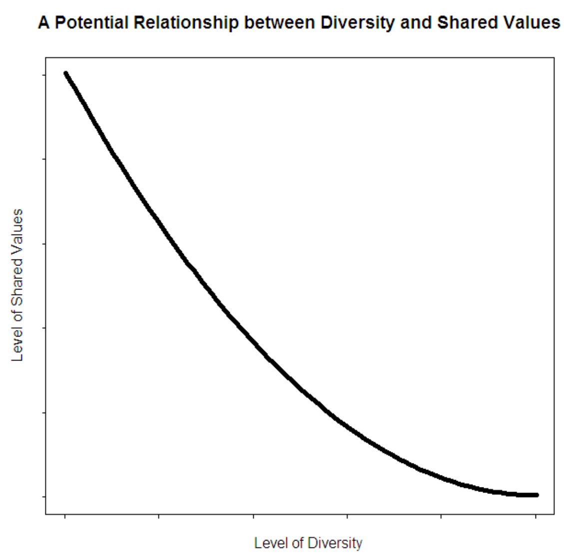
Impact of HHI on Income

The results of the long-run causality test indicate that, at levels seen in the US, increased religious diversity has caused growth in per-capita income. With respect to our "shared values" and "toleration" mechanisms for causality, this result has two different explanations. First, the marginal benefit of more toleration at high levels of diversity may be more than the marginal cost of fewer shared values, making the increase in output positive for more diversity. Second, shared values might not be a valid mechanism at all.

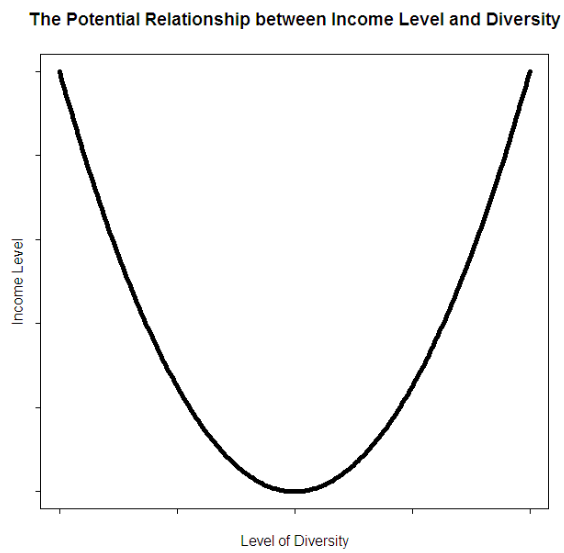
Differing Marginal Benefits

It is possible that at high levels of diversity, the gains to growth from increased toleration are more than the losses to growth from decreased shared values. The graphs below illustrate this point more clearly. It is important to note that these graphs are qualitative, showing the type effect that might be present, not a quantitative assessment of the actual relationship.





This pair of relationships fits with our proposed mechanisms and the existing literature. Since the United States has a relatively high level of diversity, the toleration mechanisms appear to be dominating the shared values mechanisms in my sample. An important implication of this conclusion is the potential existence of two optimal levels of diversity at both maximum and minimum diversity. The graph below illustrates this point more clearly.



I find this argument highly persuasive for three reasons. First, it allows me to stand by the validity of my economic reasoning on the impact of shared values on economic growth. Second, it is supported by some of the literature, particularly Alesina and Ferrara (2005), which finds this very effect. Ratna, Grafton and Kompas (2009) found no effect of religious diversity, but did not look at interaction terms or time-series data. This explanation also prevents me from extrapolating outside the dataset. Just because shared values are not the dominant mechanism in my range of points does not mean that they are not the dominant mechanism at other ranges. So this particular conclusion allows me to remain confident in my empirical results and economic analysis, while also acknowledging the validity of existing research on the subject. This is a highly desirable outcome.

Shared Values are Irrelevant

As shown in the Mechanisms section, the validity of "shared values" as a causal channel would indicate that diversity would have a negative effect on growth. However, this is the opposite from what we observe in the empirical results. This may mean that "shared values" have no effect at all. This would imply a single corner solution for optimal levels of diversity at the maximum. Since the specific causal drivers like public goods provision, low transaction costs, low barriers to trade and anti-Taylorism that have been previously discussed are each supported by a considerable amount of established research, I find this conclusion to be the least plausible interpretation of the empirical results.

