Religiosity Dynamics

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Abstract: We develop a dynamic general equilibrium model where religiosity, treated as an endogenous state variable, evolves gradually in response to shocks and societal factors. The model integrates religiosity into the utility function alongside consumption and leisure, allowing analysis of time allocation, resource use, and religiosity's impact on capital accumulation. Numerical simulations illustrate how changes in productivity, religiosity costs, religiosity-enhancing factors, and secularization intensity affect equilibrium dynamics. The findings contribute to understanding religiosity's role in economic systems and provide insights into observed patterns of religious behavior and economic performance.

JEL Classification: Z12, E1

Keywords: Religiosity, Labor Supply, General Equilibrium

1. Introduction

The present paper proposes a dynamic general equilibrium model where utility-generating religiosity is explicitly introduced. By introducing religiosity in a macrodynamic model, we can trace the time paths of religiosity observed in different countries as well as the changing nature of religiosity even for a particular religious group within a country. This also allows us to reconcile the apparent disconnect between the predictions of some prominent theories of the economics of religion and the empirical observations. Although there are a few attempts to include religiosity in the utility functions, our main departure from these existing models is to treat religiosity as an endogenous sluggish variable. Consequently, our dynamic model allows us to examine time paths for, among others, capital, labor supply, religiosity, and expenditure patterns, and thereby we can better understand a few prominent puzzles of the economics of religion.

It is undeniable that the religiosity of a society and the economic outcome of that society are intertwined. The extent of religiosity has a significant impact on economic activities by influencing work ethic, honesty, and thrift, thereby engendering different rates of capital accumulation and different modes of time allocation behavior (Weber, 1904). This, in effect, can influence economic growth and the standard of living of a country. Researchers who examine the dynamic interplay between religion and economic activities observe the following interesting patterns regarding the extent of religiosity. (1) The per capita GDP and church attendance are negatively related (Azzi and Ehrenberg, 1975; Iannaccone, 1998; and McCleary and Barro, 2019). (2) The level of education has virtually no effect on the level of religiosity. McCleary and Barro (2019) show that the

effect of years of schooling on participation in formal religious services is close to zero. (3) Urbanization and religiosity are negatively related. The participation in religious activities is higher in rural areas than in urban areas (McCleary and Barro, 2019). (4) Women attend church more than men (Iannaccone, 1998). (5) Blacks attend church more than whites and give more to their churches (Iannaccone, 1998). All these have profound economic consequences.

The relationship between religiosity and economic outcomes has received much attention in the context of the relationships between social infrastructure, culture, and economic growth (Weber, 1904; Hall and Jones, 1999; Iyer, 2016, and a recent contribution by McCleary and Barro, 2019). The widely hailed secularization hypothesis posits that economic development leads to decreased religiosity and the role of organized religions in one's life diminishes with development. This is due to the results of increased education and increased urbanization (Weber, 1904). However, empirically, these predictions are not validated, and it is even observed that science professors are more religious than the other professors (Innaccone, 1998). On the one hand, Barro and McCleary (2005) observe that the manifestation of religiosity changes as people's income increases. The higher the opportunity cost of time for an individual, the lower the time use on religious activities, but the agent spends more resources on religious activities. On the other hand, Buser (2014), using data from Ecuador, shows that households with higher income have higher church attendance.

The research on the role of state religion on the level of religiosity also yields inconclusive results. For example, McCleary and Barro (2006), by examining data from 188 countries, report that state subsidies to religion engender both demand and supply

side effects of religion. Thus, the exact change in religiosity would depend on the strength of these effects. Examining data from Western countries, North and Gwin (2014) find that the overall religiosity in religiously heterogeneous populations is reduced by the presence of a state religion. Some empirical studies focused on the relationship between the prevalence of a particular religion (Islam or Protestantism) in a country and economic growth. While others focus on econometric issues regarding identification schemes in the context of religiosity and macroeconomic outcomes.

It seems researchers agree that religion yields utility for an individual. Although it is hard to quantify, its presence seems overwhelming (Azzi and Ehrenberg, 1975; Iannaccone, 1998; Iyer, 2016). Some even tried to include afterlife utility in the total utility calculation[1]. One way to evaluate the utility an agent receives from religion is to see how much of the agent's resources are allocated to his/her own religious activities. This use of resources for the purpose of adhering to religion opens up the possibility of a reduction in resources available for consumption or investment. These, in turn, would affect both present and future utility as well as capital accumulation. As a result, this would have a significant influence on economic growth.

Another common element in the extant literature on religion and economic performance is the time use for religious activities (Azzi and Ehrenberg, 1975; Iyer, 2016). It is observed that more religious people provide labor services/time for religious activities

[1] Some researchers even argue that religiosity may yield negative utility. For example, Mookerjee and Beron (2005) discuss the role between religious fractionalization, gender and happiness. Their results indicate that religiosity lowers happiness of individuals. However, the authors believe that it is the *fractionalization* that actually causes the negative impact on happiness, e.g. heterogeneity in the workplace causes unhappiness.

more than less religious people. Time allocation between leisure, labor, and religious activities would potentially alter not only current production and utility but also future production and utility by changing capital accumulation.

There are many definitions of religiosity. Kecsekes and Wolf (1994), for example, define religiosity as an individual trait that embodies the degree of agreement with the values, norms, and practices of one's religion. Hubert (2015) argues that a religious person expresses her/his religiosity in the forms of expression that are empirically measurable. One can surmise that the time use and resource use patterns for religious purposes would reveal the extent of one's religiosity. Religiosity, however, is not a static variable. It changes as society changes. The prominent determinants of religiosity are time-dependent variables such as income level, technological changes, rate of urbanization, and demographic composition of the society (Buser, 2015; Jackson et. al, 2023; Pew Research, 2015). Thus, the extent of religiosity in a country or a society changes over time, suggesting that religiosity is a dynamic variable.

Although we observe the dominance of one or more organized religions in different countries, the extent of religiosity of the adherents of the organized religions changes significantly depending on the income level and cultural and social environment. Researchers show that as income increases, church attendance declines (Strom, 2017). To what extent people may substitute time with resources spent on religion remains an important research question (Iannaccone, 1990). For instance, McCleary and Barro (2019) report that rich people provide more resources and less labor time/volunteer for religion.

We observe that the extent of religiosity in a country changes over time. As income increases, people in some countries become less religious, and church attendance declines, while in other countries, we observe signs of increased religiosity. For example, in India, we observe a sustained increase in political power for religious parties while the economy has been growing steadily over the last 30 years or so. Iyer (2006) notices that religion remains strongly pervasive and persistent even as countries become richer. Even within a country, increased income cannot dampen the fervor of religiosity manifested through the increased support for religion-inspired policies in conservative states like Texas and Oklahoma. Furthermore, Innaccone (1998) shows that the religious service attendance in the USA yields a U-shaped relationship with respect to age.

A few models are proposed to explain the relationship between religiosity and economic performance (Iannaccone, 1990). In most of the models, religiosity is treated as an exogenous variable and thus, researchers can only examine comparative static properties of a change in religiosity. These static models cannot incorporate the changing nature of religiosity along with changes in other time-dependent variables. A model for religion and economic performance should consider religiosity as an endogenous variable. The inability of traditional models to incorporate these crucial elements results in the failure to obtain explanations of the apparently puzzling behavior of the agents in the realm of religiosity. This warrants a class of dynamic models where the intertemporal nature of output and religiosity is adequately addressed. As Bowles (1998) and Friedman (2008)

suggest that the evolution of markets and the evolution of morals, culture, and institutions, including religion, need to be studied together[2].

