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Javier Rodero Cosano y Pablo Brañas Garza*

Dirección para comentarios y críticas

Departamento de Economía Aplicada
Universidad de Jaén
Paraje las Lagunillas s/n
23071 Jaén
email: jcosano@ujaen.es

* Área de Fundamentos del Análisis Económico. Departamento de Economía Aplicada. Universidad de Jaén.

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Hotelling and the Olympus: Modelling Differences in Religious Prices

Javier Rodero[1] *, **Pablo Brañas**

[1] Department of Economics. University of Jaén. Spain.

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Abstract An introduction to the modelling of a market for religious commodities is presented in this paper. The model focuses on the household choice for different religions and on the religious institutions supply. Many religions compete in the market, each offering a price to their followers. This model is partially based on the spatial competition of Hotelling. The main result we obtain is that, in equilibrium, radical religions have an (price) advantage against the moderate ones as there are a lot of worshipers that have no other (economically affordable) religious option.

J.E.L. Classification: P40, K39, D81

Key words Economics of Religion – Religious Consumer Behaviour – Hotelling Model – Spatial Competition

1 Introduction

There has been a growing interest in the Economics of Religion in recent years, especially since the seminal paper of Azzi and Ehrenberg [1] (A–E in the sequel)

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published in the *Journal of Political Economy*. Moreover, as a result of sociological research on religious behaviour several economists have attempted to apply the standard microeconomic analysis of individual behaviour to the study of religious behaviour. Some empirical studies of church attendance, and church membership have been done in addition, examples of which are Azzi and Ehrenberg [1], Ehrenberg [4], Long and Settle [16], Tomes [29], Neuman [19], Olds [20], Montgomery [18] and Stark, Iannaccone and Finke [25]. Most of these studies analyse the relationship between individuals and religious institutions (i.e. churches) and how this behaviour changes with age, race, gender, rural area and income. There are other studies that have analysed the presence of free-riders who participate less energetically in religious clubs (see for instance, Iannaccone [12]) and the need of "sacrifice and stigma".

To date, no attempt has been made to analyse the market for religion —from a theoretical point of view. Some papers have analysed a specific element of this market: Melton [17] has counted the number of religious alternatives; Iannaccone [14] argues that religious institutions can be observed as neoclassical firms *in which priestly producers sell their religious goods and services to lay consumers*; other authors find a negative correlation between congregational size and per-member rates of annual giving (Sullivan [28], Stonebraker [27], Zaleski and Zech [30]). There are some other papers such as Stark and Bainbridge [24] and Dolin *et al.* [3] that deal with marketing practices in religious institutions.

An important concept was introduced in the economics of religion by Ekelund *et al.* [5]: the view of the church as a monopolistic "multi-divisional" firm. Our own contribution, the analysis of the equilibrium in the market for religion, is based in this idea of a monopolistic behaviour of the religious institutions.

The objective of this paper is to offer a theoretical overview of religious markets. To this end, the second section introduces the concept "beliefs" and our idea of "religious commodities". The third section is devoted to solve a model formally based on Hotelling [10] spatial competition approach. Along this third section we also show the properties of the model, a graphical example and equilibriums with radicalism. Fourth section illustrates some empirical facts. Fifth concludes.

2 Beliefs and Religious Commodities

The first question to be answered is why individuals gain utility when practising religion; why do people feel relief? Assuming that the agents are risk averse it is easy to reach a potential answer: By practising any religion, the uncertainty of the people (about their *a priory* afterlife utility level) diminishes. This argument is close to the "salvation motive" idea presented in the A – E model can be also used to prove why religion increases individuals' utility. We can, consequently, say that practising religion is a rational choice.

We, thus, interpret religion (or the attitude over any supreme institution) as the way to purchase an insurance contract to protect themselves against uncertainty —that is, life after death. With such a contract individuals derive some present utility from feeling safer. Consequently, consumers go to the religion market to buy the good — the insurance contract— paying the price P for it (price of religious precepts).

2.1 The religious space

There exists a cultural space that defines the whole set of possible religious options; a generic[1] cultural attribute that summarises all the possible characteristics of the society. A possible interpretation of this set is the degree of social integration. A "low" value means very strict fulfilment for that particular society rules, instead a "high" value means a high deviations from these rules. Also this interpretation allows to use an ordered set, that is used in our model. Then, the attribute space (a measurable ordered set) is the the unitary interval $[0, 1]$. More formally,

Definition 1 *Cultural space $\mathcal{X}$ is the cartesian product of the N attributes spaces, that is, $\mathcal{X} \equiv \bigotimes_{i=1}^{N} \mathcal{X}_i$. To simplify $N = 1$, and $\mathcal{X}_1 \equiv [0, 1] \subset \mathbb{R}$, so the cultural space is $\mathcal{X} \equiv [0, 1]$.*

Both consumers and firms are positioned in a point of this space. The consumer position represents his preferences on religion. A deviation from this point means lesser satisfaction (utility) with the religious option chosen. Below we will formalise this disaffection as a transportation cost.

The religious firms (denominations) establish a set of rules, that all their followers must obey. The firms spatial position reflects these rules.