Potential Resolutions

More research could help in deciding which of the two conclusions drawn from the data are most likely correct. If similar analysis, using the same econometric method, was to be conducted in a country with low levels of diversity, then the first conclusion could receive extra support. As shown in Appendix 5, the United States is on the high side of the diversity index; there are plenty of less diverse nations to choose from. Repeating the analysis at a number of different levels of diversity would help to flesh out how effective toleration and shared values are as mechanisms at different areas in the diversity spectrum.

Finally, our empirical method never stated that toleration was the causal mechanism. Given the existing literature, toleration was suggested as the primary causal umbrella factor, with entrepreneurialism, resource allocation, complementarities in productivity and decreased rent-seeking as aspects of that mechanism. One possible way for testing the validity of this mechanism would be to analyze the relationship between religious diversity and patents received, by state, on a per-capita basis. In Appendix 6, I present a basic statistical analysis. The intuition here is that patents per capita may be a good proxy for levels of innovation and entrepreneurship. Based on the results, I conclude that HHI appears to be associated with per capita patents received in 2000. While this could be caused by any number of factors and more analysis is necessary for more conclusive understanding, the results are promising.

Whatever the reason, the empirical results suggest that at the levels seen in the United States, religious diversity has created economic growth. I postulate, supported by the existing literature on the subject and some preliminary analysis, that the mechanism for this effect is more toleration at higher levels of diversity, leading to more entrepreneurialism, complementarities and resource re-allocation, driving economic expansion. While shared values may have an effect, they do not appear to be dominant at these levels. More research is needed to determine the veracity of these causal claims.

Impact of Income on HHI

The results of the long-run causality test indicate that, at levels seen in the US, increased per-capita incomes have caused an increase in religious diversity. This empirical result aligns with our proposed mechanisms for this direction of causality. The dominant story here is most likely migration. Areas of rapid growth attract people, especially recent immigrants looking to start a new life in an area where opportunities are plentiful, and these people bring with them the diversity of the world. One way to tell if migration really is the source of the increased religious diversity would be to construct some measure of migration or population flows and test a causal link between that and economic growth. Since this causal mechanism is supported by the results of our empirical analysis and the existing literature, I find that the migration mechanism for the observed causality is highly persuasive.

Impact of PI on Income

The results of the long-run causality test indicate that, at levels seen in the US, increased religious polarization has hurt per-capita income. This conclusion should be qualified in light of the weak performance of the PI and Income variables in the co-integration tests and sign test. Resource allocations to rent-seeking instead of economically productive purposes may have restricted economic growth in my sample. A contributing factor may also be the under-provision of public goods in highly polarized environments since those goods can be utilized by members of opposing groups. Furthermore, complementarities may have decreased impact across highly polarized boundaries. The veracity of all these mechanisms has been demonstrated in studies like Montalvo and Reynal-Querol (2003) and Alesina and Ferrara (2005), among others.

Impact of Income on PI

The results of the long-run causality test indicate that, at levels seen in the US, increased per-capita incomes have lowered religious polarization. Again, this conclusion should be qualified in light of the weak performance of the PI and Income variables in the co-integration tests. Migration may be the correct answer for which causal channel is at work, and additional research like that suggested earlier might be able to prove that this is the case. Since migration may move the PI either higher or lower, depending on the demographic profile of the region and the entering population, this story may be more nuanced than is presented here. Since the empirical results do not indicate which mechanism is present, and the conclusions drawn from this line of analysis are not central towards this research, it will suffice to say that additional research on migration and polarization should be explored.

Weaknesses in Analysis

The research presented here has limitations. Six potentially important weaknesses are discussed below.

I. There are biases that arise from limitations in the data.
II. There are biases that arise from weaknesses in the long-run causality methodology.
III. States may be too large a geographic region for many of my mechanisms to apply, and the effects of the mechanisms may change their area of impact over time.
IV. The indices may not measure the true level of heterogeneity of identity.
V. The causal link illuminated by my analysis may not show the effect of religious diversity on growth, but instead a simple "Protestant Effect."

VI. People unaffiliated with any religious group are simply uncounted.

Data Weaknesses

These weaknesses present the most fundamental and significant critique of my research. My variables, especially the diversity and polarization indices, are imprecise and noisy proxies for underlying heterogeneity of identity, which is what I am actually trying to measure. The indices themselves are constructed using imprecise and vague definitions of what a “Catholic” or “Other” is. While the religious categories themselves include a wide range of religious traditions, each tradition includes many levels of adherence. There are notable holes in the data, a subject addressed more substantially in the Data Description section. Despite these weaknesses, I was forced to work with the data as it exists, not as I wish it to exist. This decision is supported by the use of this data set in Rupasingha and Chilton (2009), Heath et al (1995), Bainbridge (1989), Hull and Bold (1995) and Lipford and Tollison (2003).