In response, we propose a dynamic general equilibrium model where agents' religiosity is treated as a state variable, meaning it changes gradually. Religiosity yields positive utility, and the agent can allocate his/her time among leisure, work, and/or religious services. Since religiosity is treated here as a sluggish variable, any shock will not immediately change one's religiosity. An agent can become more (or less) religious over time, but the immediate impact of any shock would be on the changes in the shadow price of religiosity or the composition of the labor use, among others. We construct an infinite-horizon, dynamic general equilibrium model where output is produced by capital and labor. By allowing for the accumulation of both capital and religiosity, we are able to understand the effects of various shocks on the dynamic paths of both output and religiosity, which was not possible in the conventional framework with exogenous religiosity.

Our dynamic general equilibrium model allows us to understand the contradictory empirical results related to macroeconomic variables and religiosity. We are able to demonstrate that the observed contradictory results regarding the secularization hypothesis of religion are essentially artifacts of the nature of the dynamics of religiosity. Our main results have been engendered from the idea that religiosity is a sluggish

[2] Lowes et al. (2025) using six waves of World Value Surveys for emerging and developing countries observe that the prediction of the Secularization Hypothesis remained are not empirically validated. Becker et al. (2024) examine the relationship between religion and economic growth by incorporating religion as one of the determining factors of total factor productivity.

variable, and a proper accounting of this characteristic allows us to reconcile the relationship between other economic issues and religiosity, such as time use for religious purposes, rural-urban migration and religion, and gender differences in religiosity.

We have chosen numerical simulation to examine the effects of different shocks in the macrodynamic model, and we find that when the aggregate productivity increases (income increases), the level of religiosity also increases in the long run. However, we find that a higher income, coupled with no significant change in religiosity in the short run, apparently confirms the conjecture of the Secularization Hypothesis. In respect of time spent on religious activities, we observe a jump in labor use, which engenders the beginning of the increase in religiosity. As capital and religiosity change slowly, the time use on religious activities starts declining from the initially reached higher level and eventually starts rising as capital accumulations dampen the change in religiosity. Thus, we obtain a U-shaped time path for time spent on religious activities.

Although this paper is an attempt to understand the dynamic paths of religiosity in a country in the face of changes in the social and economic environment, it can be adopted to understand the observed religious behavior and economic performances of different groups, even within a country.

2. The Output Cost of Religiosity

An integral part of being religious is to spend some resources for sustaining/expanding one's religious institutions, like churches, mosques, synagogues, temples, and religious schools. There are distinct suggestions in some religious doctrines of how many resources should be allocated for religious purposes, while in some religions, it is kept

vague. For example, the amount of Zakat (and Sadaqah) to be paid by a Muslim depends on the amount of wealth and the type of assets an individual possesses. Now, the Quran does not provide specific guidelines on what types of wealth are taxable, nor does it specify percentages to be given. However, customary practice for the amount paid on capital assets is $1/40$ or 2.5 percent (see Kuran (1993) and Kuran (2004). The reason that Zakat is a good indicator of *religiosity* is that Zakat is collected through a voluntary system where eligible Muslims are expected to pay the Zakat based on their assets and religiosity. However, in some countries, such as Saudi Arabia and Pakistan, Zakat is obligatory. In Jordan, Bahrain, Lebanon, and Bangladesh, Zakat collections are regulated by the state, but contributions are voluntary (Tripp 2006, Kogelmann 2002).

Tzedakah, like Zakat, is a voluntary obligation for a Jewish household. It is similar to the term Sadaqah as discussed previously. Most Jewish practitioners carry out Tzedakah by donating a portion of their income to charitable institutions. Traditionally, the valuation, ma'aser kesafim (tithing), of their income should be 10 percent. Thumma (2023) reports that in the USA, the Mainline Protestants contribute a median of $2,748 per person, Conservative Protestants contribute $2,100, while Catholics and Orthodox participants contribute $1,581 to their churches. The adherents of the Latter-Day-Saints churches pay about 10% of their annual income. This suggests that maintaining religiosity is costly.

Iannaccone (1990) examines the contributions of money and time for religious purposes and observes that there is a trade-off between time and money. He finds that people who value their time more will contribute more to religious donations, such that monetary contributions are greater than their rates of church attendance and vice versa. McCleary

and Barro (2019) observe similar patterns. This suggests that religious participation can certainly be examined as a typical economic decision.

2. Model

To understand the dynamic properties of religiosity, we construct a simple macrodynamic model by introducing religiosity explicitly. Agents in this economy receive utility not only from the consumption of output and leisure but also from the consumption of religiosity. Our incorporation of religiosity into the utility function is similar to Gundlach and Opfinger (2013), who added religion into their "happiness" function. Following Azzi and Ehrenberg (1975), Iannaccone (1990), and Montgomery (1996) where they assume that people gain utility from a composite consumption goods, leisure activities, and religiosity, we, in addition, allow that agents to allocate their income between consumption, investment, and religious activities, and they can allocate their time among gainful employment, leisure, and spending time for religious activities. This allows us to determine not only the equilibrium allocations of resources and time, but also can examine the dynamics of these variables along with both capital accumulation and religiosity enhancements.

The agent obtains utility from consumption, C, leisure, l, and the level of religiosity, R, and maximizes the following standard intertemporal utility function:

$$\int_0^{\infty} U\,(C, l, R) e^{-\beta t} dt \qquad (1)$$

Agents also produce a final good that can be used for consumption and can be converted into capital without any adjustment costs. Moreover, being religious requires spending resources on religious activities. As a result, the final output can be used for consumption, investment, and religious activities. The production of the final output requires capital and labor. The capital accumulation equation is thus given in Equation (2).

$$\dot{K} = F(K, L) - C - G(R) \qquad (2)$$

Here R is the level of religiosity, and $G(R)$ is the output cost of maintaining religiosity R. If people become more religious, they spend more for religious purposes, i.e., $G'(R) > 0$, and as they become more religious, they increase their spending on religious purposes more, i.e., $G''(R) > 0$. This is empirically reasonable as Iannaccone (1998) reports that the level of contributions for religious purposes is positively related to the overall levels of conservatism and strictness. He reports that the members of liberal Protestant denominations contribute about 1.5% of their income, while more conservative denominations such as the Southern Baptists contribute between 2 to 4 percent.

McCleary and Barro (2019) observe that the changes in religiosity are a slow and gradual process. This encouraged us to assume that religiosity does not change abruptly. This implies that we treat religiosity as a sluggish variable, and the changes in religiosity not only depend on how much time and effort we put into religious activities but also on the level of income. The secularization hypothesis suggests that as people become more well-off, the level of religiosity declines. We introduce this secularization factor in our accumulation of religiosity in the following manner.

$$\dot{R} = \Phi(L_r) - \Psi(K) \qquad (3)$$

Here L_r is the amount of time spent on religious activities. An increase in time on religious activities increases the level of religiosity at a decreasing rate, i.e., $\Phi'(L_r) > 0$ and $\Phi''(L_r) < 0$. This is plausible as Iannaccone (1998) shows that the level of church attendance is positively related to the overall levels of conservatism and strictness. Following the secularization hypothesis (for a recent contribution, see Norris and Inglehart, 2004), we assume that an increase in wealth, K, reduces the level of religiosity at a decreasing rate, i.e., $\Psi'(K) > 0$ and $\Psi''(K) < 0$. This assertion seems reasonable as Norris and Inglehart (2004) show that rich societies are becoming more secular[3].

The representative agent is endowed with 1 unit of time and allocates it either to work, religious activities, or leisure, i.e.,

$$1 = L + l + L_r \qquad (4)$$

The representative agent maximizes lifetime utility (Equation 1) subject to the constraints in Equations (2)-(4) with given the initial stocks of capital $K(0) = K_0$ and initial level of religiosity $R(0) = R_0$. The instantaneous utility function is assumed to be concave, and the agent's rate of time preference, β, is taken to be constant.