It is not usual that an agent changes his religious preferences, and if this happens it will be the result of a complicated dynamic evolution of the equilibrium. But as we are considering only a static model, we will also assume that each agent has a fixed position in the $\mathcal{X}$ space (see 3.1 below for a full rationalisation of this assumption).

2.2 The commodity

We define a religious commodity as an exchange contract of units of religious precepts per unit of human contentment and peace. The most relevant question is how individuals transfer to the present the benefits of a future salvation ("expected afterlife consumption" in A–E; "illusory benefits" in Iannaccone [14]). That is, as he feels more content today, his utility increases. We can alternatively think about religious behaviour from a hedonistic point of view as a way of having a good mental health, that is, it is an alternative to other possible therapies such as psychoanalysis. This second approach would implicitly assume the existence of very close substitute goods to religions.

[1] This set represents a full range of social and personal rules of behaviour, so it should be defined on as much dimensions as different cultural attributes are considered. But each new attribute implies a new dimension in the working space, with increasing notation difficulties. We limit our study to the simplest case.

The commodity is formed by a set of goods (defined by the position of each firm on the religious space). Generally, practising different religions jointly it's not allowed; agents have to choose only one at any moment in their life. The quantity of "religion commodity" is thus unitary in our model (differing from A–E's), that is, the individual only chooses his preferred institution, pays a fixed price, and spend the rest of his income on other goods.

There is an important remaining issue we need to discuss before we formalise these ideas. The issue goes as follows: The real exchange between God and individuals (if it happens to be) will be done only after death, so it is out of the choice period of the model. The individual can, however, anticipate part of such "heaven portion" or "expected afterlife consumption" at the present moment. This is what we call the religious goods or contracts, which are supplied by the religious institutions.

3 The Model

Along this section, we develop a model on which the following considerations are observed:

1. There is a continuum of individuals with a definite and fixed belief distributed in the attribute space (religion).
2. The place of birth is determinant in the initial choice of religion.
3. The number of suppliers (religions) is finite, so it is small compared with the number of consumers (a continuum). That is, there is a discrete number of firms, but not necessary a small number.
4. Religious institutions are located in the attribute space, and this position is fixed, exogenously given.

We are presenting a model of spatial competence *à la* Hotelling [10]. Our space is a closed segment. Each monopolistic firm has a share of the market (also this model could be interpreted as a unique Religion offering discriminatorily different attributes or branches). Firms, however, compete between each other, but the cultural barriers permit each institution to operate in the market with more freedom than in the case of purely competitive firms.

3.1 Supply and Firms

Let us assume that a set D of firms that offer the religious good, and that this set is finite and not empty, $D \subset \mathbb{N},\ \ D \neq \emptyset$. We use the index $j \in D$ to refer to any element of such set. We also use D to refer to the cardinal of D, the total number of institutions. As each firm offers only one good so there will be the same number of churches than goods.

In a dynamic context each firm will try to differentiate its product by allocating itself in the "space" of "cultural-religious belief" to get a monopolistic position

(Ekelund *et al* [5]). But, as noted above, we assume that this position is fixed a priori for each church. In a static model it is not necessary to consider the possibility of displacement of the institutions.

Let us define a distribution function of the "ideological" position of each institution, $G : D \to \mathcal{X} \equiv [0, 1]$. We call each element of the discrete distribution function G_j, we suppose that $G_i \neq G_j$ for all i, j[2]. Without a loss of generality, we can consider that all the religions are increasingly ranked, depending on their ideological positions; so that $G_1 \leq G_2 \leq, \ldots, \leq G_D$. We also define,

Definition 2 *We call* extreme religions *to the closer ones to the interval limits. That is, for us the extreme institutions are denomination* 1 *(with position* G_1*) and denomination* D *(with position* G_D*). We also say that a denomination* i *is* more extreme *than other* j *if it is closer to one of the limits of the interval* $[0, 1]$*, that is, if* $|G_i - 1/2| > |G_j - 1/2|$.

Note that extremism is a pure technical definition without relation with the definition of radicalism to be defined below (definition 4).

The price P_j is the amount that each firm charges in the market. This price is defined in terms of total resources measured in any standard such as money. P_j could be interpreted as the set of rules that the church imposes on their followers —to obtain economic resources of the consumer to support the firm. For simplicity, we assume that the price of the j-religion will be the same for all the followers (there is no discrimination).

We assume that firms have a constant returns production function —in terms of resources, which depends on the quantity produced (number of worshippers). If A_j is the number of worshippers of the j-option, the cost function is:

$$C(A_j) = \gamma A_j, \text{ being } \gamma > 0. \tag{1}$$

Following Iannaccone's [14], our firms are neoclassical. The institution objective is choosing the price of religion that maximises its resources surplus (profits). Their only choice variable is the price of the religious good (remember that we consider the ideological position of each institution, G_j, as exogenous).