The economic data ignores the informal economy, which may be significant in terms of the contributions of social capital toward growth. As discussed earlier, the advantages of the administrative data, of which the data I use are the most high-quality and methodologically constant, outweigh the weaknesses.

Methodological Weaknesses

There are three weaknesses in the methodology that cast doubt on my conclusions. These are an insufficient number of lags, lack of power in the tests and no methodology for determining the magnitude of effect of one variable on the other. In my analysis I use only a single lag due to the short nature of the panel in the T dimension. In general, lags are used to capture long-term trends that are independent of short-term fluctuations related to seasons, business cycles, or any other cyclic events. Since my data points are widely spaced from each other, these short-run phenomena are unlikely to be present serially and impersonating a long-run trend.

Another ramification of a short T dimension is a lack of power inherent in my empirical tests. Since we reject the null hypothesis for the co-integration tests and the long-run causality tests, a lack of power does not appear to be a fundamental problem. However, for the unit root test, we fail to reject the null hypothesis. While this is good for our analysis, it is possible that were our tests to have more power, that null would be rejected. Because of these weaknesses, the conclusions drawn here are suggestive, not definitive. Additional research will overlap with, and expand on, my work.

Lastly, the limitations of the long-run causality for co-integrated panels methodology prevent any knowledge regarding the magnitude of the effect of on variable on the other. I cannot determine how much more diversity would cause how much more growth, on average, or vice versa. Additional econometric research and innovations will likely allow this analysis to be complete.

State-Level Analysis

It is possible that a state is too large a geographic unit for proper analysis. Critiques along this line of reasoning would focus on the fact that many states vary widely in terms of religious make-up between different regions. Lumping together the religious diversity found in New York City with that found in the Adirondacks may be inappropriate, leading to flawed analysis. Furthermore, my causal mechanisms from religious diversity and polarization to growth focus on social capital models, which revolve around communities. In that sense, a Williamstown, Massachusetts resident may have more in common with someone from Pownal, Vermont than from Roxbury, Mass. The state-level analysis ignores these lines of reasoning.

This is a valid critique. County-level analysis would significantly reduce the heterogeneity of geographic region plaguing state-level analysis. However, this turns out to strengthen my conclusions. The causal link that was predicted by economic analysis and observed in the empirical results would most likely be even stronger were it to be measured at the county level, free from the “smoothing” effects of state-wide aggregation. For this reason, I find my results on the causal relationship between religious diversity and economic growth robust to the state-level aggregation that very likely underestimates the strength of that relationship.

Population Percentage and Cultural Influence

The mechanisms presented here focus on toleration and shared values between, and within, religious groups. However, it may be possible that the impact of a particular religious group on the cultural discourse of a community may be disproportionate to the population of that religious group. Since I measure religious diversity in terms of population, my indices of religious diversity and polarization may not reflect the true level of heterogeneity of identity present in a society. As stated earlier, these indices are noisy and imprecise measures of something that cannot be measured. Despite these weaknesses, HHI and PI are used in a vast number of studies like Voas et al. (2002), Montalvo and Reynal-Querol (2005), Alesina et al (2003), Ratna, Grafton and Kompas

(2009), Montalvo and Reynal-Querol (2002) and many others to estimate religious diversity at the national, regional and local level. The preponderance of published studies that use these indices supports my decision to use them as well.

The Protestant Effect

Since the United States has always been a largely Protestant nation, it is possible that, instead of measuring religious diversity, my index instead measures the extent to which a geographic unit is Protestant. It is possible that the empirical results of the test for long-run causality have unearthed a link between "Percent Protestant" and "Per Capita Income." However, a closer look at the numbers invalidates this hypothesis. The empirical results show that religious diversity has a positive, causal effect on economic growth. Since religious diversity and percent Protestant move in opposite directions, this would imply that higher Protestant concentrations would have a *negative* effect on long-term growth. This would contradict the majority of empirical studies on the subject, of which Grier (1997), Guiso, Sapienza and Zingales (2003), Heath et al. (1995) and Noland (2005) are only miniscule proportion. In addition, I thought it prudent to re-run my analysis using "*Pct. Protestant*" as a variable and test for long-run causality with *log(Income)*. The test statistics for both the IPS test for unit roots and pooled t-test for co-integration with one lag are reported below.

