2023

Heaven? Is it worth it?: The Effect of Belief on Religious Participation and Signaling

Claudia R. Chin
Scripps College

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Senior Thesis by Claudia Chin

Readers: Professor Nayana Bose and Professor Sean Flynn

Acknowledgements

This thesis would not have been possible without the incredible help and advice from my two readers: Professor Nayana Bose and Professor Sean Flynn. Thank you to Professor Bose for instilling a love for game theory in me when I took her intro game theory class, and for kindly re-explaining concepts to me as I wrote this thesis. I was so lucky to have her support and enthusiasm for my topic. Thank you to Professor Flynn for always being excited about my topic and continually pushing me to immerse myself in learning about the religions I was studying. I am so truly grateful for all I have learned from both of you!

I would also like to thank the other Scripps economics professors (especially my advisor Professor Patrick Van Horn) who have taught me to be continually curious about the field and for always having an open office door if I need it. I could not have asked for a cooler department, or a department who believed in me more.

Without the professors in the math department and religious studies department this thesis also would not be what it is today. I am so lucky I found my way to your disciplines at Scripps and the involvement of math and religious studies in my thesis made me truly excited to work on it, even towards the end.

As promised, I would like to thank my friends for finding creative ways to motivate me to work on my thesis and saying “good job Claudia” every time I made them look at my models. I’m so lucky to have friends who can always make me laugh.

Lastly, I would like to thank my family. To my mother, thank you for editing every paper I wrote before I got to Scripps and to my father, thank you for suggesting I take courses in economics. Definitely not least, thank you to my brother for being cool too.

1 Introduction

Religion has long been a subject that baffles economists because of its seemingly inefficient requirements. It is hard to get one's mind around why an individual would be willing to give up secular commodities for religion, or face the strict entry costs and stigma society associates with the religion. Although many reasons have been suggested, the most widely accepted solution to why we engage in these behaviors is Religious Signaling Theory (RST). RST argues that people engage in these ineffective costs as a way to signal their commitment to the religion, and religions were utilized by society to enforce these costs and to be the community whom the commitment will benefit. People are eager to join different religions because of the benefits they gain from the religious community. For people who believe in the religions teachings, they also benefit because they believe they are doing the right thing in following religious doctrine. The gatekeepers of the religion want to prevent some people from joining because if they accept people who do not participate, the average participation and quality of the religion will decrease. There is also an incentive for people who are not interested in participating to join the religion as they will still benefit from the community without participating. These people are called free-riders and the religion would wish to exclude them. Music sung during a religious service provides a great explanation for free-riding and the payoff including the average participation. A member of a religion will gain more utility from hearing the music during a service if everyone is singing. If you join the religion but do not sing (free-riding) you will still enjoy the service, however, if nobody is singing, a member would get less utility from the experience. The more people are singing, the more powerful the experience will be. Religions vary in how strict and how accepting they are. Some religions, such as mega-churches, open their doors to everyone no matter their participation level because they are

geared towards entrants with lower commitment. Stricter religions or cults have high entry costs or engage in monitoring to ensure the quality of their religion/participation levels stay high. These groups are made up of people who are significantly more committed.

Religious recruitment can work in different ways. To explain the process of religious recruitment I will use the example of the Mormon Church (LDS), as explained by Michael McBride in "Club Mormon: Free-riders, Monitoring and Exclusion in the LDS Church." The LDS church is known for being extremely successful when it comes to expanding their religion and for being extremely persistent. Many churches start by inviting you to a service or sharing their religious text with you. Mormonism specifically has missionaries in charge of attempting to convert you, while other religions usually rely on leaders in the church or members of the congregation. The point of inviting someone to a religious service is to integrate them in the community, so that they start receiving utility from being a part of it. This is also done in Mormonism with visits to your home. This both helps the potential entrant feel intimately connected to the community and allows the church to monitor them. The way one truly joins the Church of Jesus Christ of Latter-Day Saints is through receiving the ordinances of the church and living a "Godly" life. The process of converting allows both the potential entrant and the religion to explore if their commitment/participation levels are compatible.

With this thesis, I am interested in understanding why people engage in inefficient costs in the name of religion, and the effect that their levels of utility from secular activities and belief have on their behavior. The ideas I focus on (inefficient costs and utility from secular activity) were originally developed by Iannaccone in his 1992 paper, "Sacrifice and stigma: Reducing free-riding in cults, communes, and other collectives." The paper uses microeconomic utility functions to model the incentives for players to signal their commitment in the form of a

seemingly inefficient cost. He also uses the same approach to model the effect a player's utility from secular activity has on their religious participation and behavior. In his models, Iannaccone excludes belief as a variable, basing the player's decisions off more measurable factors. However, I argue belief should be included because it is an important component in the decision an individual makes about how much to commit to a religion. Belief can play a significant part in how much a person participates in and commits to a religion, defining how much a person wants to contribute because it affects the religion's importance to that person. Iannaccone's approach relies solely on whether the person is committed or not, but commitment is non-synonymous to belief because someone can believe but not be committed, or be committed but not believe. Without the inclusion of beliefs in the models, people's actions concerning religion will appear irrational because their beliefs affect their perceived costs and benefits when making decisions.

My contribution to the literature with this thesis will be to first replicate Iannaccone's two main propositions using a different methodology: a game theoretical approach. I will then extend the model to include religious beliefs. My thesis utilizes two different game theoretical models: a signaling and screening model and a moral hazard model. The former will explore the external effects on religious signaling and the latter will explore the effect of secular utility on religious participation. The signaling and screening model is used to see the players' responses to different percentages of the base engaging in signaling, and to explain the value of the signaling cost. The moral hazard model shows how the gatekeepers of the religion would choose values for participation and utility from success, and the effect of different levels of effort put into the religion.

My results from my models were mostly what I expected. Through my research I found that the addition of belief does not drastically affect the result, but it does change the effects of

the variables. In the signaling and screening model, belief provides an explanation on why an uncommitted person would signal (other than free-riding). In the moral hazard model, belief explains an increased interest in a member putting effort into the religion. Overall, my models explained why people act as they do when engaging, or not, in religious signaling and in contributing to their religion.

This thesis paper is organized into three parts. First, a literature review which explores the existing research on the topic from an economic standpoint but also from anthropological, sociological, psychological, and biological (evolution) viewpoints. The methodology section explains the reasoning behind taking a game theoretical approach, and the specific issues I am addressing. Finally, the models section narrows in on the models I created and solve for an equilibrium that benefits both players.

2 Literature Review

In this section I will review the literature that exists on religious signaling that is pertinent to my thesis with an additional focus on signaling costs, free-riding, and religious belief.

2.1 Signaling Models

Organized religion relies on the cooperation that comes from existing within a group. If we assume religion is a club good – where the utility one gains from involvement in the club/religion is the product of average input of the religions members – it opens religion up to the free-rider problem. There is an incentive for people to free-ride on religions, contributing less while still benefiting from others' commitment. Free-riding creates a problem because, although everyone is incentivised to do it, it brings down the utility of the club good if fewer people contribute. In one of the first contributions to religious signaling literature,"Sacrifice and Stigma:

Reducing Free-riding in Cults, Communes, and Other Collectives," Iannaccone (1992) argues that religious signaling is the solution to the free-rider problem. Seemingly unproductive religious costs act as a signal of a potential entrant's commitment; the cost, which comes from both the unappealing action and stigma received, is too high for a free-rider who is not interested in contributing. The religious signaling described tells us that the stricter the religion is after joining, the more costs potential entrants incur, which would encourage only the most committed members to join the religion. Similarly, because religious signaling costs often entail giving up secular activities or goods, active members in strict sects or religions usually are people who get less utility out of secular society (either because they value their connections with it less or they are less economically productive within society). Therefore, we understand that stricter religions have fewer members. The strictness of a religion can classify whether or not it is considered a cult/sect. Iannaccone defines "sects" and "cults" as "groups whose deviant norms place members at odds with the prevailing culture" (Iannaccone, 283). This definition is relatively vague as few religious traditions can claim no aspect of their group does not conform to societal norms. It is widely accepted, however, that cults/sects will separate their members from the outside (secular) world and will require higher levels of group participation than more moderate religions.