Thus, the problem that each institution faces is,

$$\max_{P_j} A_j P_j - \gamma A_j, \quad \forall j \in D. \tag{2}$$

Observations:

1. Money is not the unique or main source when considering church incomes, proselytism could be considered as an important source of resources for the main objective of the church, that is, long-term survival. Other habitual income sources are church attendance, or church nominated charities. Most religions

[2] For the case of mobile religions' positions the choice between an open or closed interval in the ideological space could be interesting, as this could imply opportunistic behaviour. However, as the positions are fixed in this paper, we only analyze the closed interval case (both hypothesis are equivalent in this case).

allow a certain degree of substitutability between these different contributions, in order to let followers to optimise their resource allocation. This might explain the strong positive correlation between individuals' income and gifts found by Iannaccone [14]. Neuman [19] finds a substitution effect between an increase in wages and church attendance. We exclude irrational public or non-observable private behaviour because it would not mean any income for the church, and it seems to be a —club style— control mechanism of the church members. Also general ethical restrictions no considered in the attribute space (like for example the christian, thou shall no kill) are omitted because they seem to be social integration systems which are included in the attribute space.
2. In the real world the exchange system for this sector is quite special, as most churches do not have an apparent fixed price; but this fee depends instead on the generosity of the individuals. In our model, the need of an unique price does not allow us to consider individuals with a higher degree of commitment than the standard church requirements.
3. It is not obvious why churches must maximise profits. We can think easily of some other objective functions like total demand or the demand long-term fidelity. In a dynamic evolutive model is easy to suppose that firms try to maximise their probability of survival (or duration of their life if we use a model without uncertainty). But these survival chances are optimised if the accumulative expected profit function is maximised. The survival of each firm depends on these profits, not on the demand, which can be modified through the price P_j. Even more, the institutions can survive for a long time without followers, if they have enough resources to pay for the depreciation of the capital. The firm profits —in our model— could be a proxy of the dynamic objective if we interpret the static outcome as the long-term equilibrium. Of course there is no way to prove that this equilibrium is perfect in subgames, as this will ask for a dynamic model, so we have to suppose that profit optimisation is independent in each period to ensure this. Anyway, if we accept the objective of long-term survival, profit maximisation is a very realistic assumption in a static model.
4. Also we suppose that each religion has a defined belief —a fixed point— so this position is not changing in time. This is the main point of departure from the Hotelling model, as our unique variable of choice is price. We justify this on the supposition that, due to the reputation effects of any change in position of the denominations, they change their ideas only at a very slow speed. Thus, we will ignore it.

3.2 Demand and Consumers

We assume a continuum of consumers, $Y \equiv [0, 1]$, with homothetic preferences (Cobb–Douglas) over consumption and religion[3]. The individuals are located in

[3] Any utility function that complies with the Inada conditions will give us the same result, if we suppose that individuals have enough resources to buy the religious good and have also any money left for other goods. If we allow zero religious consumption in the utility optimisation, the problem will be different as will appear atheistic behaviours.

the attribute space $\mathcal{X}$ under a distribution function $Z : Y \to \mathcal{X} \equiv [0, 1]$, which is exogenously given and uniform by assumption.

Each agent y has to decide the amount he is going to spend in material and total religious consumption —according to his income; we are thus only considering the "salvation motive" (A–E model). He has also to decide how much of his income is spent in each religious option (this choice is discrete, the individual can consume only 0 or 1 units of each religious good). By assuming that an individual receives utility from his preferred religion only, we know that all his religious consumption will be spent on one institution alone.

As previously noted, the difference between the religious preferences of the individual y and the position of the religion of his choice G_j means a reduction of the religious good utility. To introduce this effect in our model in a compatible way to the Hotelling model, we consider an extra cost in addition to P_j. The distance cost which is proportional to the cultural distance between the individual and the denomination. So for any individual $y \in Y$ we assimilate such seeking cost $d(y, G_j) \equiv c\,|y - G_j|$, where c is a constant bigger than zero.

Definition 3 (Consumer' problem) *Let F^y be material consumption and R^y_j the religious consumption devoted to the firm j by individual y. Let $x(y) \equiv \{\max_{j \in D} R^y_j\}, \quad y \in Y$. If w is the total exogenous income of the individual y, the consumers' optimisation problem is,*

$$\begin{aligned}
&\max_{\substack{R^y_j, j\in D \\ F^y}} U^y \equiv \left(R^y_{x(y)}\right)^{\alpha} \left(F^y\right)^{(1-\alpha)} \\
&\text{s.t.} \sum_{j \in D} R^y_j \big(P_j + d(y, G_j)\big) + F^y = w \\
&R^y_j, F^y \geq 0
\end{aligned} \tag{3}$$

As for the consumer only his main choice is relevant in terms of religious utility, if he follows an optimising behaviour, the problem is reduced to the allocation of the amount of income devoted to one religion (P_j), being zero the amount spent on all other religious choices. The rest of his income is spend in other goods F^y; notice that first-order conditions do not apply to this problem. The individual will chose the option which maximises his utility. Then, if we define $V^y_j \equiv \max_{\substack{R^y_j \\ F^y}} U(R^y_j, F^y) = \left(R^y_j\right)^{\alpha} \left(F^y\right)^{(1-\alpha)}$, the consumer's problem is:

$$\begin{aligned}
&\max_{j \in D} \left\{V^y_j\right\} \\
&\text{s.t.} \sum_{j \in D} R^y_j \left(P_j + c|y - G_j|\right) + F^y = w \\
&R^y_j = 1,\ F^y \geq 0,\ R^y_k = 0\,\forall k \in D \,/\, k \neq j.
\end{aligned} \tag{4}$$

3.3 General Model Solution

If we define A_j as the set of individuals that choose the same religious option, i.e. the *j-th* religion, so that $A_j \equiv \left\{y \in Y \mid V^y_j \geq V^y_k, \forall k \in D, k \neq j\right\}$. Such set is closed and convex if the utility function is Cobb-Douglas. So, $A_j = [s_{j-1}, s_j]$, where $s_0 = 0$, $s_D = 1$, and $s_j \equiv \{y \in Y \mid V_j^y = V_{j+1}^y, \forall j \in D, j \neq 0, D\}$.