Variable	IPS Test	Pooled t-test
Pct. Protestant	-2.77167	-10.13180

Note: * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.

The results of the bootstrap, with the associated critical values, are presented in Appendix 7. While I fail to reject the null hypothesis for the presence of unit roots, I also fail to reject the null hypothesis for no co-integration with *log(Income)*. Thus, I conclude that there is no stable long-run relationship between *Pct. Protestant* and *log(Income)*. On the basis of both the empirical tests and the existing literature, I find my results on the causal relationship between religious diversity and economic growth robust to the "Protestant Effect."

Ignoring the Unaffiliated

My research on the relationship between religious diversity and economic growth ignores any US resident who does not declare themselves as part of any religious group. While those that self-identify as "Other" are included, those that self-identify as "None" are not. The reason for this omission was entirely logistical. Since many of my early data points are not from years in which the decennial census was taken, there is no definitive number as to the true population of a state in the years in which I require such information. These residents do contribute to the heterogeneity of identity that I attempt to measure, but are left uncounted. Ethnic, religious and linguistic diversity, as well as socioeconomic and even occupational diversity play a causal role in the creation of economic growth through social capital channels. My indices thus attempt to measure one small portion of the overall level of cultural diversity. Additional research on the contributions of these other types of diversity towards growth, which may capture some of the religiously unaffiliated residents, will help close this gap.

9. Conclusion

While the research I have conducted touches briefly on many different subfields of economic analysis, the fundamental question addressed by my paper is a macroeconomic one: what causes economic growth? I posit that religious diversity and polarization can be seen as relevant inputs into the economic growth function. The results of the long-run causality test for co-integrated panels support my twin hypotheses and indicate that there have been positive economic returns to religious diversity in the United States. I postulate that these economic gains to diversity are due to the dominating effect of increased entrepreneurialism, more efficient resource allocation, gains from complementarities and decreased rent-seeking in tolerant atmospheres over "shared values" mechanisms.

Most relevantly, this result is similar to that found in Alesina and Ferrara (2005), including the identification of different marginal benefits of the mechanisms at different levels of income. By using panel data and methods, I extend the status of research on the contribution of social capital to growth in a novel way. The fact that the results of this approach seem to agree with the existing literature supports the choice of this approach in this and future research.

Since at least the time of Adam Smith, but very probably dating back to David Hume and John Locke, economists have admitted that social capital models provide a valuable perspective on economic growth and behavior. While *homo economicus* disagrees, *homo sapiens* intuitively recognizes the importance of "instantiated informal norms," like toleration, in promoting economic growth. This paper suggests that religious diversity may contribute to the creation of those norms.

Appendices

Appendix 1

The following is a general outline of the derivation of the Polarization Index from a rent-seeking model from Montalvo and Reynal-Querol (2005). Let society be comprised of N individuals in M groups, and π_i is the population percentage of the i^{th} group. There is to be some allocation of rents to one of the M groups. Allocation to group i, called outcome i, is preferred by group i. Furthermore, let u_i be the utility derived by group i from outcome i, since no member of group i receives any utility from any outcome other than outcome i.

Individuals in this society expend resources in order to increase the probability of rent-allocation to their group. Let us define x_i as the resources allocated by an individual in group i towards obtaining outcome i. Total resources, R, devoted to obtaining the desired outcome, that is, resources devoted to lobbying, are then:

$$R = \sum_{i=1}^{M} \pi_i x_i$$

Since R measures the resources devoted to lobbying, it can be seen as a measure of the intensity of social conflict. The cost of allocating the x_i resources, $c(x_i)$, is assumed to be a quadratic;

$$c(x_i) = \frac{1}{2} x_i^{\,2}$$

The probability of success in obtaining rents is defined as:

$$p_j = \frac{\pi_j x_j}{\sum_{j=1}^{M} \pi_j x_j} = \frac{\pi_j x_j}{R}$$

In this model, each member of each group must decide how much resources to allocate towards receiving the rents in order to maximize his or her expected utility. That is:

$$E(u_i) = p_i u_i - c(x_i) = p_i u_i - \frac{1}{2} x_i^2$$

The first order conditions that solve the problem are:

$$\pi_i^2 (u_i - p_i u_i) = \pi_i x_i R$$

Summing the first order conditions for each group i:

$$\sum_{i=1}^{M} \pi_i^2 (u_i - p_i u_i) = \sum_{i=1}^{M} \pi_i x_i R = R \sum_{i=1}^{M} \pi_i x_i = R^2$$