The Hamiltonian equation for this problem is given in Equation (5),

[3] Although Iannaccone (1998) shows that the secularization hypothesis is not empirically validated. Barro and McCleary (2005) show that people in rich countries spend more resources and less time for religion.

$$
\begin{aligned}
H = U(C,l,R)e^{-\beta t} \quad & +\lambda_1 e^{-\beta t}[F(K,L) - C - G(R) - \dot{K}] \\
& +\lambda_2 e^{-\beta t}[\Phi(L_r) - \Psi(K) - \dot{R}] \\
& +V_1 e^{-\beta t}[1 - l - L - L_r]
\end{aligned} \qquad (5)
$$

where λ_1 is the shadow value of capital, λ_2 is the shadow value of religiosity, and V_1 is the shadow price of time.

The agents choose C, l, R, K, L, L_r, and the optimality conditions are:

$$
\begin{aligned}
U_c &= \lambda_1 && (6a) \\
U_l &= V_1 = \lambda_1 F_L = \lambda_2 \Phi_{L_r} && (6b) \\
\beta - \frac{\dot{\lambda}_1}{\lambda_1} &= F_K - \frac{\lambda_2}{\lambda_1}\Psi_K && (6c) \\
\beta - \frac{\dot{\lambda}_2}{\lambda_2} &= \frac{\lambda_1}{\lambda_2}G'(R) + \frac{1}{\lambda_2}U_R && (6d)
\end{aligned}
$$

Equations (6a)-(6b) are static efficiency conditions where (6a) shows that the marginal utility of consumption is equal to the shadow value of capital, and Equation (6b) represents the equality of the return from allocation of time in all three different activities: leisure, work, and time spent on religious activities. Equation 6 (c) states that since the final output can be allocated for consumption and capital, the returns from consumption and the return from capital are equal. In contrast to the conventional macro model, in the return from capital, we have a second component, $\lambda_2\Psi_K$, which assumes the effect of capital on religiosity evaluated in the same unit, as it represents the negative effects of capital on religiosity. Equation 6(d) equates the return from spending resources for religious purposes and the adjusted marginal utility of religiosity. The transversality conditions are

$$
lim_{t\to\infty}\lambda_1 K e^{-\beta t} = lim_{t\to\infty}\lambda_2 R e^{-\beta t} = 0 \qquad (6e)
$$

2.1 Equilibrium

Using the first-order conditions for C, l, L, and L_r, we get:

$U_l(C,l,R)=\lambda_1 F_L(K,L)$ (7a)

$U_l(C,l,R)=\lambda_2 \Phi_{L_r}(L_r)$ (7b)

$U_c(C,l,R)=\lambda_1$ (7c)

$1=l+L+L_r$ (4)

These four equations allow us to solve for *C*, *l*, L, and L_r in the following form

$C=C(K,R,\lambda_1,\lambda_2)$, L = L $(K,R,\lambda_1,\lambda_2)$, L_r= $L_r(K,R,\lambda_1,\lambda_2)$ and $l=l(K,R,\lambda_1,\lambda_2)$.

Utilizing these solutions of C, l, L, and L_r in terms of *K*, *R*, λ_1, and λ_2 and the Equations (2). (3), (6c), and 6d), the equilibrium can be summarized by the following autonomous system of four variables, *K*, *R*, λ_1, and λ_2:

$\dot{K}= F(K,L(K,R,\lambda_1,\lambda_2))-C(K,R,\lambda_1,\lambda_2)-\mathrm{G(R)}$ (8a)

$\dot{R}= \Phi(L_r(K,R,\lambda_1,\lambda_2))-\Psi(K)$ (8b)

$\dot{\lambda}_1= \beta\lambda_1-\lambda_1 F_K(K,L(K,R,\lambda_1,\lambda_2))+\lambda_2\Psi_K(K)$ (8c)

$\dot{\lambda}_2= \beta\lambda_2-U_R(C(K,R,\lambda_1,\lambda_2),l(K,R,\lambda_1,\lambda_2),R)+\lambda_1 G'(R)$ (8d)

At steady-state, $\dot{\lambda}_1=\dot{\lambda}_2=\dot{K}=\dot{R}=0$. We can solve for the steady-state values of the shadow price of capital, shadow price of religiosity, capital stock, and the extent of religiosity($\widetilde{\lambda_1}$, $\widetilde{\lambda_2}$, $\widetilde{K}$, $\widetilde{R}$).

2.2 Equilibrium Dynamics

Using Equations (7a- 7c) and (4), we can easily derive the partial derivative of consumption, leisure, labor use in production, and labor use in religiosity production with respect to the shadow price of capital, the shadow price of religiosity, capital, and the level of religiosity.

Linearizing (8a)-8(d) around the steady-state, the dynamics of λ_1, λ_2, K, and R can be approximated by a system of differential equations of these four variables.

Since it is a fourth-order non-linear dynamic system, we will use numerical simulations to examine the dynamics of these variables. We show from our numerical simulations that there are two positive and two negative eigenvalues, implying that the equilibrium is a saddle point. Since capital K and religiosity, R are sluggish variables, while the shadow prices, λ_1 and λ_2, are free to jump, the equilibrium yields a unique saddle path.

Let's assume stable (negative) eigenvalues are μ_1 and μ_2. So the solutions are:

$$\begin{aligned} \mathrm{K} - \widetilde{\mathrm{K}} &= B_1 e^{\mu_1 t} + B_2 e^{\mu_2 t} && (9a) \\ R - \widetilde{R} &= B_1 V_{21} e^{\mu_1 t} + B_2 V_{22} e^{\mu_2 t} && (9b) \\ \lambda_1 - \widetilde{\lambda_1} &= B_1 V_{31} e^{\mu_1 t} + B_2 V_{32} e^{\mu_2 t} && (9c) \\ \lambda_2 - \widetilde{\lambda_2} &= B_1 V_{41} e^{\mu_1 t} + B_2 V_{42} e^{\mu_2 t} && (9d) \end{aligned}$$

where B_1 and B_2 are constants, the vector $[1 \quad V_{2.i} \quad V_{3.i} \quad V_{4.i}]'$, $i = 1,2$, and the prime denotes the transpose of the vector is the normalized eigenvector associated with the stable eigenvalue, μ_i.

The constants B_1 and B_2 are obtained by considering the value of state K and R at $t = 0$, are given by:

$$B_1 = \left[\frac{(R_0 - \widetilde{R}) - V_{22}(K_0 - \widetilde{K})}{V_{21} - V_{22}}\right]$$
$$B_2 = \frac{V_{21}(K_0 - \widetilde{K}) - (R_0 - \widetilde{R})}{V_{21} - V_{22}}$$

Plugging in B_1 and B_2 in Equations (10a-10d), we get solutions for the time paths of K, R, λ_1, and λ_2,.

3. Numerical Simulations

Our fourth-order nonlinear dynamic system warrants numerical simulation. To conduct the numerical simulations, following the extant literature, we use the following explicit utility function:

$$U(C, l, R) = \frac{\left(Cl^{\rho}R^{\theta}\right)^{\gamma}}{\gamma}$$

where $\frac{1}{1-\gamma}$ is the intertemporal elasticity of substitution, θ parameterizes the importance of religion to the agent, ρ is the importance of leisure, and the agent's rate of time preference β, is taken to be constant.

We assume a Cobb-Douglas production function for final output as $F(K, L) = AK^{\alpha}L^{1-\alpha}$, where A is the productivity parameter and $0 < \alpha < 1$ is the capital intensity parameter. Both capital and labor exhibit increasing but diminishing marginal product. An increase in A would imply an increase in aggregate productivity of the output sector.

We have chosen the output cost of religiosity function as $G(R) = BR^{\delta}$ where $\delta > 1$. This implies that as people get more religious, they spend more to satisfy their religious needs. It is observed that more religious people spend more on religion than less religious people

(Barro and McCleary, 2003). This also indicates that an increase in religiosity increases the religion-induced output costs (Iannaccone, 1998).

