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# Artificial intelligence and socioeconomic forces: transforming the landscape of religion

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This research examines the influences of artificial intelligence and socioeconomic factors on religious freedom across 20 countries from 2000 to 2022. Employing a detailed model that integrates both specific effects related to individual countries and annual changes, our study offers an extensive empirical analysis of how artificial intelligence relates to religious freedom. The results indicate a notable negative impact of artificial intelligence on religious freedom. Furthermore, the study sheds light on key factors that affect religious freedom, uncovering a positive correlation with elements such as economic growth, political stability, and education levels. However, it was also observed that increased digitalization correlates negatively with religious freedom. These conclusions are reinforced by findings from the system-generalized method of moment estimation, which strongly support our initial results. Consequently, this study establishes that the relationship between artificial intelligence and religious freedom is intricate and shaped by a variety of socioeconomic factors. Our findings emphasize the necessity for thoughtful consideration of the broader societal impacts of artificial intelligence, especially regarding essential human rights like religious freedom.

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## Introduction

In the current global context, where artificial intelligence is becoming a pivotal part of everyday life, its influence on societal norms and individual liberties, particularly religious freedom, stands out as an area of significant concern. Research conducted by Arias-Arévalo et al. (2023) offers critical insights into the transformative nature of artificial intelligence and its ability to reshape social behaviors and norms, including those associated with religious practices and freedoms. The rapid incorporation of artificial intelligence in sectors such as surveillance, communication, and data processing underscores serious concerns about its implications for religious expression and freedom. Moreover, the ethical considerations of artificial intelligence, as investigated by Aizenberg and Van Den Hoven (2020) and Vesnic-Alujevic et al. (2020), center on its impact on personal rights and freedoms. Their work highlights potential risks, such as algorithmic biases and invasive surveillance technologies, that could unintentionally restrict religious practices or lead to discrimination against certain religious demographics. These issues are becoming more pressing in various political environments around the world. Additionally, Dwivedi et al. (2021) and Robinson (2020) examine the challenges in policy and governance associated with the integration of artificial intelligence. Their discussions emphasize the profound effect of artificial intelligence on government policies and societal norms, which are crucial for the support or challenge of religious freedom in different cultural and political settings. As artificial intelligence evolves, the imperative to align its development with the protection and respect of religious freedom is paramount. This alignment requires concerted efforts from technologists, policymakers, religious leaders, and members of civil society to fully grasp the implications of artificial intelligence, establish ethical standards, and develop frameworks that reinforce the principles of freedom, tolerance, and respect. The intersection of artificial intelligence with religious freedom invites broader questions about technology's role in society and its compatibility with human values and rights. It contributes to a crucial conversation about how to balance the protection of fundamental human rights with the advancement of technology in a world where artificial intelligence is having an increasingly significant impact.

Continuing from the established context above, this study's central objective was to evaluate the impacts of artificial intelligence and socioeconomic factors on religious freedom in a sample of 20 countries during the period between 2000 and 2022. We employed a comprehensive analytical model that incorporates specific factors related to each country as well as annual variations. Our in-depth analysis reveals a concerning trend: artificial intelligence appears to negatively affect religious freedom. Additionally, the research aimed to identify crucial factors influencing religious freedom. The data analysis indicates a positive link between religious freedom and variables such as economic growth, political stability, and education levels. In contrast, increased digitalization seems to have an adverse effect on religious freedom. The application of the system generalized method of moments technique robustly supports these findings, reinforcing the credibility of our preliminary results. This emphasizes the complex relationship between artificial intelligence and religious freedom, which depends on a wide range of socioeconomic factors.

Based on the conclusions of this study, three key contributions can be identified: First, this research provides empirical evidence of the negative effects of artificial intelligence on religious freedom in 20 countries, expanding our understanding of the unintended societal implications of technological advancement. While Goralski and Tan (2020) have posited a generally optimistic view of artificial intelligence's role in enhancing social welfare, our