If M=2, it is clear that each individual allocates the same amount of resources towards rent-seeking, $x_i = x_2$, and thus $p_i = u_i$. Then:

$$R^2 = \sum_{i=1}^{2} \pi_i^2 (u_i - \pi_i u_i) = \sum_{i=1}^{M} \pi_i (u_i \pi_i - u_i \pi_i^2) = \sum_{i=1}^{M} \pi_i (1 - 1 + u_i \pi_i - u_i \pi_i^2)$$

$$= \sum_{i=1}^{M} \pi_i (1 - u_i (\frac{1}{u_i} + u_i \pi_i - u_i \pi_i^2) = \sum_{i=1}^{M} \pi_i + \sum \pi_i u_i (\frac{1}{u_i} + u_i \pi_i - u_i \pi_i^2)$$

$$= 1 - \sum_{i=1}^{2} \pi_i u_i (\frac{1}{u_i} + u_i \pi_i - u_i \pi_i^2)$$

Notice that $u_i = 4$ scales R^2 to the interval [0,1], appropriate for an index. Since utility is all relative anyway, we will use this value for u_i.

$$R^2 = 1 - \sum_{i=1}^{2} \pi_i 4(\frac{1}{4} + 4\pi_i - 4\pi_i^2) = 1 - \sum_{i=1}^{2} (\frac{.5 - \pi_i}{.5})^2 \pi_i$$

This is the Polarization Index. If M>2, then the further assumption that all groups are of equal size yields the Polarization Index using the same method as above.

While the assumption of equal group size is certainly not true, the point of this derivation is that the Polarization Index is grounded, both intuitively and mathematically, in rent-seeking models.

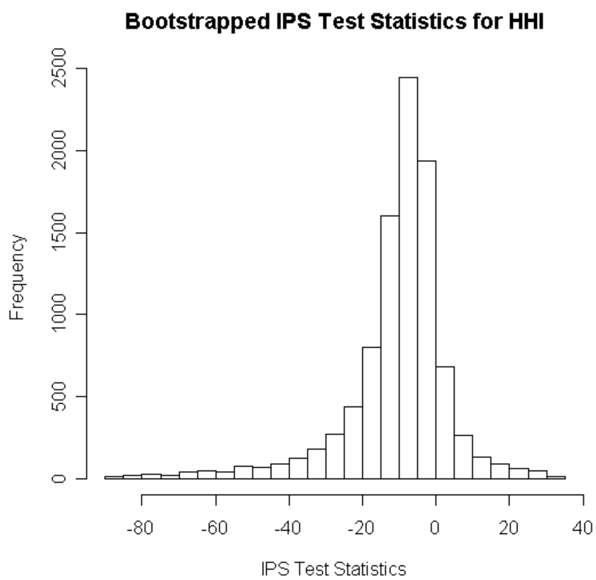
Appendix 2

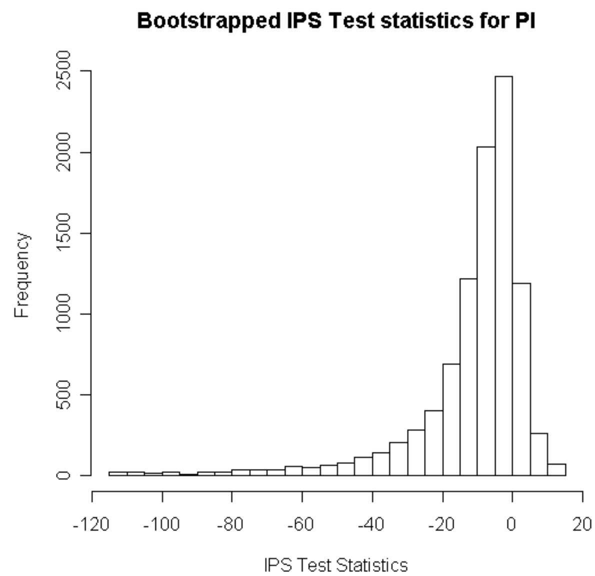
	1929	1936	1952	1980	1990	2000
Mean Observed HHI	0.4448	0.4606	0.4657	0.3687	0.3886	0.4764
Mean Balanced HHI	0.3480	0.3520	0.3580	0.3630	0.3617	0.3892
Difference	0.0969	0.1086	0.1078	0.0057	0.0269	0.0872
Median Observed HHI	0.5125	0.5192	0.5166	0.4238	0.4536	0.5239
Median Balanced HHI	0.4271	0.4212	0.4231	0.4209	0.4278	0.4485
Difference	0.0855	0.0980	0.0935	0.0029	0.0258	0.0754