In respect of how religiosity evolves, following the extant literature, we assume that as people spend more time on religious activities, they become more religious, but the impact on the level of religiosity for an increase in time spent on religious activities is increasing but diminishing. So, our religiosity-enhancing function is $\Phi(L_r) = ML_r^{\eta}$, where $0 < \eta < 1$, and M is the exogenous parameter that embodies all the influences of other religiosity-enhancing forces. An increase in M would imply an exogenous increase in forces that enhances the religiosity of an agent.

To incorporate the secularization hypothesis of religion in our model, we introduce a simple religiosity-reducing function of output/wealth. For simplicity, we assume the following function to incorporate this secularization hypothesis.

$$\Psi(K) = NK^{\epsilon}$$

Where N is a level parameter where an increase in N indicates a reduction in religiosity for an agent with a given amount of capital/wealth. Following the extant literature, we assume $0 < \epsilon < 1$, implying that a capital increase will reduce the level of religiosity but at a decreasing rate (Barro, 2003, and Buser, 2015). For example, an increase in N implies that the agent becomes less interested/involved in religious activities for a given level of economic well-being. This can potentially be an outcome from the bad or irreverent behavior of the church leaders, church scandals, or support of the religious institutions from an unhealthy political process.

We report base parameter values in Table 1. These values are chosen so that they yield a reasonable equilibrium for a representative economy. In particular, we assume that γ = -1.5, such that the intertemporal elasticity of substitution is 0.4[4]. The capital's share in output parameter α is chosen to be 0.3, as we know that for countries like the USA, the capital's share is about 0.33 (Turnovsky, 1984), and the rate of time preference β is chosen to be 0.045 (Turnovsky, 1996; Turnovsky and Rojas-Vallejos, 2016; Turnovsky, 2000). The elasticity of leisure in utility ρ is chosen to be 1.75 so that we obtain the labor supply to be 27.8% of a unit of total time available, as Cooley (1995) reported it to be around 30%.

Since unlike other studies we include religiosity in our utility function and its impact on utility is not directly available, we choose religiosity elasticity of utility θ to be 0.2 so that we obtain a level of religiosity that generates the level of labor used in religious activities around 10% of the available time and the spending on religious activities to be around 7.8% of output. The "output cost" of religiosity is generally what is expected of the faithful. These costs are different for people with different religious beliefs, such as Zakat for Muslims, Tzedakah for Jewish people, and Tithe for Christians. This is not to argue that all individuals practicing these religions pay the "required" amount, but the theological threshold prescribed is the lowest, being 0.025, and the highest being 0.20. If we assume that the individual pays in this range, we can solve $\frac{BR^{\delta}}{Y} \in [0.025,\ 0.20]$, we find that δ should assume a value around 2.1, which yields a value closer to the midpoint

[4] Estimates of the intertemporal elasticty of substitution range between 0 and 1 and the choice of γ = -1.5 is consistent with empirical evidence by Ogaki and Reinhart (1998).

of 0.078. The *Bangladesh Time Use Survey 2021* reports that individuals aged 15 and above spend about 2.2 hours daily on social and religious activities, reflecting a significant allocation of time to faith-based practices (Bangladesh Bureau of Statistics, 2023). In contrast, the *American Time Use Survey (ATUS)* finds that the average American spends approximately 8 minutes per day on religious activities, indicating lower engagement levels in formal religious practices compared to Bangladesh (U.S. Bureau of Labor Statistics, 2021). So we obtain a wide range of time use for religious purposes.

Table 1

Base Parameter Values

Parameters	Values
Preference Parameter, γ	-1.5
Rate of Time Preference, β	0.045
Leisure Elasticity, ρ	1.75
Religiosity Elasticity of Utility, θ	0.2
Capital's Share in Output, α	0.3
Religiosity Elasticity of Output, δ	2.1
Religious Labor uses Elasticity of Religiosity Enhancement, η	0.5
Capital Elasticity of Decline in Religiosity, ϵ	0.25
Aggregate Productivity Parameter, A	5
Exogenous Output Cost of Religiosity Parameter, B	1.2
Exogenous Religiosity Enhancer, M	2
Exogenous Effect of Capital on Religiosity, N	0.3

In Column 2 of Table 2, we report the steady-state equilibrium values for key variables for the parameter values reported in Table 1. These steady-state variables are not related to a particular country, but these key variables are reasonable for a more generic country. For example, we attempt to match our capital-output ratio, religiosity cost-output ratio, labor use in different activities, and consumption output ratios with those of an average country of similar characteristics. We then examine the effects of different shocks on the

steady-state values of these variables in the long run (Table 2) and the dynamic paths of the macro variables such as capital, consumption, and labor supply in response to the same shocks (Figures 1-4).

We obtain a benchmark equilibrium that can represent an average economy. Although it is now a common practice in numerical simulations to match moments with a particular country's data or for a group of countries, we chose a more general average country, as some of the variables included in this model do not have observable quantifiable dimensions, such as religiosity. Our benchmark capital-output ratio is 3.88, which is quite plausible as we observe the range for capital-output ratio for countries hovers between 2.1 to 5.0, aligning with estimates from World Bank data on capital accumulation (World Bank, 2014). Research on wealth-income ratios by Piketty and Zucman (2013) supports the observed variation in capital-output ratios across different economies.

The benchmark religious expenditure output ratio is 0.078, which can be comparable to the religious expenditure patterns of Muslim, Christian, and Jewish households. The labor supply obtained for the benchmark equilibrium is comparable to the actual patterns of labor supply of about 8 hours a day, which is about 30% of the available time for an agent. The labor used for religious purposes in the benchmark equilibrium is about 9.8% of the available time. This is quite reasonable in light of the time use survey of both Bangladesh and the US. It is found that the Bangladeshi households spent 2.6 hours on religious purposes, whereas the US population spent time use for religious for 8 minutes

per day. Overall, the benchmark equilibrium is quite a reasonable macroeconomic equilibrium.

4. Results

To examine the effects of different shocks on the equilibrium outcomes as well as the dynamic paths of capital, religiosity, output, labor supply, and time spent on religious activities, we change the shock parameters by 10%[5].

4.1. Economic Growth and Religiosity Dynamics

We examine the effects of an increase in aggregate productivity of the final output sector on macroeconomic variables such as religiosity, labor use for religious activities, and resource use for religious activities. An increase in the overall productivity of the final output, A, suggests that the economy is growing, and the numerical simulation results for the long run are reported in column 3 of Table 2, while the dynamic paths of capital, the level of religiosity, output, labor use for religious services, and labor supply are given in Figure 1.

[5] Since we are examining the dynamics around the steady-state, following convention, we opted for a smaller shock.

Table 2

Effects of different shocks on long-run values

Variable	Benchmark	A 10% increase in Total Factor Productivity "A"	A 10% increase in output Cost of Religiosity "B"	A 10% increase in Religiosity Sustainer "M"	A 10% increase in the religiosity dampening parameter "N"
K/Y	3.881	3.750	3.881	4.233	3.509
Religious Exp/Y	0.078	0.077	0.078	0.079	0.078
C/Y	0.922	0.923	0.922	0.921	0.922
Output, Y	4.865	5.465	4.866	5.117	4.598
Labor	0.273	0.272	0.273	0.277	0.269
Leisure	0.629	0.627	0.629	0.637	0.621
Labor Use for Religious Purposes	0.098	0.102	0.098	0.087	0.109
Capital	18.880	20.492	18.887	21.660	16.135
Religiosity Level	0.576	0.608	0.553	0.596	0.561
Shadow Price of Capital, λ_1	0.093	0.069	0.095	0.079	0.112
λ_1 at time 0		0.075	0.095	0.090	0.093
Shadow Price of Religiosity, λ_2	0.364	0.312	0.369	0.274	0.442
Shadow Price of Religiosity λ_2 at time 0		0.333	0.353	0.292	0.412
Consumption	4.486	5.043	4.485	4.712	4.242

As expected, an increase in aggregate productivity, A, by 10% increases the long-run aggregate output and capital. Since an increase in religiosity increases utility and it is treated as a normal good, an increase in productivity raises income/wealth and thus increases the level of religiosity in the long run. Since an increase in productivity raises the aggregate output, agents allocate these additional outputs to both consumption and an

increase in religious expenditure. We observe a higher level of religious expenditure as it is positively related to the level of religiosity.