For the case of Cobb–Douglas utility functions, the indifferent individual (s_j) is who pays exactly the same total price (including the distance cost) for the two adjacent denominations, that is, if we choose an individual y such as $G_j < y < G_{j+1}$ and he is indifferent between institution j and $j+1$, and we call him s_j, then,

$$P_j + c(s_j - G_j) = P_{j+1} + c(G_{j+1} - s_j) \text{ , and then} \tag{5}$$

$$s_j = \frac{P_{j+1} - P_j + c(G_{j+1} + Gj)}{2c}. \tag{6}$$

The demand for each religious option as a function of its price is $A_j = Z(s_{j+1}) - Z(s_j)$, and due to our assumption of an uniform consumers distribution function, $A_j = s_{j+1} - s_j$, then:

$$\begin{aligned}
A_1 &= \frac{P_2 - P_1 + c(G_2 + G_1)}{2c} \\
&\vdots \\
A_j &= \frac{P_{j-1} + P_{j+1} - 2P_j + c(G_{j+1} - G_{j-1})}{2c}, \quad j = 2, \ldots, D-1 \\
&\vdots \\
A_D &= \frac{2c - P_D + P_{D-1} - c(G_D + G_{D-1})}{2c}.
\end{aligned} \tag{7}$$

The (reduced-form) problem of the religious institutions is,

$$\max_{P_j} \; A(P_j)[P_j - \gamma], \quad \forall j \in D. \tag{8}$$

The solution to the problem for each institution is its reaction function and it is defined by the behaviour of the other firms. The equilibrium prices are, thus, obtained from the following set of equations,

$$\begin{aligned}
P_2 - 2P_1 + c(G_2 + G_1) + \gamma &= 0 \\
&\vdots \\
P_{j+1} + P_{j-1} - 4P_j + c(G_{j+1} - G_{j-1}) + 2\gamma &= 0 \\
&\vdots \\
P_{D-1} - 2P_D + c(2 - G_D - G_{D-1}) + \gamma &= 0.
\end{aligned} \tag{9}$$

The above are D linearly independent equations with D unknowns system, so it has a unique solution (see appendix A.1). As there is not a predefined number of firms, to obtain an explicit solution for the system, the solution coefficients depend on D. The total number of institutions also determines the number of iterations necessary to eliminate all but one price variable. These coefficients can be defined in a generic solution using the second order difference equation given by:

$$C_j \equiv 4C_{j-1} - C_{j-2}, \quad j = 3, 4, \ldots, D. \text{ with } C_1 = 1, C_2 = 2. \tag{10}$$

Equation (10) defines a series with values $C_3 = 7$, $C_4 = 26$, $C_5 = 97$,... we also assume for compactness that $C_0 = 1$ (although its real value must be 2), the equilibrium price of each institution (see also appendix A.1) is therefore:

$$P_j = \gamma + \frac{c}{2C_D - C_{D-1}} \left[2C_j + \sum_{i=j+1}^{D} G_i C_j (C_{D-i+2} - C_{D-i}) + \right. \\ \left. + G_j (C_{j-1} C_{D-j+1} - C_j C_{D-j}) - \sum_{i=1}^{j-1} G_i C_{D-j+1} (C_{i+1} - C_{i-1}) \right], \tag{11}$$

where the sum of a null number or negative number of terms is null. The equilibrium demands for all institutions are:

$$\begin{aligned} A_1 &= \frac{2 + \sum_{i=2}^{D} G_i (C_{D-i+2} - C_{D-i}) + G_1 (C_D - C_{D-1}}{2(2C_D - C_{D-1})} \\ A_j &= \frac{1}{2(2C_D - C_{D-1})} \left[4C_j + \sum_{i=j+2}^{D} 2C_i C_j (C_{D-i+2} - C_{D-i} + \right. \\ &\quad + G_{j+1} (C_{D-j+1} C_{j-1} - 7C_{D-j} C_j + 2C_D - C_{D-1}) + \\ &\quad + G_j (C_{j-1} (2C_{D-j+1} - C_{D-j}) - C_{D-j} (2C_j - C_{j-1})) - \\ &\quad - G_{j-1} (C_{D-j} C_j - 7C_{D-j+1} C_{j-1} + 2C_D - C_{D-1}) - \\ &\quad \left. - \sum_{i=1}^{j-2} G_i C_{D+j+1} (C_{i+1} - C_{i-1}) \right] \\ A_D &= \frac{2C_D - G_D (C_D - C_{D-1}) - \sum_{i=1}^{D-1} G_i (C_{i+1} - C_{i-1})}{2(2C_D - C_{D-1})}. \end{aligned} \tag{12}$$

That is, these solutions have the specification (the signs below each one represents the sign of the first partial derivative of the function with respect to each variable).