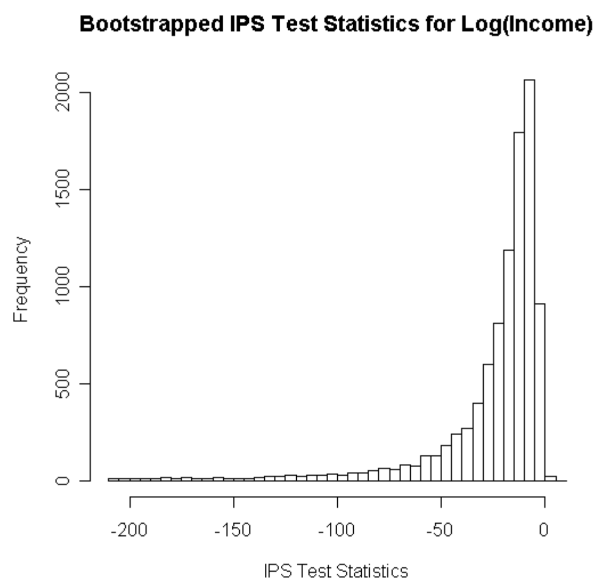
Highest Differences Between Observed HHI and Balanced HHI

1929	1936	1952	1980	1990	2000
New York	New York	Utah	New York	New York	New York
Colorado	Colorado	Idaho	New Jersey	New Jersey	Nevada
Oregon	Tennessee	New York	Massachusetts	Florida	New Jersey
Connecticut	North Carolina	Oregon	Connecticut	Massachusetts	Massachusetts
Oklahoma	Florida	Nevada	Maryland	Maryland	California

Appendix 3



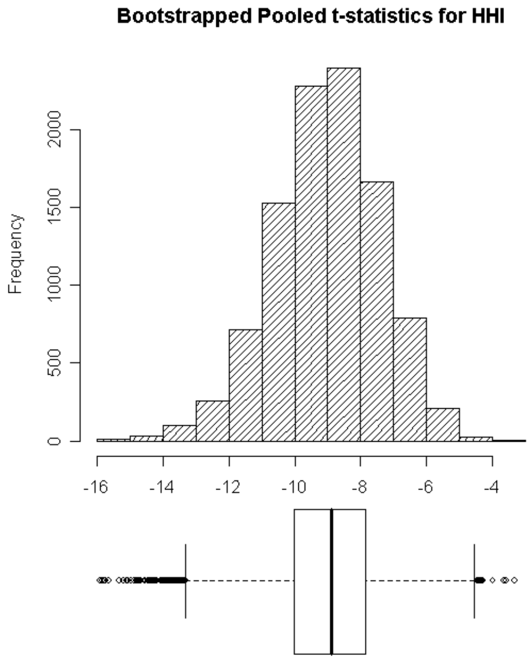


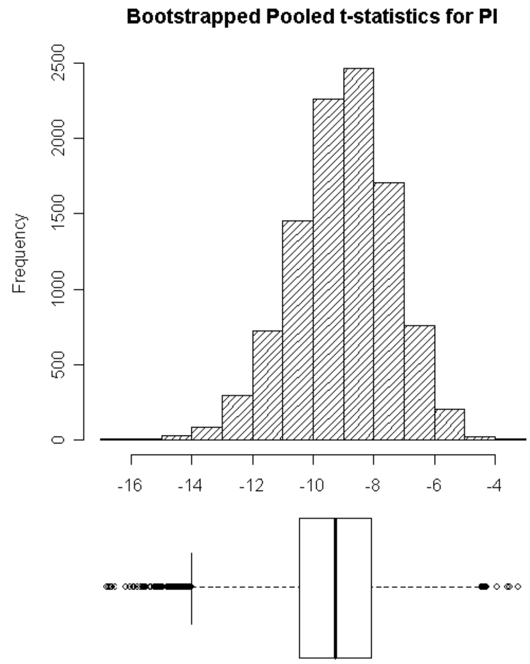


Critical Values

Confidence Level	HHI	PI	Log(Income)
10%	-24.988	-29.186	-53.0101
5%	-38.206	-43.993	-83.6423
1%	-67.566	-84.969	-164.239