As the higher level of capital tends to affect religiosity negatively (Equation 3) and to maintain religiosity at the long-run steady-state level, the labor use in religious services has to increase. Thus, we obtain a higher level of output, capital, religiosity, and time use for religious purposes. Although we have explicitly introduced an element representing the tenet of the secularization hypothesis in Equation (3), we obtain results different from the prediction of the secularization hypothesis. Iyer (2016) noted that in reality, the prediction of the secularization hypothesis does not hold by suggesting that religion remains pervasive and persistent even as countries become richer. For example, India remained on a sustained growth path since the 1990s, still the electoral performances of the religious/religion-affiliated parties improved consistently. The Bharatiya Janata Party (BJP) had only two seats in the Indian parliament in 1984, while it secured more than 303 seats in the 2019 election. The party has been in power in India since 2014.

However, the time paths of output and religiosity show an interesting pattern (Figure 1). When aggregate productivity increases, output increases quickly, whereas capital and religiosity, the sluggish variables, do not change that fast. As a result, we observe in the interim an increase in output but no change in religiosity, which may appear to be a negative or no relationship between these two variables (compare initial changes in output and religiosity, Figure 1.b and 1.c). Since capital and religiosity are sluggish variables and so on impact of this productivity shock, the shadow price of capital and the shadow price of religiosity drop because of the anticipated larger new equilibrium values

of capital and religiosity. Consumption has to jump from 4.49 to 4.91to restore equilibrium in response to this productivity shock. As capital is being accumulated and the religiosity level starts rising, the increase in consumption then follows a gradual process to reach the long-run equilibrium level of 5.04.

[Figure 1 about here]

The dynamics of labor supply show an interesting pattern. In response to an initial productivity shock, the labor supply sharply drops to allow for a larger jump in the time spent on religious activities. The shadow price of capital and the shadow price of religiosity both drop with the anticipation of larger values of capital and religiosity in the long run; the time use for religious purposes immediately increases. As capital starts rising, the combined effect of productivity increase and capital increase would raise output significantly. This will start raising the level of religiosity since religiosity is a normal good, which requires a larger increase in labor use in religious purposes to engender a gradual increase in religiosity. This, together with the increased marginal productivity of labor due to a larger capital level, results in a substantial increase in the total labor supply. Thus, we observe an inverted U-shaped path for the labor supply (Figure 1.e).

The initial jump in labor use for religious purposes starts the motion to increase the religiosity level (Equation 3). As both religiosity and capital level start increasing, the increased capital will moderate the rate of increase of the religiosity level, which in turn starts reducing the time use for religious purposes from the very high level it jumped

when the productivity shock is realized. However, as the capital-increase gains momentum, the labor use for religious purposes has to start rising to achieve a larger equilibrium value for religiosity. This is because as capital starts rising, it will have a negative effect on the level of religiosity, and without a larger jump in labor use in religious activities, this capital increase will, in effect, reduce the level of religiosity. This increase in labor use for religiosity reduces both labor use in output and leisure.

As the forces against the growth of religiosity strengthen (secularization effects kick in) and so the labor used for religious purposes again starts rising and reaches new equilibrium values. This U-shaped response of labor use in religious activities in response to a productivity shock arguably can explain conflicting cross-country evidence regarding labor use in religious activities and income level (Barro and McCleary, 2003; McCleary and Barro, 2006).

These results suggest that we may obtain a negative relationship between output and labor use in religious purposes in the short run, whereas in the long run, obtain a positive relationship.

4.2 An Exogenous Increase in Output Costs of Religiosity, B

An increase in the price of religiosity in terms of output implies that for the agents with the same level of religiosity, the output cost is now larger. There are several ways this shock can be rationalized. For example, some denominations of churches require more sacrifice from the church members. Generally, a Latter-Day Saint church member would spend more resources than the same for a Baptist church member. A church member in rural areas has to spend more than that for an urban church member, as population

density is lower in rural areas than in urban areas. Similarly, old people with similar levels of religiosity spend more on the church than young people. In addition, one can argue that the level of B is larger for conservative states in the USA than the same for the more liberal states.

The results from this increase in the price of religiosity in the long run are reported in column 4 of Table 2, and the short-run dynamics are reported in Figure 2. We find that capital and output remain virtually the same in the long run, as well as labor and leisure, although the short-run dynamics turn out to be very interesting. The higher price of religiosity results in a decline in the level of religiosity from 0.58 to 0.53 in the long run, as expected. Since religiosity, R, is a sluggish variable, and so we observe no change in the values of R when an increase in B is realized, this shock turns out to be somewhat similar to a lump-sum tax shock. This negative income shock reduces the level of consumption immediately.

[Figure 2 about here]

In the short run, however, we observe an interesting pattern. Since capital K is a sluggish variable, then consumption C and labor used in the output sector, L, have to increase [Equation (2)]. As a result, we observe an initial drop in labor use in religious activities (Figure 2). So, the increase in labor raises the marginal product of capital, and capital starts accumulating. As capital is being accumulated along with an increased labor supply, output rose as well. However, this will be reversed soon as higher capital and higher output will raise consumption, and even consumption will rise above the long-run level as consumption and religiosity are substitutes and the price of religiosity increases.

This will start the process of capital decumulation, and eventually, capital will return to the long-run level. A decline in labor for religious activities and a capital increase would commence, lowering the level of religiosity. We observe that the output (as well as the output cost of religiosity) and time used for religious activities show an inverse relationship in transition (Figures 2 and 3). This is analogous to what McCleary and Barro (2006) observe that people in rich countries spend less time devoted to religion but spend more to support organized religion.

Although in the long run output and capital do not change that much, during the transition, we observe an initial increase in output. This increase in output is materialized because of a sharp rise in the labor supply. Since religiosity is a sluggish variable, we observe a gradual decline in religiosity. One way we can visualize the increase in the output costs of religion, B, is through a reduction in the government support for religion. Many countries use taxpayers' money to support religious institutions. This is true not only for developing countries like India and Pakistan, but also for developed countries like Norway, Sweden, and Denmark. Our model suggests that under those circumstances (an increase in B), labor supply and final output are increased, and labor use for religious purposes declined upon the impact of the shock, but eventually these variables will return to close to the original equilibrium. Thus, the policy for reducing support for religious activities and institutions to raise output may seem successful in the short run, but there will be no long-run effect.

4.3. Improvement of Religious Environment and Religiosity Dynamics

An increase in the exogenous religiosity sustainer, M, implies that for a given allocation of labor for religious purposes, the increase in religiosity is larger. This can be characteristic of a change towards a more religious social and cultural environment. In general, societies place more emphasis on religious morals in majority Catholic countries than in majority protestant countries. In recent times, the socio-political environment in India has been more religion-centric than before. The frequent natural disasters in the World can raise the awareness of the people about their mortality, which may essentially increase the importance of religion for many people. In the context of our model, we can argue that these natural disasters, such as the COVID-19 pandemic, may actually raise M, meaning that for the same amount of labor use for religious services, people can sustain a higher level of religiosity. The results are reported in column 5 in Table 2, and the transitional dynamics are shown in Figure 3.