2.2 Other Background

Religious signaling evolved as a tool to foster intergroup cooperation, to exclude free-riders from taking resources. Costly signals are prevalent also in other species and among other human communities to convey anything from reproductive strength to gang affiliation (Sosis and Alcorta, 2003). The cost is a necessary solution when commitment is able to be faked by free-riders (Brusse, 2020). Religious behavior is often costly to fake because it is grounded in commitment to the belief system. Signaling through involvement in rituals is a more accurate

signal and much more costly than signaling through ‘good works,’ which involves monitoring by the religion. The signal of participation in rituals is more accurate because there are many reasons someone might engage in good works. Engaging in costly religious rituals increases one’s self-control, which in turn increases one's religious utility as it makes it easier for you to commit and abide by religious prohibitions (Hall and Gonzales, 2017). Self-control is an important quality to have and evolution would reflect that. Costly religious signals promote cooperation within the group, and their role as communicators can help societies stabilize and grow. Hall and Gonzales also discuss how religions choose their level of strictness when choosing how costly their signals will be and how commonly executed they will be. The different types of signals, specifically between ritual-based religions (catholics/orthodox religions) and discipline-based religions (protestant) are explored by Levy and Razin (2014).

2.3 Additions to the Model

One of the main critiques of Iannaccone’s model is that it does not incorporate religious belief as a factor. Montgomery (1996) argues that religious beliefs are not always formed rationally and an individual's level of belief is not the same as their participation. Iannaccone’s model treats beliefs as fixed so that a change in a member's religious utility comes from a change in the group's average input. Sosis and Bressler (2003) also disagree with the exclusion of belief in their empirical paper, which uses data on secular and religious communes in the 19th century. They argue that supernatural belief in a ritual gives members a feeling of numinosity, a divine presence. This increases the individual's belief and value placed on engaging in rituals. Overall, this feeling of numinous is only found to come from religious ritual, which means the individual gains more religious utility. Both Montgomery (1996) and Sosis and Bressler (2003) argue for an

inclusion of religious belief, an irrational variable, in Iannaccone's model on religious commitment and free-riding.

Although Iannaccone's model argues that religious groups should avoid free-riders because they decrease religious utility, religious groups are often found courting new members who are not going to contribute as highly. This disconnect is addressed by McBride (2015), who pushes for a model that reflects a religion's desire to have free-riders. The paper argues that individuals, with greater exposure and ability to participate in the religion, are more likely to become contributing members because the value of the religion will increase with exposure. Therefore, free-riders become a risky investment for religious groups. The strictness of the religion determines whether it will court free-riders, as some ultra-strict groups only source free-riders amongst their members' families. This is discussed by McBride about Mormonism (2007), which is a strict religion that is still focused on recruiting, especially of people who were previously involved but are not contributing (free-riding).

Carvalho and Sacks (2021) argue for three inclusions in Iannaccone's model. Firstly, increasing returns which argues that larger religious groups offer a higher payoff for joining. This creates a choice for religious leaders between an inclusive and populated religion that does little costly screening or an intimate and committed group. They also suggest adding discrimination as a factor, as blanket discrimination against all group members fosters a stronger community but stigma affecting the 'actively religious' group members incentivized them to assimilate into society. Lastly, Carvalho and Sacks seek to include religious competition as it moderates religious participation. Groups vary in strictness since some are in pursuit of gaining more members who are averse to the costs.

2.4 Case Studies of Religious Signaling

High entry costs in religious groups work to screen out free-riders. An example of high entry costs is voluntary religious castration (VCR), a characteristic of the Skoptsy Sect (Maltsev, 2022). On top of being a painful personal cost, the visible physical changes that resulted from VCR became a stigma from the outside world. The Russian government's outlawing of the sect, and the societal stigma against feminine traits in men also increased the cost of being in the sect because should they leave one would not be accepted by wider society. Despite its extreme entry cost, the Skoptsy sect was especially financially successful and committed to each other, presumably because of the intergroup cooperation the costs fostered.

Religious costs can exist as escalating costs to accommodate for different levels of commitment in the religion. A religion can be modeled as a club good with a tiered menu, acting as a stricter religion for more committed members (McBride, 2007). In order to enforce this system, the Church of Jesus Christ of Latter-Day Saints has a sophisticated administrative structure that organizes monitoring of its members. Despite different levels of religious utility and monitoring, Mormons focus inward on their community and have one of the highest levels of satisfaction in their religion.

Costs can be voluntary, optional costs enact an extension of the theory that people will endogenously sort into groups with others who have a similar level of commitment. Berg and Kim (2014) explore voluntary involvement in Islamic Banks (IB's) as a cost. Using an IB is a cost because the bank prohibits Riba ("usury") and Gharar ("hazard") for all clients. Riba and Gharar are costly religious requirements that cause interest rates to increase, leading to higher financial costs for the client. Despite this, this system is effective because pious Muslims want to

signal their piety to other pious-types, as well as limit their financial partners to similarly minded individuals.

Controlled studies can also model the behavior surrounding religious signaling, and the incentives that cause people to signal or not. A recent study set up an experiment utilizing a modified voluntary contribution mechanism (VCM) game to recreate the sacrifice people consent to so they can join a group (Aimone, Jason A et al., 2013). The study also modeled the endogenous sorting that occurs when people choose different religions based on their commitment level and the incentive for some agents to free-ride on groups that have a higher religious utility (and stricter costs).

Stricter religious groups have longer lifespans because their costly signals foster intergroup cooperation and increased satisfaction in the religion. Another study uses a cultural anthropological approach to show why stricter religious communes exhibit more longevity (Sosis and Bressler, 2003). Their data collection found that religious communes last longer the stricter they are, specifically showing a positive correlation between costly requirements and commune longevity. However, when religious and secular communes are split, costly signals only affect the lifespan of religious communes. This difference shows the effect that having a belief system behind a club has. Religious communes are also much more likely to exist for longer because their costly requirements act as signaling costs and are also backed by a belief system. Through these results we can assume a higher level of religious utility in stricter communes as a cause of their longevity.

2.5 Additions to the Literature

In this thesis, I would like to expand on the involvement of belief in a signaling model of religious commitment started by Montgomery (1996) and Sosis and Bresselar (2003). I want to

further understand how religious belief affects the benefit one receives from religious involvement and how religious involvement can increase religious belief.

3 Methodology

This thesis aims to answer the question “why do we engage in seemingly inefficient actions when it comes to religion?” This thesis also seeks to further understand the involvement religious belief has in the decision-making process. Iannaccone presents a very rational model to explain why people signal and the free-rider problem with a microeconomic utility function. He also models the effect that a person's utility from secular activity can have on their decision making. However, Iannaccone's paper lacks an element of religious belief in the potential entrant/signalers decision making; his model is focused purely on logical benefit and not on the irrational element of belief.

I chose to add belief because I believe that there is an emotional aspect to how people make decisions about religions. In my thesis, I address Iannaccone’s shortfall by modeling Iannaccone’s two main propositions using game theory, and adding the element of belief to both models using bonus from belief and discounted signaling costs. Beliefs have an important role because many people justify paying these inefficient costs through the religious beliefs they have. Religious beliefs can also make it risky for the person to not follow the religions prohibitions or pay their strict costs because they believe they will not reach Heaven if they do not, worse that they will be eternally punished.

To answer my question, I used two game theory models that deal with asymmetric information: moral hazard and signaling/screening. The term “asymmetric information” refers to a difference in information between two parties, specifically when one knows more than the

other. Asymmetric information is central to the interaction studied because the religion does not know for certain if religion will benefit from adding a specific person. Specifically, I model the religion's lack of knowledge about the person's level of commitment and belief. Uncertainty plays a large role in my thesis because the gatekeepers of the religion do not know the potential entrants "type" (committed or not, believing or atheist) or which actions they will take if accepted. This is explored in the signaling and screening model. The moral hazard model also accounts for uncertainty by considering whether or not an entrant's effort within the religion will be met with success or failure.

I used game theory models to develop two propositions from Iannaccone's paper. The first proposition says when there are two groups of people, where one group is more committed than the other, people will separate themselves into religions with similar commitment levels. Iannaccone also says that there will be a signaling equilibrium where committed-types end up in groups that require a sacrifice (or signaling cost) to prove their commitment level. The second proposition argues for a positive correlation between a nonclub commodity and the members utility from the club. This also means there is a negative correlation between one's utility from secular commodities/activities and the likelihood of choosing to put effort into the religion. I develop the propositions using two models: for the proposition that separates society into committed and not committed, I use a signaling and screening model, and for the proposition that deals with utility from secular activity, I used a moral hazard model.