Appendix 4



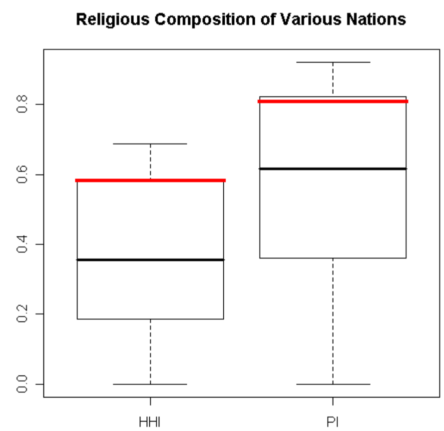


Critical Values

Confidence Level	HHI	PI
10%	-11.1334	-11.1457
5%	-11.7995	-11.8178
1%	-13.2794	-13.1293

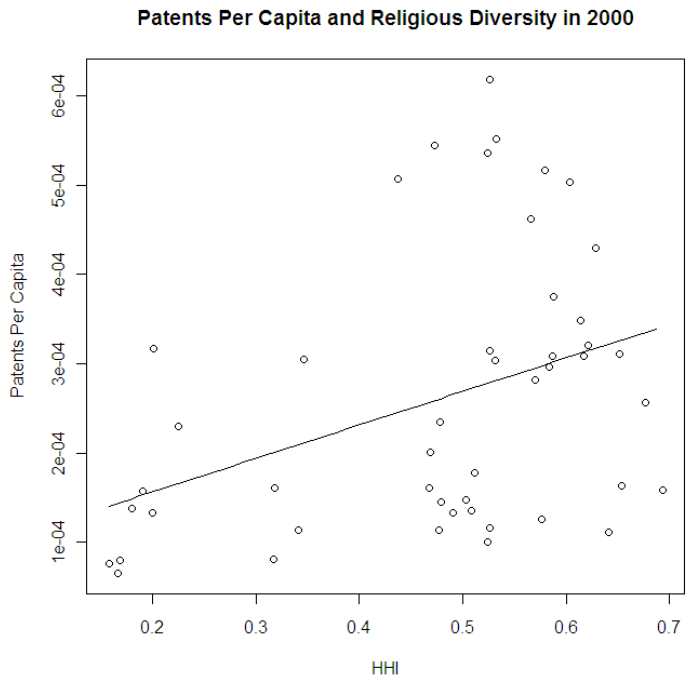
Appendix 5

Shown below are the HHI and PI levels for a handful of nations. All data is from the CIA World Factbook and constitutes the most up-to-date information regarding the nation in question. Not all dates, methodologies and definitions are equivalent, as the CIA World Factbook merely reports what each individual nation reports. For this reason, it would be unwise to read too much into the following information. It is merely presented as a general and rough perspective from which to view religious diversity in the United States. The red line shows the index level for the United States.



Country	HHI	Country	PI
Germany	0.687342	Nigeria	0.92
Uganda	0.631798	New Zealand	0.914577
New Zealand	0.599478	Uganda	0.874874
USA	0.59652	Germany	0.845337
Nigeria	0.58	USA	0.823036
Russia	0.5256	Russia	0.802368
Brazil	0.422488	Brazil	0.695362
Costa Rica	0.386782	Mexico	0.66297
Mexico	0.381222	Costa Rica	0.658565
India	0.332046	India	0.575283
Peru	0.319562	Peru	0.563515
Indonesia	0.25305	Indonesia	0.433661
France	0.2198	France	0.393472
Italy	0.1866	Syria	0.36
China	0.18585	Japan	0.342939
Syria	0.18	China	0.339813
Japan	0.179912	Italy	0.337032
Saudi Arabia	0	Saudi Arabia	0