$$P_j = f_1(\underset{+}{\gamma}, \underset{+}{c}, \underset{+}{G_k}, \underset{?}{G_j}, \underset{-}{G_l}) \qquad \text{for } k < j \text{ , and } l > j \tag{13}$$

$$A_j = f_2(\underset{+}{G_k}, \underset{?}{G_j}, \underset{-}{G_l}) \qquad \text{for } k < j \text{ , and } l > j. \tag{14}$$

The equilibrium price[4] of each firm (institution) depends on the position of all the other institutions, the cost of searching for individuals, and the marginal cost γ (recall that the C's are only terms in a specific series of numbers). An increase in marginal cost tends, as expected, to raise prices in a homogeneous way for all firms. That is, all the prices will grow in the same quantity as the rise in the marginal cost . Also as γ is bigger than 0, the equilibrium price for each institution is always positive.

The commuting costs have also a (linear) positive relation with price, but not with the equilibrium demand of each firm, as this cost is lineal and symmetrical for the firms. The relationship with the position of the rest of the firms is as expected: an increase of the position for all the firms on the left (right) tends to decrease (increase) the price of each religion, the sign of this effect depends of its relative position.

Notice that in equilibrium, it is not only important the distance of the institution to the closest ones, (G_{j-1}, G_{j+1}) but the positions of all the institutions affects the j-firm reaction, as these positions determines other firms reactions and prices through a chain of reaction functions (this effect is clarified in 3.6).

3.4 A Graphical Example

Figure 1 illustrates a spatial equilibrium between five religious institutions[5]. The horizontal axis is the real interval $[0, 1]$, the vertical is the total price paid by the consumers. This includes the price charged by every institution P_i plus the distance cost,$c\,|y - G_j|$, also, on this axis it is represented the constant unitary cost of each firm (gamma). The thick solid lines represent the consumer's perceived price for each institution. Every firm is positioned in a point of the x axis, given by G_i, and represented by the vertical thick dashed lines. A consumer positioned in a point of the horizontal axis will choose the denomination with lesser perceived price (that is, the solid line which at that point have less height). The intersection of the lines between adjacent institutions give us the s_j indifference points, defined by the thin vertical dashed lines. The horizontal space between the s_i points are the demand for each firm A_i, represented by the lines with arrows.

Two interesting ideas can be derived from figure 1. 1) The religions closer to the centre charge smaller prices than the extreme (that can be interpreted as radical, although we will give a more precise definition of radical institutions below) options. The latter is similar to the "stylised facts" shown in Iannaccone [14], where the author states that sectarian religions use to claim strict behavioural standards and high rates of church attendance. Zaleski and Zech [30] also shows that majority religions followers, such as Catholics, contribute much less than others. 2) The extreme religions have an important advantage against the central ones: they have a portion of worshippers $([0, G_1] \text{ or } [G_d, 1])$ that have no other religious option,

[4] A numerical example is given in the preliminary version of this paper, Rodero *et al.* [21]. See also the graphical example below.

[5] The exact value of the parameters used in this simulation are: $\gamma = 0.5$, $c = 2$, $G_1 = 0.15$, $G_2 = 0.4$, $G_3 = 0.55$, $G_4 = 0.8$, $G_5 = 0.9$.

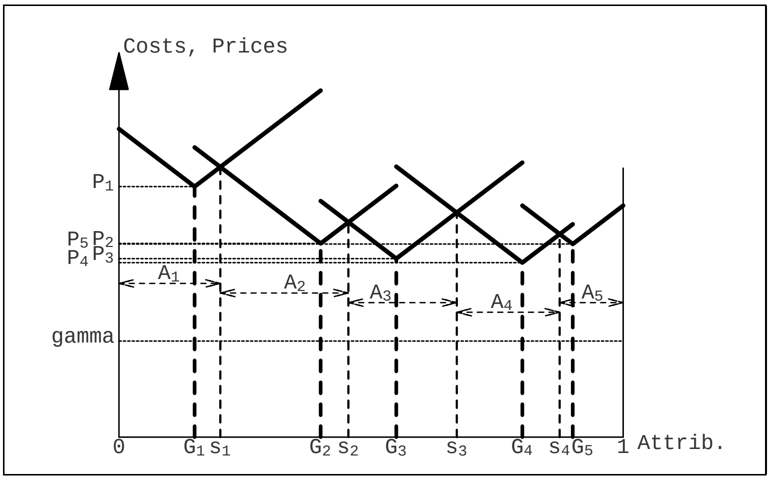

Fig. 1 Equilibrium for five institutions

so they can ask for a higher price for these worshippers (remaining everything else symmetric for all institutions).

3.5 Properties of a Simple Model

The properties noted above are not general (for any distribution function G), only for three institutions we can assure that at least one of the extreme denominations will charge the highest price.

Proposition 1 *In a market with three institutions ($D = 3$), in equilibrium, either P_1 or P_3 is bigger than the central price P_2, that is: $P_1 > P_2$ or $P_3 > P_2$.*

Proof: see the appendix A.2[6].