Signaling and screening models are applicable when there are two types of people and there is a way for them to attempt to signal their type. A classic example is the market for lemons, there are cars of good and bad quality but the buyer can't tell, in order for the sellers of good cars to signal their quality they will often offer a warranty. Iannaccone's proposition is

relevant because people who want admission to the religion are either committed or uncommitted and they can signal their commitment to the religion. The model divides people into whether they are committed and uncommitted, and then whether or not each type signals. The church/religion cannot see if an individual is committed, just if they have signaled or not. Based on the knowledge they have available, the church chooses whether to welcome the potential entrant. The model shows the incentives the potential entrant has to signal in different situations. Signals to religions are often the inefficient costs we see people undertaking. People make sacrifices because it is a way to signal their commitment to the church/religion and increase their likelihood of being accepted into the group. By including belief in the model, it introduces the idea that one might believe the cost is not as high, or that signaling provides a "bonus" because you know you are doing what God or your belief system expects of you.

Moral hazard models are applicable when one player has to make a decision about the other, before the other reveals the decision they will make. An example is an employer chooses the wage and bonus for a position, and then chooses whether to accept or reject an applicant before they show whether they will put in high or low effort, and if their effort will be successful or not. Because the first player does not know what will happen there is asymmetric information. This is applicable to Iannaccone's proposition because before a potential entrant shows whether they are committed, the gatekeepers of the religion have to decide whether to accept or reject them. I employ the moral hazard model in an effort to understand the utility from secular activities, as well as the level of participation and "bonus" (the additional utility the potential entrant gets from recognized religious effort) that is optimal. The moral hazard model illustrates the decision the member makes to put effort into the religion as being partially decided by the draw that secular commodities have on the potential entrant. Utility from secular activity is the

potential entrants payoff if rejected, and they also get a discounted amount if they exert low effort. Giving up secular commodities is a signaling cost often utilized by religions, so the more utility an individual gets from secular utility, the less likely they are to join a strict, or sect-like, religion. Secular utility can be many things, such as consumption of alcohol or socializing with people outside of the religion, it is any benefit you can have from engaging in society outside of the religion. Because people can produce different amounts of money within society, more educated and financially successful people are less likely to join a strict, sect-like religion because the cost of giving up their secular utility is higher, similarly people with more established social networks are also less likely to join.

4 Models

My thesis, which is an exploration of the effects of belief on religious participation and signaling, is an extension of Iannaccone's paper. Iannaccone developed the propositions discussed in the previous section to support his argument, and I will develop them further using a different methodology. Where Iannaccone uses microeconomics, specifically utility functions, I will approach the subject from a game theoretical perspective. The novelty of my paper is that I am adding religious belief as a variable to the models on the two propositions. This is done through the addition of a belief bonus, discounting the signaling cost and altering the probability that a potential entrant will make certain choices. The addition of belief is novel because, although previous papers have lightly touched on the idea of religious belief in combination with Iannaccone's paper, game theory models of Iannaccone's two main propositions have not been published. Iannaccone's model does not incorporate that people have religious beliefs that

strongly affect their decision making and their payoff, nor does his paper contemplate how they are formed.

Both models have two players, Player 1, who is a potential entrant of the religion and Player 2, the gatekeepers of the religion. Player 1's motive is to increase their utility, maybe through joining the religion. Player 2's goal is to achieve the greatest possible average input, or religious quality, they can.

Throughout the preceding section, a more in depth description of the math and logic used to solve for the equilibriums, and the conditions they require, can be found in the appendix (section 6).

4.1 Signaling and Screening Model

One of Iannaccone's propositions states that a religion will always have two separate types of people, which are described as Type 1 and Type 2 (no relation to Player 1 and Player 2). Type 2 people always participate more than Type 1 and they value the quality of the group more than Type 1 people do. Thus, the paper argues that if there is a significant enough population of Type 1 people, the equilibrium will be that Type 2 people will be required to make a sacrifice to signal their type in order to join the religion. If Type 1 people end up in a religion it will be one that does not require a sacrifice. In my model, I will refer to Type 1 as "uncommitted" and Type 2 as "committed."

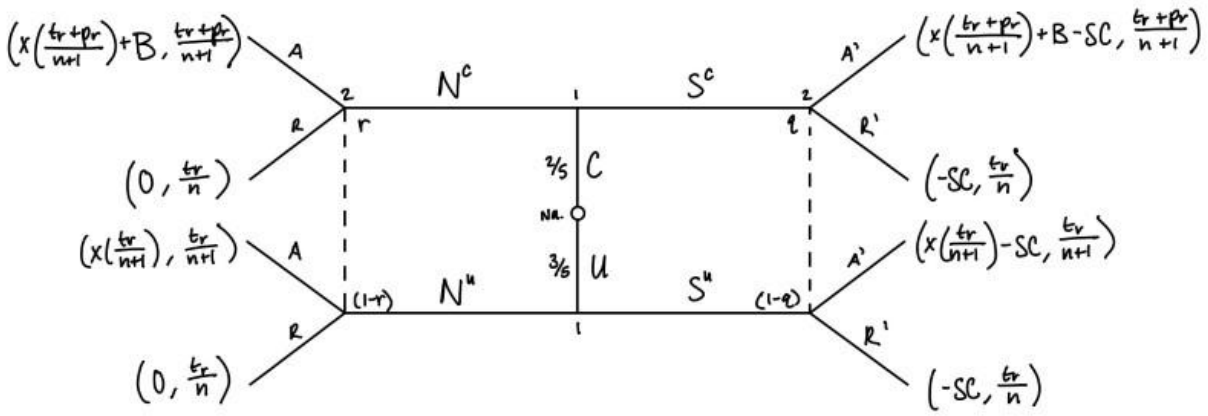

fig. 1

I will use signaling/screening to develop a model to illustrate Iannaccone's point. The model consists of two players and Nature. The first move is made by Nature, who decides if a person is committed (C) or uncommitted (U). Although Player 1 knows their type, they have no control over it. In my model, $\frac{2}{5}$ of the population is committed and $\frac{3}{5}$ are not. This is known by all players, but Player 2 will not know which group Player 1 belongs to. I identified $\frac{2}{5}$ for the percent of the population that is committed from data collected by Pew Research Center. In 2022, only 43% of adults in the United States attended a religious service, in person or online, within the last month (Nortey), with numbers as low as 31% in 2020 and 2021(Smith). Pew Research's National Public Opinion Reference Surveys from 2020 and 2021 show that 4 in 10 Americans consider religion very important in their lives and 45% pray daily. Regular attendance of religious services and regular prayer are both indicative of commitment level because they show continued participation. After Nature moves, Player 1 will either signal or not, with the knowledge of whether they are committed or not. Since they could be at either position in the model, signaling (S^C) and not signaling (N^C) when committed, are different variables than

signaling (S^u) and not signaling (N^u) when uncommitted. Based on the signal, Player 2 will choose whether to accept (A) or reject (R) Player 1, because Player 2 knows if Player 1 has signaled or not, the difference in accept/reject is shown as an apostrophe above accept/reject when the player has signaled. After all of these moves have played out the game is over and the players receive their payoff.

Terms listed below are variables used in payoffs, as well as payoffs:

Terms:

t_r: total member participation, without Player 1

p_r: Player 1's potential participation

r: subscript used to denote a relation to participation

n: number of current members in the religion, without Player 1

SC: signaling cost

B: bonus from commitment

$\frac{t_r}{n}$: average member participation where Player 1 is not a member

$\frac{t_r}{n+1}$: average participation where Player 1 is a member but not participating

$\frac{t_r+p_r}{n+1}$: average participation where Player 1 is a member and participating, their participation level is p_r

$x(\,)$: discount to the average participation where $0 \leq x \leq 1$, Player 1's utility from the average religious participation

$x\left(\frac{t_r+p_r}{n+1}\right) + B$: If Player 1 is committed and does not signal, then is accepted, their payoff will consist of their utility from the quality of the religion (see above definitions for $\left[\frac{t_r+p_r}{n+1}\right]$ and $[x(\,)]$) and a bonus, $[B]$, because their commitment paid off

$x\left(\frac{t_r}{n+1}\right)$: If Player 1 is uncommitted and does not signal, then is accepted, their payoff will consist of their utility from the quality of the religion (see above definitions for $\left[\frac{t_r}{n+1}\right]$ and $[x(\,)]$)

$x\left(\frac{t_r+p_r}{n+1}\right) + B - SC$: If Player 1 is committed and signals, then is accepted, their payoff will consist of their utility from the quality of the religion (see above definitions for $\left[\frac{t_r+p_r}{n+1}\right]$ and $[x(\,)]$), a bonus, $[B]$, because their commitment paid off and the negative signaling cost, $[-SC]$, because they signaled