[Figure 3 about here]

We find that output, capital, consumption, and religiosity all increase in response to an increase in the religiosity sustainer. As we have an increase in the religiosity sustainer, agents need less amount of time to keep their religiosity sustained than before. This allows agents to use more of their time working or enjoying leisure. As a result, we observe capital accumulation and, consequently, a much higher output. The income effect of this increased output results in the consumption of leisure and an increased level of religiosity. Again, we can have a higher output and a higher religiosity (also a higher amount of religious expenditure) while the time spent on religious activities is lower.

Since capital and religiosity are sluggish variables, we find that at the impact, labor use for religious activities declines sharply below the long-run level, and as capital starts accumulating, it starts increasing again and reaches a new equilibrium level which is much lower than the initial labor use for religious purposes. This suggests that we may observe higher spending on religious activities while people spend less time on religious purposes in countries. People increase their leisure, which can be manifested by caring for non-economic issues more, and thereby may raise the level of religiosity. In a recent report, authors found that people care more about religion after the COVID-19 pandemic. (NYTimes, April 20, 2025). This is similar to what is observed in the existing literature (Barro and McCleary, 2017).

4.4. Cultural Shifts and Religiosity Dynamics

An increase in the measure of the intensity of secularization, N, lowers output, labor use in the output sector, and lowers the levels of religiosity, capital, and consumption (results are reported in Column 5 of Table 2. Since, for a given level of religiosity, an increased intensity of secularization affects religiosity negatively, the labor used for religious purposes needs to be raised as religiosity is a sluggish variable. This results in a sharp increase in labor use for religiosity. We even observe that religious work hour yields an overshooting. The labor use in output has dropped from 0.273 to 0.259, and output has dropped to 4.688. However, the shadow price of capital (equal to the marginal utility of consumption) and the shadow price of religiosity dropped sharply below the long-run value, and so we observe a small increase in consumption from 4.486 to 4.514

immediately after this shock is realized. The increase in intensity of secularization tends to reduce religiosity R. Since religiosity R is a sluggish variable, the labor used for religious activities, L_r, has to increase to keep R at the initial level. So, L_r jumps to a higher level.

As the capital starts decumulating and religiosity starts declining, the level of time used in religious services starts declining and eventually reaches the new equilibrium level, which is higher than the previous equilibrium. As capital and religiosity start declining, output also starts declining further, while labor use in output starts increasing as the shadow price of capital and the shadow price of religiosity start increasing. Initially, religiosity and the output used for religious purposes stayed the same, while the religious work hours increased dramatically. In the long run, we observe an increase in the time spent on religious activities, a decline in the level of religiosity, and a corresponding decline in the expenditure for religious activities.

Figure 1

An Increase in the Productivity of the

Output Sector (Increase in A)

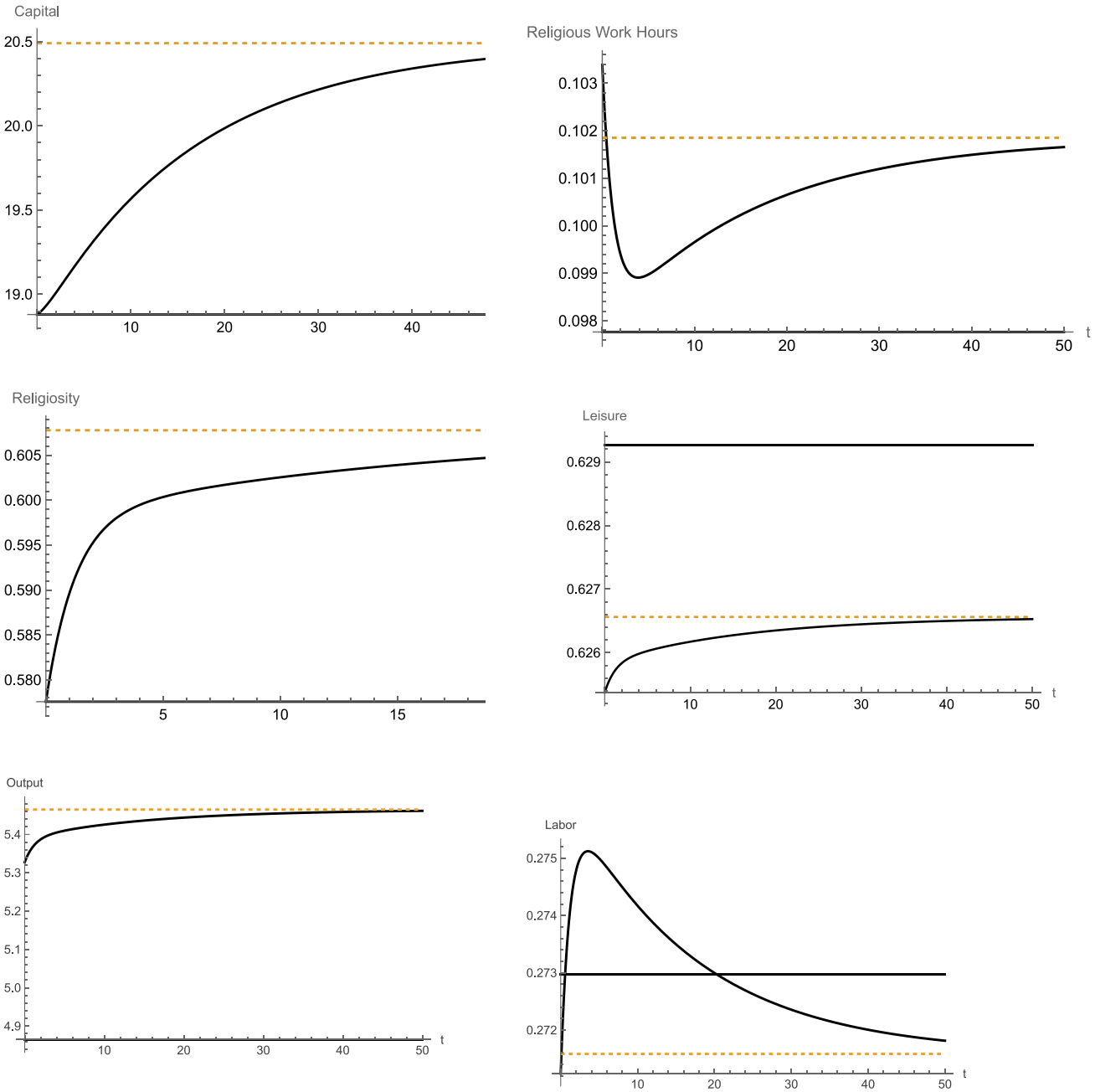


Figure 2

An Increase in Output Costs of Religiosity (Increase in B)