As previously denoted this property is not general, it is easy to construct examples where there are more firms close to the interval edge than in the middle and then, the prices of the first ones are lower. Only with a "regular" distribution of firms we can assure that extreme religions charge higher prices, and then interpret extreme as radical. Next section follows a different approach where the extreme positions in the interval are not identified with radicalism (deviations from the cultural norm). There is no general relation between position and price because Hotelling' model supposes zero demand price elasticity all along the unit interval (that is all the consumers have the same interest in the religious good). The source of competitive advantage of extreme firms is the interval $[0, G_1]$ or $[G_D, 1]$, if this interval is small the firms could not have enough space to have prices above the rest. The relative prices will depend on the distance to other denominations $G_j - G_1$ or $G_D - G_j$, specially the closer ones (see below).

[6] We wish to thank S. Puy for some suggestions regarding this point.

3.6 Degree of Radicalism and its Effect on the Equilibrium

In this section we follow a different approach than in the previous one, we define radical options not depending on their rank on the interval but on the distance to other denominations. That is we consider that an option is extremist if is very far from other options in the cultural space.

Definition 4 *The degree of radicalism g_j of option j is the half-distance towards the closest options $j-1$, $j+1$ plus any segment that don't have any religious option but j. That is:*

$$\begin{aligned}
g_1 &= G_1 + \frac{G_2 - G_1}{2} = \frac{G_1 + G_2}{2} \\
&\vdots \\
g_j &= \frac{G_{j+1} - G_j}{2} + \frac{G_j - G_{j-1}}{2} = \frac{G_{j+1} - G_{j-1}}{2}, \quad j = 2, \dots, D-1 \qquad (15) \\
&\vdots \\
g_D &= 1 - G_D + \frac{G_D - G_{D-1}}{2} = \frac{2 - G_D - G_{D-1}}{2}.
\end{aligned}$$

Note that this definition is very similar to the definition of firm demand function given in (7). This allow us to obtain a model solution more compact than the one characterised by (11) and (12).

Now we can rewrite the price system (9) as a function of g_j:

$$\begin{aligned}
P_2 - 2P_1 + 2cg_1 + \gamma &= 0 \\
&\vdots \\
P_{j+1} + P_{j-1} - 4P_j + 2cg_j + 2\gamma &= 0 \qquad (16) \\
&\vdots \\
P_{D-1} - 2P_D + 2cg_D + \gamma &= 0.
\end{aligned}$$

The solution process is equivalent to the previous one (see also appendix A.1); The price solution is:

$$P_j = \gamma + \frac{2c}{2C_D - C_{D-1}} \left[C_j \sum_{i=j+1}^{D} g_i C_{D-i+1} + C_{D-j+1} \sum_{i=1}^{j} g_i C_i \right]. \qquad (17)$$

Being the demands:

$$
\begin{aligned}
A_1 &= \frac{1}{2C_D - C_{D-1}} \left[\sum_{i=1}^{D} g_i C_{D-i+1} \right] \\
&\vdots \\
A_j &= \frac{2}{2C_D - C_{D-1}} \left[C_j \sum_{i=j}^{D} g_i C_{D-i+1} + C_{D-j+1} \sum_{i=1}^{j-1} g_i C_i \right] \qquad (18) \\
&\vdots \\
A_D &= \frac{1}{2C_D - C_{D-1}} \left[\sum_{i=1}^{D} g_i C_i \right].
\end{aligned}
$$

With these solutions we can prove the following.

Proposition 2 *The equilibrium prices and demand for each firm increase as their level of radicalism increase. That is, if the new value of g_j is g_j', so that $g_j' = g_j + \delta$, for $\delta > 0$, then $P_j' = P_j + \epsilon$, and $A_j' = A_j + \eta$, being $\epsilon, \eta > 0$.*

Proof: see appendix A.3.

4 Empirical evidence: The model and religious stylised facts

Different stylised facts shown in the literature are analysed in this section. These facts are related with some of our hypothesis and conclusions such as: the rationality of religious behaviour (the effect of religion on human welfare and health), or the substitution between church attendance and the rates of gifts/contributions. The main idea of this paper is also empirically supported; that is, there are different prices and religious requirements for different churches with higher contributions in the most radical religions.

Many different authors have noted the *positive effect of religious behaviour on human health and welfare*. Freeman [7] or Hull and Bold [11] observed that churchgoing affects favourably the allocation of time to school attendance and work activity. They also noted a negative correlation with deviant activities (crime, drugs and alcohol). Bergin [2] found a positive rather than negative relationship between being religious and mental health. Ellison [6] strongly supported the conclusion that religious belief and practice improve self-esteem, life satisfaction, and the ability to withstand major social stress sources, while actually improving physical health. Stark, Iannaccone and Finke [25] suggested that there is a positive correlation between religious belief and health.

Finally, some papers studied the *different prices in religion practising* and strict behavioural standards.

(a) Theologically conservative denominations (labelled “fundamentalist” or “sectarian”) draw a disproportionate share of their members from among the poorer

Table 1 Some Religious Prices

PROTESTANT			JEWS	
Denomination	*Giving*	*Attend.*	*Denomination*	*Attendance*
Liberal	1.5%	low	Reformist	Low
Southern Baptist	2-4%	—	Conservative	Medium
Assemblies of God	2-4%	medium	Orthodox	High
Mormon	6%	high		
Jehovah's Witnesses	—	high		
Source: [9],[12], [13].			Source:[15], [13].	