$x\left(\frac{t_r}{n+1}\right) - SC$: If Player 1 is uncommitted and signals, then is accepted, their payoff will consist of their utility from the quality of the religion (see above definitions for $\left[\frac{t_r}{n+1}\right]$ and $[x(\,)]$) and the negative signaling cost, $[-SC]$, because they signaled

Player 1's payoff is much more variable than Player 2's because for the gatekeepers of the religion (Player 2), it is just a decision of whether or not to add one person. For the potential entrant (Player 1) it is their entire relationship with the religion. If rejected, Player 1 will either receive a payoff of zero if they didn't signal, or they will have to pay the signaling cost, a payoff

of $[-\ SC]$, if they did signal. This is because they still paid the cost required to signal even though they were rejected. If accepted, Player 1 will receive a discount of average religious participation in the group, which represents the utility they get from the quality of their religion. The average participation is the total participation including Player 1's divided by the amount of adherents to the religion. If the person is committed (therefore participating) they will have added to that average, so that their utility is $\left[x\left(\frac{t_r+p_r}{n+1}\right)\right]$. However, if they are not committed (therefore not participating) they will still receive utility from the average participation, but the average will be less since they are not participating, so they receive $\left[x\left(\frac{t_r}{n+1}\right)\right]$. If accepted and they signaled, Player 1 will still have to pay the signaling cost and if they are accepted and committed they will receive a bonus, since Iannaccone describes the committed type as valuing group quality more, they get the bonus from adding to the group "value" by adding to the average participation and therefore quality. Player 2's payoffs are relatively simple. I have chosen to assume that the religion's gatekeepers benefit from the quality/participation of their religion so their payoff is the average input. If they reject Player 1, then it is the average without Player 1, $\left[\frac{t_r}{n}\right]$, if they accept it will be either $\left[\frac{t_r+p_r}{n+1}\right]$ if they are committed and participating or $\left[\frac{t_r}{n+1}\right]$ if they are not committed and therefore not participating.

For this model there are four different strategies that Player 1 can play: S^cS^u, where no matter their commitment they will signal; N^cN^u, where they will not signal; N^cS^u, if they are committed, they will not signal, but they will if there are not committed; and S^cN^u, they will only signal if they are committed. These are organized into pooling and separating, with pooling being

when player one chooses one action no matter type, and separating is when they choose a mixed strategy.

In sequential move games with incomplete information, like the signaling and screening game, the Nash Equilibrium solution to the game is called a Perfect Bayesian Equilibrium. A Perfect Bayesian Nash Equilibrium is a Perfect Bayesian Equilibrium where there is no move any player can make where they are better off. There are two potential Perfect Bayesian Nash Equilibrium (PBNE) strategies in this model. The first is a pooling strategy, if Player 1 plays $N^c N^u$, then based on their knowledge of the commitment of the population the religion will accept if they predict Player 1's potential participation to be greater than $\left[\frac{5t_r}{2n}\right]$. This means that Player 2 has to believe that Player 1's participation level is 2.5 times greater than the average participation they currently have, p_r must be so much higher to offset the probability that Player 1 is not committed. If they predict $\left[p_r < \frac{5t_r}{2n}\right]$, then they will reject Player 1. In both of these cases, there is no incentive for Player 1 to defect because if they chose to defect it would be the same payoff but with a signaling cost, so $N^c N^u$ is a Perfect Bayesian Nash Equilibrium. The second PBNE is when Player 1 plays $S^c N^u$. In response to this strategy the religion will play RA'(if they predict Player 1's potential participation to be larger than the average participation in their group without Player 1). If they do not think that Player 1's participation is greater than average, they will reject them and Player 1 will be incentivized to defect from S^c to N^c so that they do not have to pay the signaling cost. However, if Player 2 plays RA' (because they see Player 1's participation to be greater than average) then it will be a PBNE on two conditions.

Firstly, if the signaling cost is not less than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B\right]$, because then Player 1 would have a higher payoff if they defected from S^c to N^c. Also, if the signaling cost is not less than $\left[x\left(\frac{t_r}{n+1}\right)\right]$ because then if uncommitted, Player 1 will get a higher payoff if they are signaling so they will defect from N^u to S^u. The only variable that determines this is the signaling cost because there is no way that $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B\right]$ is less than $\left[x\left(\frac{t_r}{n+1}\right)\right]$ since none of the variables are negative.

4.2 Moral Hazard Model

A second proposition argues that the price of non-club goods, or the utility a potential entrant gets from secular life, affects the payoff they get from being in a club/religion. The proposition argues that clubs/religions will likely prohibit secular commodities, since they are often close substitutes to club/religion participation. I applied this proposition to a moral hazard model to measure the involvement utility from secular activities has on religious effort and participation. In an effort to keep consistent throughout my models, Player 1 is the potential entrant to the religion and Player 2 is the gatekeepers of the religion. This model, however, focuses largely on after Player 1 is accepted or rejected. It also differs because Player 2 decides the participation from Player 1 and the bonus they get from successfully putting in effort. Participation, or p_r, is decided by the gatekeepers of the religion because they choose the demographic they are targeting. Iannaccone and Aimone, Jason A et al. have proven that people end up in religions with others of their same commitment level. Therefore, based on who is already in the religion, the gatekeepers of the religion have decided the participation level required. They can affect these variables because in this model they are all relative costs.

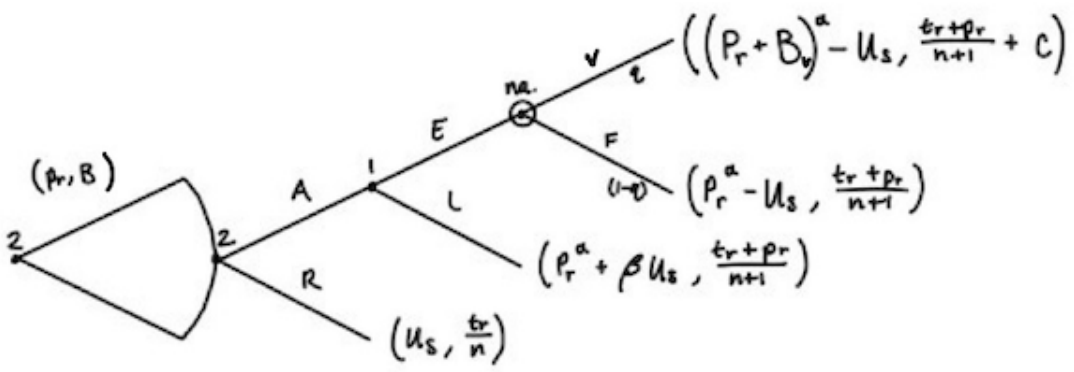

fig. 2

The variables are mostly the same as the previous model with a few additions and changes. Relevant variables and payoffs are described below:

Terms:

t_r: total member participation, without Player 1

p_r: Player 1's potential participation

r: subscript used to denote a relation to participation

n: number of current members in the religion, without Player 1

c: constant gain Player 2 gets from Player 1's successful effort

B_v: bonus from victory, the utility Player 1 gets from exerting effort and being met with victory as a result

$(\ )^{\alpha}$: utility function applied to positive outcomes of being a part of the religion

U_s: utility from secular activity

$\beta(\ )$: discount to utility from secular activity where, $0 \leq \beta \leq 1$, applied when Player 1 exerts low effort

$\frac{t_r}{n}$: average member participation where Player 1 is not a member

$\frac{t_r}{n+1}$: average participation where Player 1 is a member but not participating

$\frac{t_r+p_r}{n+1}$: average participation where Player 1 is a member and participating, their participation level is p_r

$\frac{t_r+p_r}{n+1} + c$: If Player 1 is accepted and both exerts effort and is victorious, Player 2's payoff will include the average participation and a constant (see above definitions for $\left[\frac{t_r+p_r}{n+1}\right]$ and c)

$\left(p_r + B_v\right)^{\alpha} - U_s$: Player 2's payoff if they are accepted, exert effort and are victorious, their payoff will consist of the utility they get from their participation and the bonus, minus the utility they would get from secular activities because they are giving it up to be a part of the religion

$\left(p_r\right)^{\alpha} - U_s$: Player 2's payoff if they are accepted and exert effort but fail, they will get utility from their participation but they will have to pay the opportunity cost for their lost utility from not engaging in secular activity

$\left(p_r\right)^{\alpha} + \beta U_s$: Player 2's payoff if they are accepted but exert low effort, they will still receive their utility from participation and they will get a discounted utility from secular activity because their low effort means they are not fully abandoning secular life.