<u>Appendix 6</u>

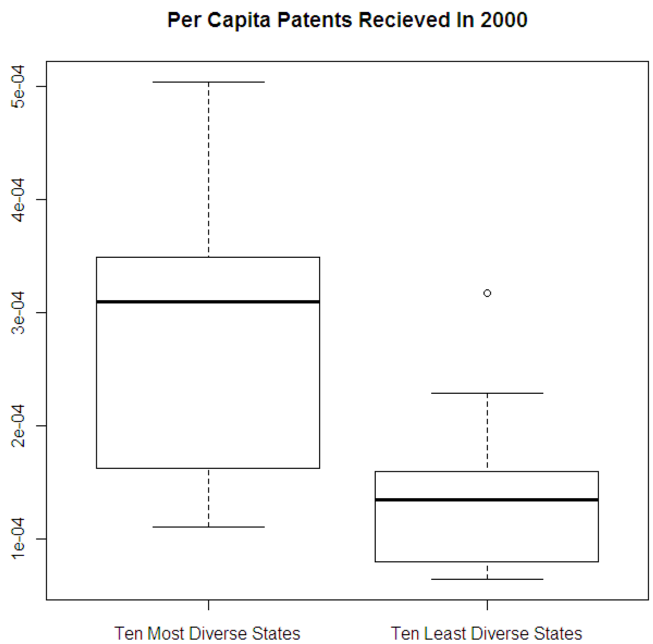


Based on the apparent linear relationship, I estimated the linear model:

$$Per.Capita.Patents_i = \beta_0 + \beta_1 HHI_i + \varepsilon_i$$

	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	8.13E-05	6.72E-05	1.21	0.23267
HHI	3.75E-04	1.35E-04	2.783	0.00785

I am 99% confident that on average, HHI has a positive effect on Patents Per Capita received in 2000. For further analysis, I investigated the 10 most religiously diverse states and the 10 least religiously diverse states, excluding an outlier (Idaho, with twice as many patents issued per capita as the next highest state).

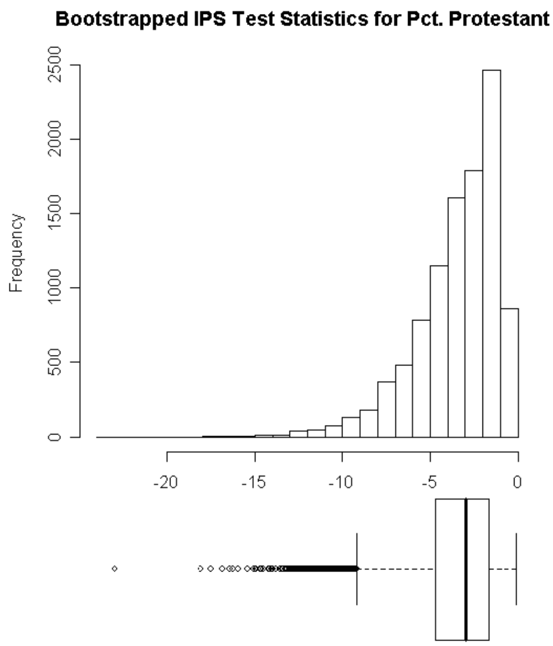


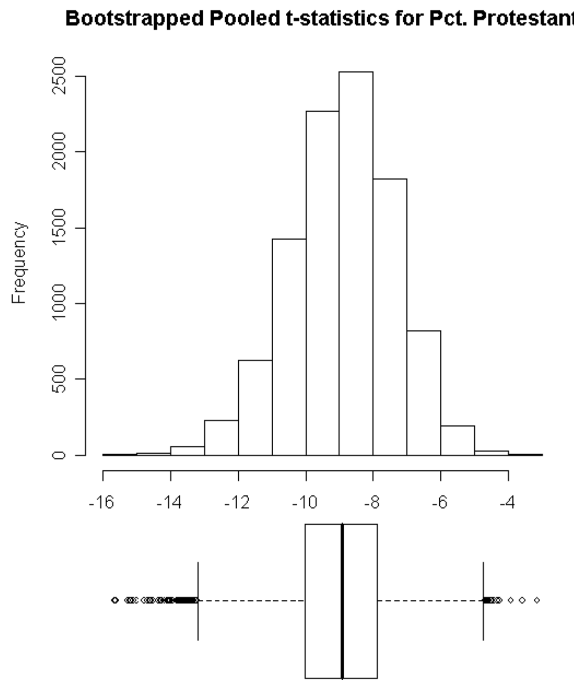
Welch Two-Sample T-test

Top 10 Mean	0.000291
Bottom 10 Mean	0.000143
T-statistic	3.181
p-value	0.00604

Based on the box plot and the result of the two-sample t-test, I reject the null hypothesis that both groups of states have the same mean number of patents received per capita in 2000. While more analysis should be conducted, a preliminary study reveals that differences in number of patents received per capita seem to exist between high religious diversity states and low religious diversity states.

<u>Appendix 7</u>





Critical Values

Confidence Level	IPS Test	Pooled t-stat
10%	-6.6760	-10.9199
5%	-8.0177	-11.5589
1%	-11.4102	-12.7924

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