Note: "attend" stands for church attendance; "giving" is the rate of income given to the church. "—" means not available data.

and less educated ranks of the society, asking them high rates of church attendance (Stark [23], Roof and McKinney [22], Iannaccone [12]). Moreover, fast growing religions (Episcopalian, Methodist, Presbyterian, Jehovah's Witnesses and others) tend to be strict, sectarian and theologically conservative.

(b) Every measure of religious commitment (belief, attendance and contributions) correlates positively with the denomination's overall level of conservatism, strictness, or sectarism. We illustrate this idea in Table 1. The first part of the table reflects average relative attendance and givings (as a percentage of income) of some Protestant denominations ranked by their degree of strictness, taken from a survey from Hoge and Yang [9], and Iannaccone [12],[13]. The second part gives the relative attendance level of some jewish denominations also in an increasing order of strictness, this is taken from surveys of Lazerwitz and Harrison [15], and Iannaccone [13].

Stark and McCann [26] and Zaleski and Zech [30] showed that the worshippers of the mainstream religions, such as Catholics, contribute less than others. Iannaccone [14] showed that members of conservative denominations tend to attend and give much more than members of liberal denominations, even after controlling for socioeconomics differences; and, sectarian religions use to claim strict behavioural standards and high rates of church attendance.

(c) However, Zaleski and Zech [31] found higher rates of giving in congregations located in areas where their denomination enjoy a low market share (and where the overall religious market is more diverse). Hamber and Petersson [8] showed similar results for Sweden.

5 Conclusions

We have tried to present in this paper an ample view of the religion market. The main ideas exposed here can be summarised as follows:

- The first part of the paper describes the religious commodity, under an economic framework. This concept is only a possible interpretation of this commodity, from the economic rational point of view.

- Later, we have modelled —in a rational way, in the economic sense— a celestial goods market ("hope of reaching heaven", "life contentment" or "expected afterlife consumption") on which religious institutions compete spatially in a monopolistic competition framework that resembles Hotelling' model. The cultural asymmetries cause differences in exigencies (prices) between the different religions.
- Also, we have modelled the agent's choice of religion. Although, this approach seems to be useful, we know it is rather deterministic. So a future research line should be devoted to improve it.
- The main conclusions of the paper are, on the one hand, that moderate institutions (those that are close to other religious options) charge smaller prices than radical options. This solution is similar to the "stylised facts" shown in Iannaccone [14], or Zaleski and Zech [30]: sectarian religions use to claim strict behavioural standards and high rates of church attendance. showed that the worshippers of the mainstream religions, such as Catholics, contribute less than others.
- On the other hand, the extreme religions (those close to the edge) have an important advantage against the moderate ones: they have a portion of worshippers $[0, G_1]$ or $[G_D, 1]$ that have no other religious choice, so they can charge them a higher price and have more chances of being radicals.

A Appendix

A.1 Firms Solutions

Given the set of equations defined in equation (9),

$$P_2 - 2P_1 + c(G_2 + G_1) + \gamma = 0 \qquad (\mathrm{S}_1)$$

$$\vdots$$

$$P_{j+1} + P_{j-1} - 4P_j + c(G_{j+1} - G_{j-1}) + 2\gamma = 0 \qquad (\mathrm{S}_j)$$

$$\vdots$$

$$P_{D-1} - 2P_D + c(2 - G_D - G_{D-1}) + \gamma = 0. \qquad (\mathrm{S}_D)$$

It is trivial to prove that are lineally independent. Using a matrix notation we can write down the system as $\mathbf{Ap} + \mathbf{b} = 0$, where $\mathbf{p} \equiv (p_1, p_2, \ldots, p_D)$, $\mathbf{b} \equiv \big(c(G_2 + G_1) + \gamma, c(G_3 - G_1) + 2\gamma, \ldots, c(G_{j+1} - G_{j-1}) + 2\gamma, \ldots, c(2 - G_D - G_{D-1}) + \gamma\big)$, and

$$\mathbf{A} \equiv \begin{pmatrix} -2 & 1 & 0 \ldots & 0 & 0 & 0 \\ 1 & -4 & 1 \ldots & 0 & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 \ldots & 1 & -4 & 1 \\ 0 & 0 & 0 \ldots & 0 & 1 & -2 \end{pmatrix}. \qquad (\mathrm{A.1.1})$$

It is easy to see that $\mathbf{A}$ has full rank. We can solve the system by iterative addition, if we define $(\mathrm{E}_1) \equiv (\mathrm{S}_1) + 2(\mathrm{S}_2)$, then we get:

$$2P_3 - 7P_2 + c(2G_3 + G_2 - G_1) + 5\gamma = 0. \tag{E$_1$}$$

As $C_2 = 2$, $C_3 = 7$, we can also write E_1,

$$C_2P_3 - C_3P_2 + c(C_2G_3 + G_2 - G_1) + (C_1 + 2C_2)\gamma = 0. \tag{E$'_1$}$$

Adding $(\mathrm{E}'_1) + C_3(\mathrm{S}_3)$ we can eliminate P_2, and then obtain (E_2) (remember that equation (10) implies that $C_4 \equiv C_3 - C_2$):

$$C_3P_4 - C_4P_3 + c(C_3G_4 + C_2G_3 - G_2 - G_1) + (C_1 + 2C_2 + 2C_3)\gamma = 0. \tag{E$_2$}$$