The first move made in the model is Player 2 deciding the three values for Player 1's participation and bonus, then Player 2 also decides to accept or reject Player 1. If rejected, Player 1 gets a payoff of the utility they would get from secular activities because they will not have any prohibitions imposed on them by a religion. If they are accepted, they will choose between putting high (E) or low (L) effort into the religion. This could be many things but two simple examples are converting people or raising money. Many religions ask that members attempt to convert others or raise money for the religion to operate or for a religious charity, it is a part of some groups religious participation. Exerting low effort could mean just raising kids in the religion or maybe only trying to convert people you know, it could also mean just asking people you know for donations or donating a small amount of money yourself. High effort can then be met with victory (V) or failure (F), which is decided by nature. Sometimes people don't end up converting or giving money even if you reach out to them and put in a lot of effort. The probability of success is denoted by the variable q, and the probability of failure is $(1 - q)$.

If Player 1 is accepted, they choose between exerting effort or not. If they exert low effort, their payoff is $\left[\left(p_r\right)^{\alpha} + \beta U_s\right]$, where the first half is their utility from participation and the second is a portion of utility from secular activities since they are not exerting effort into the religion, including the religions rules and prohibitions. If Player 1 chooses to exert high effort, their payoff will include $\left[- U_s\right]$ since they have to pay the opportunity cost of not being involved in said secular activities, put another way, the utility they would get from involvement in secular society is the cost of exerting effort. If they are unsuccessful, they will still get their utility from participation $\left[\left(p_r\right)^{\alpha}\right]$. But if they are successful, their payoff will include their utility from both

their participation and the bonus of being successful within their religion $\left[\left(p_r + B_v\right)^{\alpha}\right]$. Player 2's overall payoffs will be similar to the previous model because it is based on the average participation within the religion. The only difference is constant, c, if Player 1's effort is successful, because they get to benefit from that success (for example they get more converts or money). Otherwise, it is the average participation including Player 1's participation for all payoffs where they were accepted and if they were not then it is the average without their inclusion.

In order to solve for an equilibrium, I utilize the participation constraint and the incentive compatibility constraint. The former ensures that the potential entrant would rather be a part of the religion than not (their payoff is lower if they are rejected). The incentive compatibility constraint ensures that the entrant is motivated to act in the interests of the religion, meaning motivated to exert effort. I first set Player 1's payoffs for getting rejected from the religion equal to their payoff from getting accepted but exerting low effort. These should be equal to each other because the incentive compatibility constraint says that the expected payoff from high effort should be equal to that of low effort, because otherwise Player 1 would never exert effort or Player 2 is setting their values too high. The participation constraint says that the expected payoff from high effort is equal to Player 1's payoff if they are rejected because otherwise they would not be interested in joining or Player 2 is again setting their values too high. Since both are equal to the expected payoff from high effort, they are also equal to each other. Through this you can calculate that the optimal participation amount to be $\left[p_r = \sqrt[\alpha]{(1 - \beta)U_s}\right]$, and then we can solve for the optimal bonus amount which is $\left[B_v = \sqrt[\alpha]{\frac{(3-\beta)U_s}{q} - 2U_s}\right]$. For both the bonus and the

participation amount, with the constraints on the variables, they increase as utility from secular activity increases. These amounts were calculated and set by Player 2 so that Player 1 would want to exert high effort but this is a Perfect Bayesian Nash Equilibrium because when calculated, player two also prefers their payoff if Player 1 exerts high effort.

4.3 Addition of Belief to Both Models

Many of the critiques about Iannaccone's influential paper revolve around his exclusion of religious belief in his models. Many people make seemingly inefficient choices for religious belief which is why I have added religious belief to both of my models.

For the signaling and screening model, I added another move for Nature who decides whether or not someone is a believer or atheist before deciding if someone is committed or not. This is because someone's commitment can depend on their level of belief.

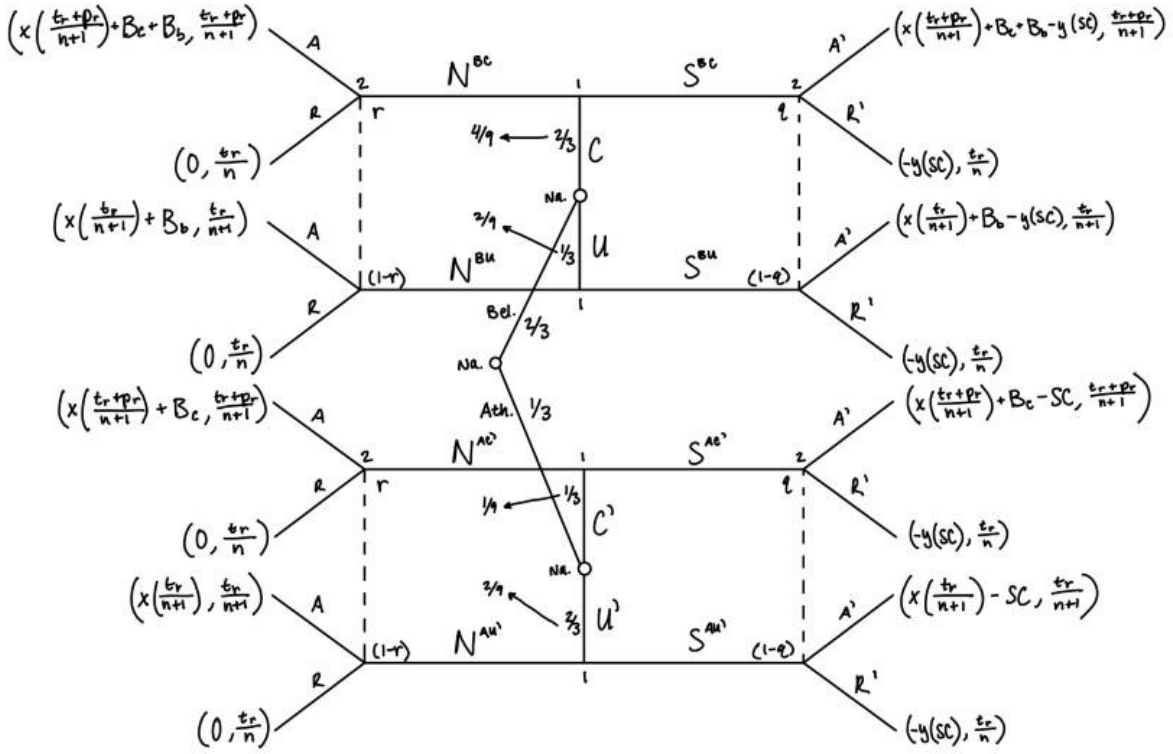

fig. 3

Based on data from Pew Research's article "About Three-in-Ten U.S. Adults Are Now Religiously Unaffiliated" (Smith), I determined $\frac{1}{3}$ of people were atheist and the remaining $\frac{2}{3}$ were believers. This is a necessary simplification that erases the existence of agnosticism. For atheists, I said that $\frac{1}{3}$ were committed to religion and the other $\frac{2}{3}$ were not. For believers, I said $\frac{2}{3}$ were committed and $\frac{1}{3}$ were not. The payoffs were also slightly tweaked, the signaling cost discounted by y if Player 1 is a believer since they will benefit from paying the cost since they see it as doing their religious duty; the variable, y, is less than 1 and greater than 0. For the belief model the bonuses are also split up into a bonus from commitment, B_c, for everyone who is committed and accepted, and a bonus from belief, B_b, for everyone who believes and is accepted. Listed below are relevant variables and payoffs that are not present in the terms for the Signaling and Screening model without belief.