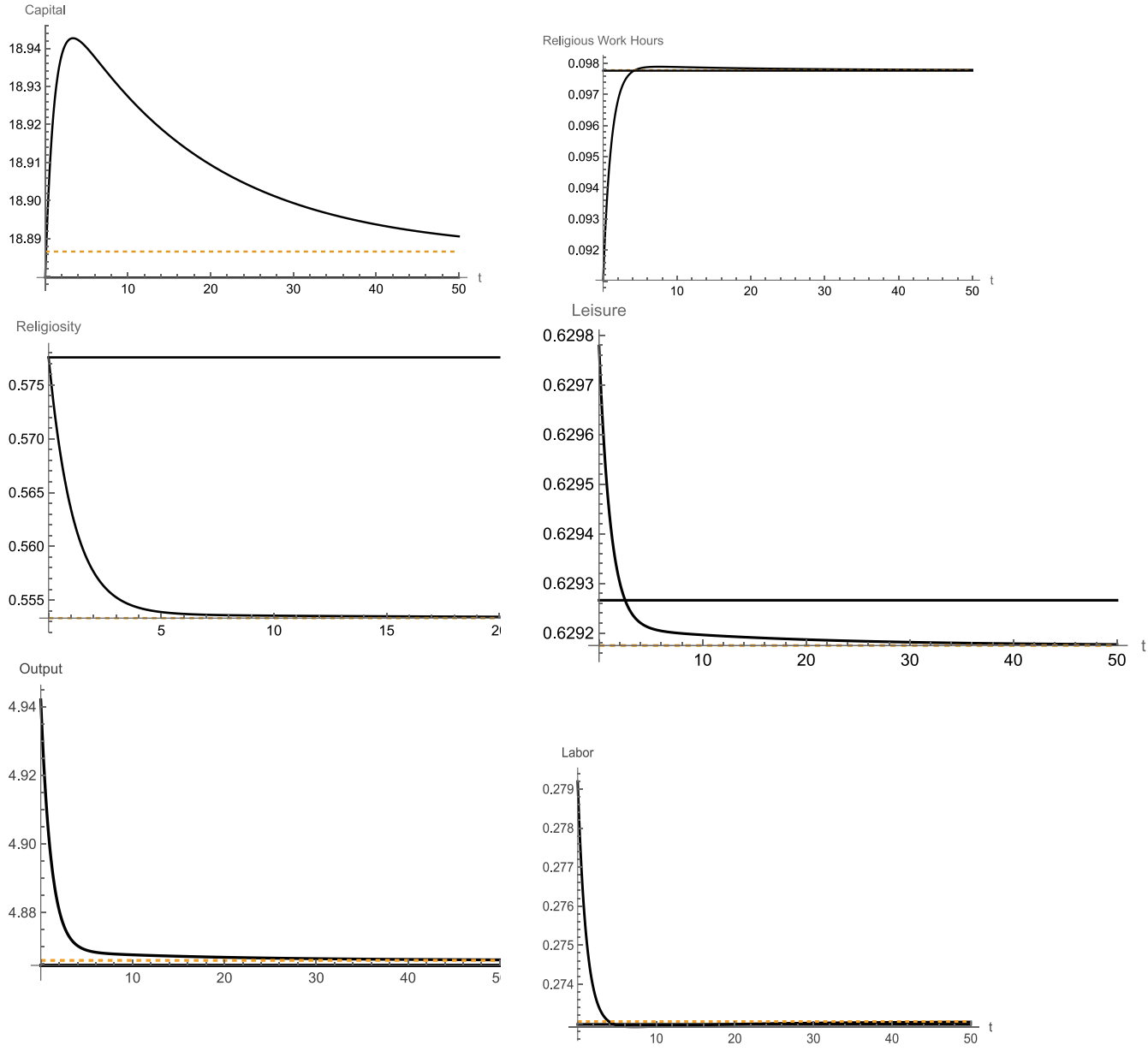


Figure 3

An Improvement in the Religious Environments (Increase in M)

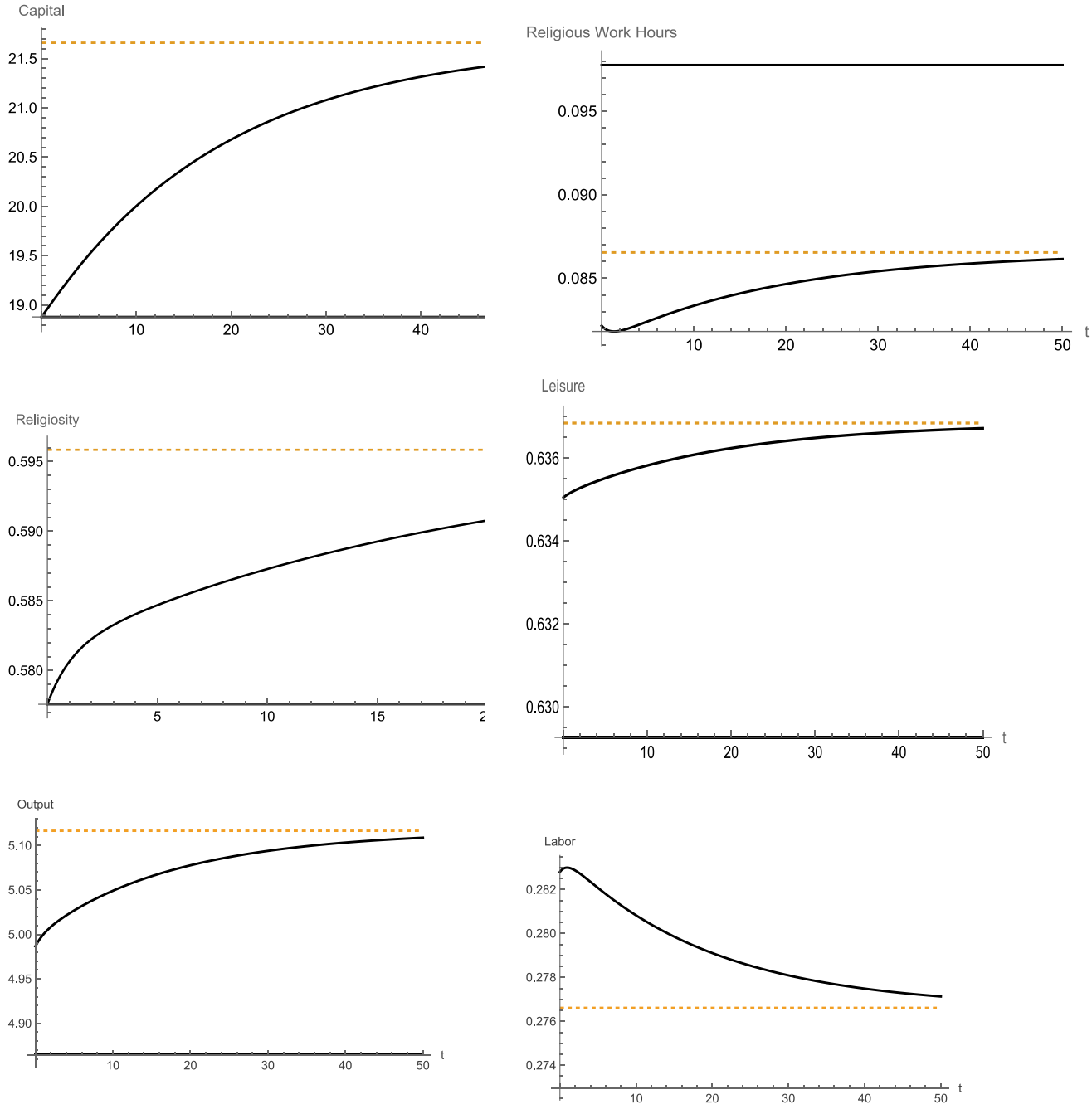
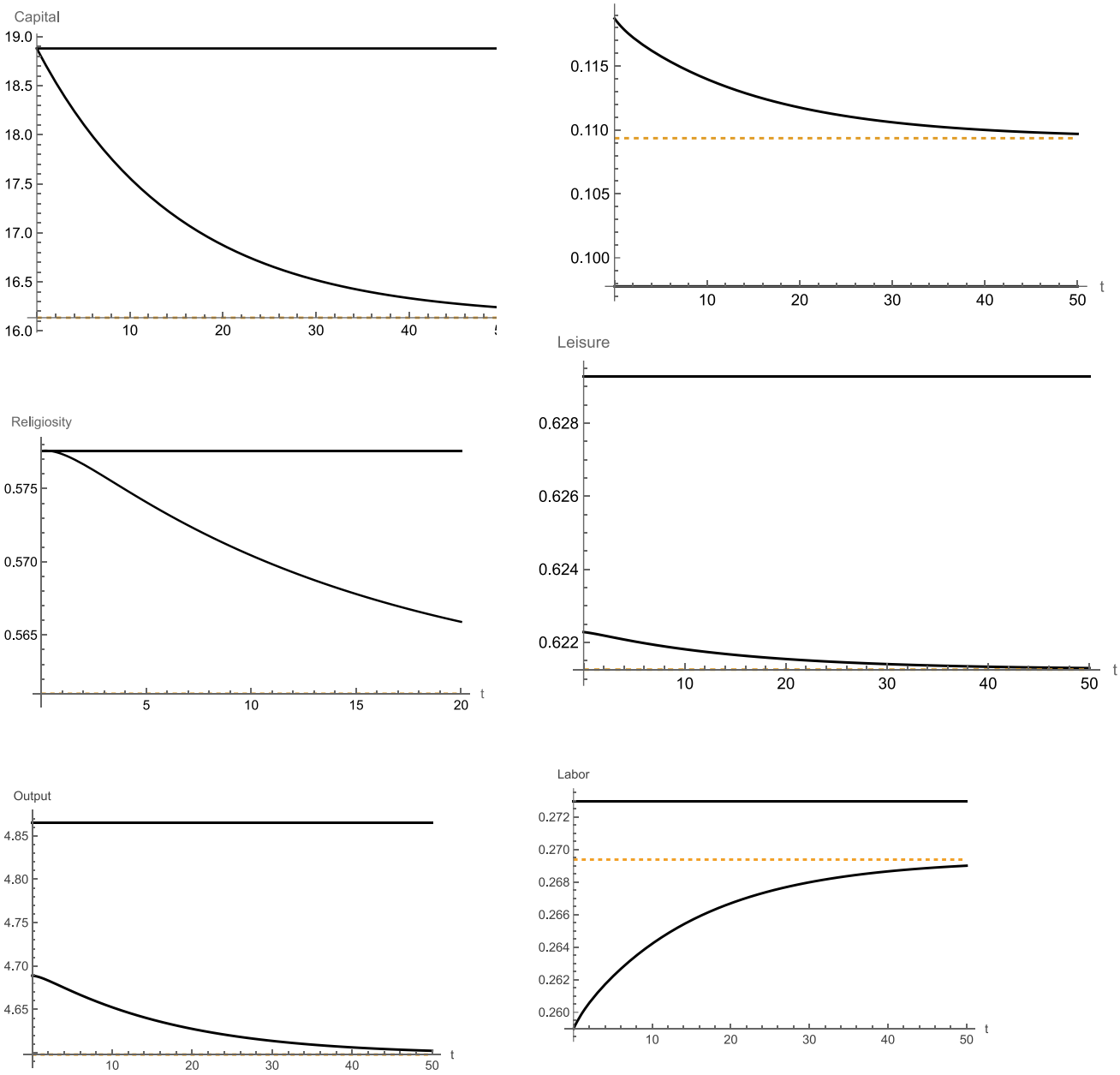