To eliminate P_3 we have to add (E_2)+C_4(S_4), and so on. In general we have to use $(\mathrm{E}_{i+1}) \equiv (\mathrm{E}_i) + C_{i+2}(\mathrm{S}_{i+2})$ to eliminate P_{i+1}, so all the E equations only depend on two variables, P_{i+1} and P_{i+2}, then $(\mathrm{E}_{D-2}) + C_D(\mathrm{S}_D)$ gives the P_D expression:

$$\begin{aligned} P_D = \gamma + \frac{c}{2C_D - C_{D-1}}\Big[&2C_D - G_D(C_D - C_{D-1}) - G_{D-1}(C_D - C_{D-2}) - \\ &- G_{D-2}(C_{D-1} - C_{D-3}) - \cdots - G_1(C_2 - C_1)\Big], \end{aligned} \tag{A.1.2}$$

so by backward substitution we can get the rest of the price solutions:

$$\begin{aligned} P_j = \gamma + \frac{c}{2C_D - C_{D-1}}\Bigg[&2C_j + \sum_{i=j+1}^{D} G_iC_j(C_{D-i+2} - C_{D-i}) + \\ &+ G_j(C_{j-1}C_{D-j+1} - C_jC_{D-j}) - \\ &- \sum_{i=1}^{j-1} G_iC_{D-j+1}(C_{i+1} - C_{i-1})\Bigg]. \end{aligned} \tag{A.1.3}$$

If we remember the expressions for the demand of each firm given by equation (7), and using again equation (10), after some long algebraic manipulations we get the demand expressions denoted in equations (12).

A.2 Proof of Proposition 1: Price relationship between denominations

Proof We use the most restrictive case (only three institutions) to characterise the price relationships between the denominations. The equilibrium prices in this case are:

$$\begin{aligned} P_1 &= \gamma + \frac{c}{12}(2 + 5G_1 + 6G_2 + G_3) \\ P_2 &= \gamma + \frac{c}{6}(2 - G_1 + G_3) \\ P_3 &= \gamma + \frac{c}{12}(14 - G_1 - 6G_2 - 5G_3). \end{aligned} \tag{A.2.1}$$

And then,

$$P_1 > P_2 \quad \text{if} \quad -2 + 7G_1 + 6G_2 - G_3 > 0 \tag{A.2.2}$$

$$P_3 > P_2 \quad \text{if} \quad 10 + G_1 - 6G_2 - 7G_3 > 0. \tag{A.2.3}$$

If none of these condition holds (that is $P_2 > P_1$ and $P_2 > P_3$),

$$-2 + 7G_1 + 6G_2 - G_3 < 0 \tag{A.2.4}$$

$$10 + G_1 - 6G_2 - 7G_3 < 0. \tag{A.2.5}$$

Adding equations (A.2.4) and (A.2.5) we have,

$$8 + 8G_1 - 8G_3 < 0. \tag{A.2.6}$$

That cannot hold for $G_i \in [0, 1]$, so at least one of the extreme prices must be bigger than the central one. Note that this result does not depend on the absolute values of G_i but on their relative ones (the order $G_1 < G_2 < G_3$) instead.

□

A.3 Proof of Proposition 2: Price relationship between denominations

Proof First of all we must note that $\sum g_j = 1$, this is obvious if we consider that a possible interpretation of g_j is the share of the space $\mathcal{X}$ that *naturally* correspond to the j-firm. Adding all g_j:

$$\sum g_j = \frac{G_1 + G_2}{2} + \frac{G_3 - G_1}{2} + \frac{G_4 - G_2}{2} + \cdots + \frac{G_D - G_{D-2}}{2} + \\ + \frac{2 - G_D - G_{D-1}}{2} = 1$$

So any increase δ in g_j must be exactly offset by a decrease of the same amount in some other g_i, for $i \neq j$. So to prove that P_j' has increased (or $\epsilon > 0$) we only have to prove that the coefficient in P_j for g_j is bigger than the coefficient for any other g_i. The coefficient for g_j is $C_{D-j+1}C_j$ and for any $i > j$, $C_j C_{D-i+1}$ —see equation (17). As $i > j$, $D - i + 1 < D - j + 1$, so $C_{D-i+1} < C_{D-j+1}$, and then the coefficients for all i are lower than for j. If now we take $i < j$, the coefficient for i is $C_{D+j+1}C_i$. Now as $i < j$, $C_i < C_j$ so these coefficients are also lower than the coefficient of j, so the increase due to the rise in g_j is bigger than the reduction due to the decrease in $\sum_{i \neq j} g_i$.

The argument for the demand can be built in a similar way: given equation (18), the coefficient for any $j \neq 1, D$ is $C_j C_{D-j+1}$, the coefficient for $i > j$ is $C_j C_{D-i+1}$ so it is inferior to the j one. For $i < j$ is $C_{D+j-1} C_i$, so it is also clearly inferior to the j coefficient. For $j = 1$ the coefficient is C_{D-i+1}, clearly superior than $CD - i + 1$ for any $i > 1$. Obviously for $j = D$, C_D is superior to any C_i for $i < D$.

$\square$

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