Terms:

B_b: bonus from belief, for Player 1 if they believe and are accepted into the religion

$y(\ )$: discount to signaling cost, where $0 \leq y \leq 1$, applied when Player 1 believes and signals

$y(SC)$: a believer only pays a discounted signaling cost because they believe they are following the religious doctrine of their group when they pay it

$x\left(\frac{t_r+p_r}{n+1}\right) + B_c + B_b - y(SC)$: If Player 1 believes and is committed, then signals, their payoff will include their utility from the average participation in their

religion (which they contribute to), a bonus from commitment, a bonus from belief, and a discounted signaling cost

$x\left(\frac{t_r+p_r}{n+1}\right) + B_c + B_b$: If Player 1 believes and is committed, but does not signal, their payoff will include their utility from the average participation in their religion (which they contribute to), a bonus from commitment, and a bonus from belief$x\left(\frac{t_r}{n+1}\right) + B_b - y(SC)$: If Player 1 believes but is uncommitted, then signals, their payoff will include their utility from the average participation in their religion (which they do not contribute to), a bonus from belief, and a discounted signaling cost

$x\left(\frac{t_r}{n+1}\right) + B_b$: If Player 1 believes but is uncommitted, but does not signal, their payoff will include their utility from the average participation in their religion (which they do not contribute to) and a bonus from belief

As a result of the extra step the strategies are more complicated, including four different positions choosing to signal or not. Therefore, there are more perfect Baysian Nash equilibriums. The only pooling equilibrium is pretty similar to the model without belief it is $N^{BC}N^{BU}N^{AC'}N^{AU'}$ .Whether or not Player 2 accepts, there is no incentive for player one to defect because of the signaling cost. There are four separating equilibriums where there could be a potential PBNE: $S^{BC}N^{BU}N^{AC'}N^{AU'}$, $S^{BC}S^{BU}N^{AC'}N^{AU'}$, $S^{BC}N^{BU}S^{AC'}N^{AU'}$, and $S^{BC}S^{BU}S^{AC'}N^{AU'}$. All cases require that Player 1's participation is greater than the average participation in the religion, otherwise the religion will reject everyone. For $S^{BC}N^{BU}N^{AC'}N^{AU'}$ to be a PBNE, $y(SC)$ needs to be less than

$\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c+B_b\right]$ but greater than $\left[x\left(\frac{t_r}{n+1}\right)+B_b\right]$ and SC needs to be greater than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c\right]$. In this case, the main effect is from the combination of the two bonuses, because that is the only time you would choose to signal. For $S^{BC}S^{BU}N^{AC'}N^{AU'}$ to be a PBNE, $y(SC)$ needs to be less than $\left[x\left(\frac{t_r}{n+1}\right)+B_b\right]$ but SC needs to be greater than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c\right]$. Since the the signaling cost (as opposed to the discounted signaling cost) has to be greater than the larger average, there is not as strict contingencies on the bonuses in order for it to be a PBNE if the discount on the signaling cost is significant enough, if it isn't, the bonus from belief should be larger than the bonus from commitment. For $S^{BC}N^{BU}S^{AC'}N^{AU'}$ to be a PBNE, $y(SC)$ needs to be less than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c+B_b\right]$ but greater than $\left[x\left(\frac{t_r}{n+1}\right)+B_b\right]$ and SC needs to be less than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c\right]$ but greater than $\left[x\left(\frac{t_r}{n+1}\right)\right]$. For this equilibrium the change in average is influential but mainly the effect of the bonus from commitment is creating a difference between the upper and lower bounds for the signaling cost. For $S^{BC}S^{BU}S^{AC'}N^{AU'}$ to be a PBNE, $y(SC)$ needs to be less than $\left[x\left(\frac{t_r}{n+1}\right)+B_b\right]$ and SC needs to be less than $\left[x\left(\frac{t_r+p_r}{n+1}\right)+B_c\right]$ but greater than $\left[x\left(\frac{t_r}{n+1}\right)\right]$. Overall, these PBNEs all make logical sense, so I think the model is sound.

In regard to the moral hazard model, I added a belief bonus for whenever Player 1 exerts effort, because they will benefit from knowing they have done what is asked of them by their beliefs, regardless of if it is successful.

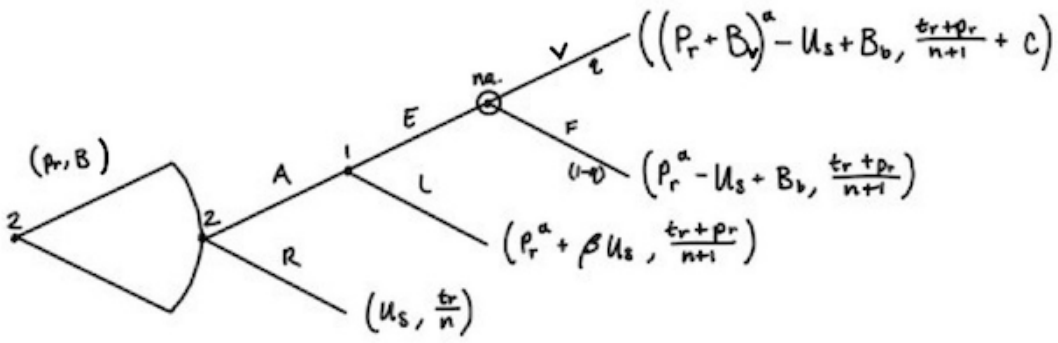

fig. 4

Listed below are relevant variables and payoffs that are not present in the terms for the Moral Hazard model without belief.

Terms:

B_b: bonus from belief

$\left(p_r + B_v\right)^{\alpha} - U_s + B_b$: Player 2's payoff if they are accepted, exert effort and are victorious, their payoff will consist of the utility they get from their participation and the bonus, minus the utility they would get from secular activities because they are giving it up to be a part of the religion. As a result of exerting effort they get a bonus from belief, B_b, because they believe they did the right thing according to their religious faith

$\left(p_r\right)^{\alpha} - U_s + B_b$: Player 2's payoff if they are accepted and exert effort but fail, they will get utility from their participation but they will have to pay the opportunity cost for their lost utility from not engaging in secular activity. As a result of exerting effort they get a bonus from belief, B_b, because they believe they did the right thing according to their religious faith

There were then two bonuses, a bonus from victory, B_v, whose role in the model is not changed with the addition of belief, and the bonus from belief, B_b, which is new. The recalculated participation amount was exactly the same, $\left[\sqrt[\alpha]{(1-\beta)U_s}\right]$, but the bonus from victory was different. The recalculated bonus was $\left[B_v = \sqrt[\alpha]{\frac{2U_s-(1-q)(1-\beta)U_s}{q} - B_b} - \sqrt[\alpha]{(1-\beta)U_s}\right]$. Player 2's payoffs are unchanged so they still prefer that Player 1 play high effort, therefore it is still a Perfect Bayesian Nash Equilibrium.

5 Conclusion

In this thesis, I explored existing literature on the subject of religious signaling and, based on Iannaccone's influential model, approached the topic using an economic perspective and game theory. I used two propositions from Iannaccone's model to create two sequential-move models that address asymmetric information. Specifically, a signaling and screening model which explores the effect of signaling commitment to a religion, and a moral hazard model which shows how the religion chooses to accept people based despite their lack of knowledge on their type. The moral hazard model also models the member;s interest in exerting effort, after being accepted into the religion. As a result of my research, I decided to incorporate belief into my models despite Iannaccone's exclusion of the aspect in his. I added a bonus from belief. I also discounted signaling costs to represent a person's altered perceptions of costs as a result of religious belief. Although belief did not have a drastic effect on the equilibriums calculated, it explained why an uncommitted person would be interested in signaling (instead of free-riding) and why a person would exert effort after being accepted into a religion. Throughout my

research, I was most surprised by how interdisciplinary research on religious signaling was. Although I primarily focused on Iannaccone's economics paper, the literature I consulted exceeded more than a handful of disciplines.

The results of my models were largely what I expected. I had expected the level of participation a religion requires and the bonus the entrant gets from success within the group to be reliant on the utility an entrant would get from secular activity. This confirms Iannaccone's proposition.. In mixed strategy equilibria, the PBNE will be committed types signaling and uncommitted types not. This confirmed another proposition from Iannaccone's model. With the addition of belief I was also not surprised that mixed strategy equilibria where those who were more committed or believing were the only ones who signaled were PBNEs. I was not expecting belief levels to have no effect on religious participation in the Moral hazard model, though they did affect the bonus from victory. This could be because participation reflects commitment level, whereas the bonus is an amount that is responsive to one's victories for the religion, which could be more easily tied to belief. I was also surprised by how high the signaling cost was related to the bonuses and utility from the quality of the religion. The price makes it a serious undertaking to signal commitment, especially with the risk of being rejected.

Since I did not rely on data for my thesis there were fewer limitations. However, limited research made it difficult to explore the literature on the subject. Many of the models in the available literature also used advanced methods to solve for an equilibrium that I could not apply in this research.

These results have important implications on religious behavior and participation. The signaling and screening model can help us understand the evolutionary reasoning behind high entry costs and extreme prohibitions in stricter religions. Specifically, it adds to our

understanding about the formation of cults and the dangers they pose. The moral hazard model contributes to our understanding of how religion motivates extreme actions that many people take.

For future research, it would be interesting to attempt to measure levels of belief. Belief is not an empirical factor, and the inclusion of a measurement of belief and applying it to religion would be an advancement in the field.