Figure 4

Cultural Shifts and Religiosity Dynamics (An Increase in N)



5. Conclusions

We examine the connection between religiosity and economic performance, focusing on how societal shifts such as urbanization, demographic transitions, and technological advancements, combined with economic factors like income growth, resource allocation, and labor market dynamics, shape religious practices and broader economic outcomes. Departing from earlier research that views religiosity as a static variable, this work treats it as a dynamic variable, evolving in response to external shocks. The novelty in our model is the introduction of religiosity as a state variable, which yields utility. To sustain a certain level of religiosity, agents need to use resources such as labor. The sluggishness of the religiosity, along with labor supply decisions by agents, yields explanations for several puzzling relationships among output, output use for religious purposes, labor use for religious purposes, and the level of religiosity. The findings illustrate how religiosity significantly affects economic variables like capital investment, labor distribution, and personal satisfaction, underscoring its dual role as a source of individual utility and a societal determinant. These insights emphasize the necessity of integrating religiosity into economic models, particularly in societies where religion is deeply interwoven with cultural and social frameworks.

Our simulations reveal the ways religiosity interacts with economic factors across scenarios such as productivity shifts, increased costs of practicing religion, external religiosity-enhancing influences, and intensifying secularization. For example, technological progress that boosts productivity enables individuals to dedicate more resources to religion, reinforcing the notion that religiosity functions as a "normal good." Conversely, rising costs of religious engagement or stronger secularization pressures

diminish participation, reflecting a complex interplay between individual preferences and societal trends. A particularly interesting finding is the U-shaped trajectory of labor allocation to religious activities following productivity shifts, which highlights the trade-offs individuals navigate between economic productivity and religious engagement. This pattern aligns with broader economic theories on opportunity cost and utility maximization, demonstrating how initial economic priorities gradually accommodate religious practices as resources stabilize. These findings offer explanations for cross-country variations in religious behaviors and their economic effects, showcasing how religious practices adapt to broader dynamics and constraints.

By conceptualizing religiosity as a variable that evolves, this study provides fresh perspectives on its implications for policymaking. These insights are particularly relevant to designing social welfare programs that account for religious participation, tailoring taxation policies to support religious donations, and allocating public resources to sustain cultural and religious institutions. Policymakers can use these findings to better understand how economic changes and cultural trends influence religious engagement and the macroeconomy. For instance, analyzing the effects of secularization or religiosity-enhancing factors on labor allocation can inform decisions about social programs, public services, and taxation structures rooted in religious values. Furthermore, the model offers a framework for crafting policies that balance economic growth with cultural and social stability, ensuring that diverse religious needs are respected without impeding developmental goals.

Our model provides a framework for further investigations into the relationship between religiosity and the macroeconomy. The model can be adapted to analyze specific contexts, such as the divergence in religious practices between urban and rural populations or variations across socio-economic groups. It also provides a platform for examining intergenerational shifts in religiosity and their implications. Future research could investigate how religiosity impacts broader systems like institutional trust, community cohesion, and the resilience of social safety nets during economic disruptions. By combining theoretical depth with practical applications, this study establishes a robust framework for understanding the multifaceted relationship between religiosity and economic performance, fostering a more inclusive perspective on how economies function within culturally and religiously diverse societies.

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Appendix 1

The equilibrium dynamics is characterized by a fourth-order system of differential equations for λ_1, λ_2, K, and R

$$\begin{bmatrix} \dot{K} \\ \dot{\mathrm{R}} \\ \dot{\lambda}_1 \\ \dot{\lambda}_2 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} \mathrm{K} - \widetilde{\mathrm{K}} \\ R - \widetilde{R} \\ \lambda_1 - \widetilde{\lambda_1} \\ \lambda_2 - \widetilde{\lambda_2} \end{bmatrix} \quad (A1.1)$$

Where

$$\begin{aligned}
a_{11} &= F_K + F_L L_K - C_{\mathrm{K}}; \\
a_{12} &= F_L L_R - C_{\mathrm{R}} - G'(R) \\
a_{13} &= F_L L_{\lambda_1} - C_{\lambda_1} \\
a_{14} &= F_L L_{\lambda_2} - C_{\lambda_2} \\
a_{21} &= \Phi_{L_R}(L_R)_K - \Psi_K \\
a_{22} &= \Phi_{L_R}(L_R)_R \\
a_{23} &= \Phi_{L_R}(L_R)_{\lambda_1} \\
a_{24} &= \Phi_{L_R}(L_R)_{\lambda_2} \\
a_{31} &= -\lambda_1[F_{KK} + F_{KL} L_{\mathrm{K}}] + \lambda_2 \Psi_{KK}; \\
a_{32} &= -\lambda_1 F_{KL} L_R \\
a_{33} &= \beta - F_K - \lambda_1 F_{KL} L_{\lambda_1} \\
a_{34} &= -\lambda_1 F_{KL} L_{\lambda_2} + \Psi_K \\
a_{41} &= -U_{RC} C_K - U_{Rl} l_K \\
a_{42} &= -U_{RC} C_R - U_{Rl} l_R - U_{RR} + \lambda_1 G''(R) \\
a_{43} &= -U_{RC} C_{\lambda_1} - U_{Rl} l_{\lambda_1} + G'(R) \\
a_{44} &= \beta - U_{RC} C_{\lambda_2} - U_{Rl} l_{\lambda_2}
\end{aligned}$$