6 Appendix

6.1 Signaling Model

Pooling equilibria:

If Player 1 plays S^cS^u, and if they are accepted by Player 2, Player 2's payoff will be:

$$q\left(\frac{t_r+p_r}{n+1}\right)+(1-q)\left(\frac{t_r}{n+1}\right)$$

$$\frac{t_r}{n+1}+q\left(\frac{p_r}{n+1}\right)$$

If Player 1 is rejected, the payoff for Player 2 will be:

$$q\left(\frac{t_r}{n}\right)+(1-q)\left(\frac{t_r}{n}\right)=\frac{t_r}{n}$$

$q=\frac{2}{5}$, assuming $\frac{2}{5}$ of the population is at that position of the model since $\frac{2}{5}$ of the population is committed. To determine when accepting or rejecting has a higher payoff, set Player 2's payoff from accepting equal to their payoff from rejecting to solve for $\left[p_r\right]$, which varies.

$$\frac{t_r}{n+1}+\frac{2}{5}\left(\frac{p_r}{n+1}\right)=\frac{t_r}{n}$$

$$t_r+\frac{2p_r}{5}=t_r+\frac{t_r}{n}$$

$$\frac{2p_r}{5} = \frac{t_r}{n}$$

$$p_r = \frac{5t_r}{2n}$$

Based on this math, if $p_r \geq \frac{5t_r}{2n}$ Player 2 will Accept and if $p_r < \frac{5t_r}{2n}$ then Player 2 will Reject. However, in both situations there is an incentive for Player 1 to defect so they do not have to pay the signaling cost. Therefore, $\left(S^c S^u,\ A'\right)$ and $\left(S^c S^u,\ R'\right)$ are not Perfect Bayesian Nash Equilibriums (PBNEs). Since Player 2's payoffs are the same whether Player 1 signals or not we know that Player 2's preferences hold if Player 1 plays $N^c N^u$. When there is no signaling, there is no incentive for Player 1 to defect, regardless of Player 2's move, because of the signaling cost if they signal. Therefore, no matter Player 2's move, both $\left(N^c N^u,\ A\right)$ and $\left(N^c N^u,\ R\right)$ are PBNEs.

Separating Equilibria:

If Player 1 chooses to employ a mixed strategy they have two options, if they play $N^c S^u$ then Player 2's move depends on their perception of Player 1's participation. If $p_r \geq \frac{t_r}{n}$, then Player 2 will want to accept should Player 1 not signal $\left(\frac{t_r + p_r}{n+1} > \frac{t_r}{n}\right)$(because Player 2 knows which strategy Player 1 is using they will know that if they do not signal they are committed). No matter the value of p_r, it will be preferable for Player 2 to reject if they do signal $\left(\frac{t_r}{n} > \frac{t_r}{n+1}\right)$. Player 2 will respond by playing AR'. If $p_r < \frac{t_r}{n}$ then Player 2 will instead play RR' since $\left(\frac{t_r + p_r}{n+1} < \frac{t_r}{n}\right)$. In both cases there is an incentive for Player 1 to defect, if Player 2 is playing AR',

it is because $\left(x\left(\frac{t_r}{n+1}\right) >- SC\right)$, and if Player 2 is playing RR' it is because $(0 >- SC)$.

Therefore, neither outcome is a PBNE.

If Player 1 plays S^cN^u then Player 2's move will also depend on the value of p_r. If $p_r \geq \frac{t_r}{n}$, then Player 2 will want to accept should Player 1 signal $\left(\frac{t_r+p_r}{n+1} > \frac{t_r}{n}\right)$, and if $p_r < \frac{t_r}{n}$ they will want to reject as that changes the inequality $\left(\frac{t_r+p_r}{n+1} < \frac{t_r}{n}\right)$. If Player 1 does not signal Player 2 will reject because they know that based off of the strategy Player 1 is employing that means Player 1 is uncommitted. If Player 2 accepts the signaler they are playing RA', and if not they are playing RR'. Should Player 2 play RR', there is an incentive for Player 1 to defect if they signaled so that they do not have to pay the signaling cost. If Player 2 plays RA' then there is only an incentive for Player 1 to defect if $x\left(\frac{t_r+p_r}{n+1}\right) + B < SC$ for the signaler/committed player and $x\left(\frac{t_r}{n+1}\right) < SC$ for the non-signaler/uncommitted player. If neither of the two previously mentioned inequalities prove true then $\left(S^cN^u, RA'\right)$ is a PBNE.

6.2 Moral Hazard Model

Participation constraint:

$$q\left(p_r + B_v\right)^{\alpha} + (1 - q){p_r}^{\alpha} - U_s = U_s$$

Incentive compatibility constraint:

$$q\left(p_r + B_v\right)^{\alpha} + (1 - q){p_r}^{\alpha} - U_s = {p_r}^{\alpha} + \beta U_s$$

In order to solve for Player 2's ideal entrant participation value, or p_r, set the participation constraint and the compatibility constraint equal to each other and isolate p_r:

$$U_s = {p_r}^{\alpha} + \beta U_s$$

$${p_r}^{\alpha} = (1 - \beta)U_s$$

$$p_r = \sqrt[\alpha]{(1 - \beta)U_s}$$

Using this value for p_r and the participation constraint, solve for B:

$$q\left(\sqrt[\alpha]{(1 - \beta)U_s} + B_v\right)^{\alpha} + (1 - q)\left(\sqrt[\alpha]{(1 - \beta)U_s}\right)^{\alpha} - U_s = U_s$$

$$q\left(\sqrt[\alpha]{(1 - \beta)U_s} + B_v\right)^{\alpha} + (1 - q)(1 - \beta)U_s = 2U_s$$

$$q\left(\sqrt[\alpha]{(1 - \beta)U_s} + B_v\right)^{\alpha} = 2U_s - (1 - q)(1 - \beta)U_s$$

$$\left(\sqrt[\alpha]{(1 - \beta)U_s} + B_v\right)^{\alpha} = \frac{2U_s - (1-q)(1-\beta)U_s}{q}$$

$$\sqrt[\alpha]{(1 - \beta)U_s} + B_v = \sqrt[\alpha]{\frac{2U_s - (1-q)(1-\beta)U_s}{q}}$$

$$B_v = \sqrt[\alpha]{\frac{2U_s - (1-q)(1-\beta)U_s}{q}} - \sqrt[\alpha]{(1 - \beta)U_s}$$

Since Player 2 set these values so that Player 1 is agnostic between being rejected, exhibiting high effort and exhibiting low effort; we know there is no better option for Player 1. However, to ensure that these values are a Nash equilibrium we have to check that it is preferable for Player 2 to accept Player 1, and that it is preferable to Player 2 that Player 1 exhibit high effort.

$$\pi_{high\ effort} = q\left(\frac{t_r + p_r}{n+1} + c\right) + (1 - q)\left(\frac{t_r + p_r}{n+1}\right) = \frac{t_r + p_r}{n+1} + q(c)$$

$$\pi_{low\ effort} = \frac{t_r + p_r}{n+1}$$

$$\pi_{reject} = \frac{t_r}{n}$$

Since $q(c)$ is a nonzero value, Player 2 would prefer that Player 1 choose to input high effort. If $p_r \geq \frac{t_r}{n}$, then even if Player 1 exerts low effort, Player 2 will still prefer to accept them. Because we know that both players do not have an incentive to not accept or exert high effort, this is a Nash equilibrium.

6.3 Addition of Belief (Signaling and Screening Model)

Since the potential endpoints have doubled in the signaling and screening model with belief, the number of potential outcomes has hugely increased. Player 1 is now able to choose from 16 possible strategies, where they can be in four different positions instead of two.

Pooling equilibria:

If Player 1 plays $S^{BC}S^{BU}S^{AC'}S^{AU'}$, and they are accepted by Player 2, their payoff will be:

$$\frac{4}{9}\left(\frac{t_r+p_r}{n+1}\right)+\frac{2}{9}\left(\frac{t_r}{n+1}\right)+\frac{1}{9}\left(\frac{t_r+p_r}{n+1}\right)+\frac{2}{9}\left(\frac{t_r}{n+1}\right)$$

$$\frac{5}{9}\left(\frac{t_r+p_r}{n+1}\right)+\frac{4}{9}\left(\frac{t_r}{n+1}\right)$$

$$\frac{t_r}{n+1}+\frac{5}{9}\left(\frac{p_r}{n+1}\right)$$

If Player 1 is rejected their payoff will be:

$$\frac{4}{9}\left(\frac{t_r}{n}\right)+\frac{2}{9}\left(\frac{t_r}{n}\right)+\frac{1}{9}\left(\frac{t_r}{n}\right)+\frac{2}{9}\left(\frac{t_r}{n}\right)$$

$$\frac{t_r}{n}$$

To know when Player 2 will accept and when they will reject we set both payoffs equal to each other:

$$\frac{t_r}{n+1}+\frac{5}{9}\left(\frac{p_r}{n+1}\right)=\frac{t_r}{n}$$

$$t_r + \frac{5}{9} p_r = t_r + \frac{t_r}{n}$$

$$\frac{5}{9} p_r = \frac{t_r}{n}$$

$$p_r = \frac{9t_r}{5n}$$

As a result, if $p_r \geq \frac{9t_r}{5n}$ then Player 2 will accept, if $p_r < \frac{9t_r}{5n}$ then Player 2 will reject. Similarly to the Signaling and Screening model without belief added, in either case there is an incentive for Player 1 to deviate because of the signaling cost, therefore $\left(S^{BC}S^{BU}S^{AC'}S^{AU'},\ A'\right)$ and $\left(S^{BC}S^{BU}S^{AC'}S^{AU'},\ R'\right)$ are not PBNE. Since Player 2's payoffs are the same whether Player 1 signals or not we know that Player 2's preferences hold if Player 1 plays $N^{BC}N^{BU}N^{AC'}N^{AU'}$. When there is no signaling, there is no incentive for Player 1 to defect, regardless of Player 2's move, because of the signaling cost if they were to signal. Therefore, no matter Player 2's move, both $\left(N^{BC}N^{BU}N^{AC'}N^{AU'},\ A\right)$ and $\left(N^{BC}N^{BU}N^{AC'}N^{AU'},\ R\right)$ are PBNEs.

Separating equilibriums:

As a result of the increased amount of equilibriums in the belief model, there are noticeable patterns in the separating equilibriums. Equilibriums can be separated into two categories, either the ratio of p_r to $\frac{t_r}{n}$ affects Player 2's move if Player 1 signals and Player 2 always rejects if they do not, or the ratio affects Player 2's move if Player 1 does not signal and Player 2 always rejects if Player 1 does. The difference is decided by the percent of the population Player 2 perceives to be at each of the four places decided by nature. If $p_r < \frac{t_r}{n}$, then Player 2 will always reject (play RR') no matter what. In that case it can not be a PBNE (unless Player 1 plays $N^{BC}N^{BU}N^{AC'}N^{AU'}$)

since there will be an incentive to defect to not signaling because of the cost. Strategies for Player 1 where the ratio affects those who do not signal are: $N^{BC}S^{BU}N^{AC'}N^{AU'}$, $N^{BC}N^{BU}N^{AC'}S^{AU'}$, $N^{BC}S^{BU}S^{AC'}N^{AU'}$, $N^{BC}N^{BU}S^{AC'}S^{AU'}$, $N^{BC}S^{BU}N^{AC'}S^{AU'}$, $N^{BC}S^{BU}S^{AC'}S^{AU'}$, and $S^{BC}S^{BU}N^{AC'}S^{AU'}$. In the case of these strategies, Player 2 will play AR' if $p_r \geq \frac{t_r}{n}$ and if not they will play RR'. Since the payoff of being accepted without signaling is greater than being rejected and having to pay the signaling cost (or discounted signaling cost if they are believing), there is an incentive in all to defect to not signaling. Therefore, none of these equilibriums are PBNEs. The strategies for Player 1 where the ratio affects those who do not signal are: $S^{BC}N^{BU}N^{AC'}N^{AU'}$, $N^{BC}N^{BU}S^{AC'}N^{AU'}$, $S^{BC}S^{BU}N^{AC'}N^{AU'}$, $S^{BC}N^{BU}N^{AC'}S^{AU'}$, $S^{BC}N^{BU}S^{AC'}N^{AU'}$, $S^{BC}N^{BU}S^{AC'}S^{AU'}$, and $S^{BC}S^{BU}S^{AC'}N^{AU'}$. In these cases, if $p_r < \frac{t_r}{n}$, Player 2 will be incentivized to reject no matter what (play RR'), and Player 1 will be incentivized to defect to not signal. However if $p_r \geq \frac{t_r}{n}$, Player 2 will play RA'. In this case, when signaling Player 1 will not have incentive to defect if the signaling cost (or discounted signaling cost if they are believing) is less than the other aspects of their payoff, because their payoff must be positive to be preferable to receiving a payoff of zero (when rejected and not signaling). Vice versa, if Player 1 is not signaling, they will not defect if the signaling cost (or discounted signaling cost if they are believing) is greater than the other aspects of the payoff for the signaling alternative. For three of these mixed strategies, they are not able to be PBNE's because there is no way the value of the signaling cost will not cause Player 1 to defect, two conditions are incompatible. These three are: $N^{BC}N^{BU}S^{AC'}N^{AU'}$, $S^{BC}N^{BU}N^{AC'}S^{AU'}$, and $S^{BC}N^{BU}S^{AC'}S^{AU'}$ (looking at the mixed strategies it seems logical, why would someone with less

bonuses signal when the other does not). Therefore there are four potential separating PBNEs: $\left(S^{BC}N^{BU}N^{AC'}N^{AU'},\ RA'\right)$, $\left(S^{BC}S^{BU}N^{AC'}N^{AU'},\ RA'\right)$, $\left(S^{BC}N^{BU}S^{AC'}N^{AU'},\ RA'\right)$, and $\left(S^{BC}S^{BU}S^{AC'}N^{AU'},\ RA'\right)$. For $\left(S^{BC}N^{BU}N^{AC'}N^{AU'},\ RA'\right)$ to be a PBNE the following conditions apply, $x\left(\frac{t_r}{n+1}\right)+B_b \le y(SC) \le x\left(\frac{t_r+p_r}{n+1}\right)+B_c+B_b$ and $SC \ge x\left(\frac{t_r+p_r}{n+1}\right)+B_c$. For $\left(S^{BC}S^{BU}N^{AC'}N^{AU'},\ RA'\right)$ to be a PBNE the following conditions apply, $y(SC) \le x\left(\frac{t_r}{n+1}\right)+B_b$ and $SC \ge x\left(\frac{t_r+p_r}{n+1}\right)+B_c$. For $\left(S^{BC}N^{BU}S^{AC'}N^{AU'},\ RA'\right)$ to be a PBNE the following conditions apply, $x\left(\frac{t_r}{n+1}\right)+B_b \le y(SC) \le x\left(\frac{t_r+p_r}{n+1}\right)+B_c+B_b$ and $x\left(\frac{t_r}{n+1}\right) \le SC \le x\left(\frac{t_r+p_r}{n+1}\right)+B_c$. Lastly, for $\left(S^{BC}S^{BU}S^{AC'}N^{AU'},\ RA'\right)$ to be a PBNE the following conditions apply, $y(SC) \le x\left(\frac{t_r}{n+1}\right)+B_b$ and $x\left(\frac{t_r}{n+1}\right) \le SC \le x\left(\frac{t_r+p_r}{n+1}\right)+B_c$. The reasoning behind the inequalities is more thoroughly explained in the models section (4.3).

6.4 Addition of Belief (Moral Hazard Model)

For the Moral Hazard model with belief, the addition is a bonus from belief, B_b, whenever Player 1 exerts effort. This does not affect the amount of participation in the religion from the entrant, however it does change the equation for the bonus from success. Using values from the Moral Hazard model without belief and the belief bonus the value for bonus from victory is recalculated to be,

$$q\left(\sqrt[\alpha]{(1-\beta)U_s}+B_v\right)^{\alpha}+(1-q)\left(\sqrt[\alpha]{(1-\beta)U_s}\right)^{\alpha}-U_s+B_b=U_s$$

$$q\left(\sqrt[\alpha]{(1-\beta)U_s}+B_v\right)^{\alpha}+(1-q)(1-\beta)U_s=2U_s-B_b$$

$$q\left(\sqrt[\alpha]{(1-\beta)U_s}+B_v\right)^{\alpha}=2U_s-(1-q)(1-\beta)U_s-B_b$$

$$\left(\sqrt[\alpha]{(1-\beta)U_s}+B_v\right)^{\alpha}=\frac{2U_s-(1-q)(1-\beta)U_s}{q}-B_b$$

$$\sqrt[\alpha]{(1-\beta)U_s}+B_v=\sqrt[\alpha]{\frac{2U_s-(1-q)(1-\beta)U_s}{q}-B_b}$$

$$B_v=\sqrt[\alpha]{\frac{2U_s-(1-q)(1-\beta)U_s}{q}-B_b}-\sqrt[\alpha]{(1-\beta)U_s}$$

Since the payoffs for Player 2 are the same as the model without belief added, these values are also a Nash equilibrium as Player 2's preferences are unchanged.

7 Works Cited

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