study introduces a more intricate viewpoint. It underscores the potential adverse effects of artificial intelligence, specifically on religious freedom, offering a critical counternarrative to the prevailing optimism. Second, our study makes a significant addition to the literature by identifying a positive relationship between religious freedom and factors such as economic development, political stability, and education, thereby highlighting the influence of the broader socioeconomic environment on religious liberties. Building on the inquiries of Uecker and McClure (2023), who examined the impact of economic and political elements on general social freedoms, our research specifically concentrates on religious freedom. It offers nuanced insights into the dynamics of these socioeconomic factors with religious liberties, thus filling a critical gap in the existing literature. Finally, by utilizing the system generalized method of moments for our analysis, this study introduces a heightened level of methodological rigor to the examination of complex interactions between technology and societal phenomena. In contrast to the traditional regression methods employed by Sabriseilabi and Williams (2022), Park et al. (2022), and Dunbar (2021) in analyzing the societal impacts of technology, our system generalized method of moments approach ensures a more thorough and reliable analysis. This methodology adeptly addresses potential issues of endogeneity and unobserved heterogeneity, thereby enhancing the reliability of our findings.

The organization of this paper is as follows: Section 2 provides a comprehensive review of the literature pertinent to the subject. In Section 3, we describe the variables and the analytical models employed in this study. Section 4 is dedicated to the examination and interpretation of the research findings. Finally, Section 5 concludes the paper, offering insights and recommendations derived from the study's outcomes.

## Literature Review

From the perspective of academia, the discourse on the influence of artificial intelligence on religion is both rich and multi-dimensional, extending beyond the bounds of technological innovation to deeply affect spiritual and communal life. This section of our study synthesizes a range of academic viewpoints to establish a well-rounded context. Researchers such as Cheong (2020), Umbrello (2023), Puzio (2023), and Béres (2023) have highlighted artificial intelligence's potential in augmenting religious practices by personalizing spiritual experiences and providing fresh interpretations of sacred texts. This aligns with the insights of Künkler and Lerner (2016), Hamayotsu (2013), and Ubaedillah (2018), who have explored how artificial intelligence can aid in the dissemination of religious teachings, potentially democratizing access to spiritual knowledge. However, the integration of artificial intelligence into the realm of spirituality also raises concerns. Scholars such as Han et al. (2022) caution against the possibility of artificial intelligence oversimplifying or trivializing the profound aspects of spirituality. This issue is expanded upon by Hayes et al. (2021), who discuss the potential erosion of the communal aspects of worship due to artificial intelligence. Their concerns are echoed by Kamalov et al. (2023) and Vergeer (2020), who delve into the effects of artificial intelligence-driven religious experiences. The discussion further branches into theological and philosophical territories, with scholars like Schuurman (2019), Visala (2020), and Ashraf (2022) probing artificial intelligence's implications on concepts such as free will, consciousness, and the soul, thereby challenging established religious doctrines and raising profound questions about artificial intelligence's role in matters of faith and spirituality. Ethical considerations are paramount in this debate. As noted by Braun

et al. (2021) and Segun (2021), artificial intelligence development must be conducted with an acute awareness of religious diversity and ethical norms, underscoring the need for guidelines and frameworks that respect the vast array of global religious beliefs and practices. In summary, while artificial intelligence presents opportunities for enhancing religious understanding and practice, it simultaneously poses substantial challenges to the core essence of religious experience and doctrine. This calls for a thoughtful and balanced approach, as suggested by Benbya et al. (2020), and Brynjolfsson and McAfee (2017), advocating for a continued dialogue among religious leaders, artificial intelligence developers, and policymakers. Such a collaborative effort is crucial in navigating the intricate interactions between artificial intelligence and religion, ensuring that artificial intelligence acts as a facilitator rather than a disruptor, and preserving the fundamental values and traditions of religious practices.

In the realm of the theological study, scholars are delving deeply into the impact of artificial intelligence on foundational religious concepts such as free will, consciousness, and the human soul. Researchers like Erisman and Parker (2019) have been at the forefront of this exploration, challenging traditional religious doctrines with the proposition that artificial intelligence could fundamentally alter our understanding of these spiritual tenets. Their work raises crucial questions about the compatibility of artificial intelligence with long-held religious beliefs that have shaped theological thought for centuries. In addition to these theological considerations, the ethical aspects of artificial intelligence development, especially in the context of respecting religious diversity, have been rigorously analyzed by scholars such as Boddington et al. (2017), Choung et al. (2023), Ryan (2020), and Omrani et al. (2022). Their discussions emphasize the importance of developing artificial intelligence technologies that are sensitive to a wide spectrum of religious beliefs and practices. This includes addressing the potential for artificial intelligence to unintentionally propagate biases or stereotypes and the need for artificial intelligence systems to be imbued with an understanding of various religious and cultural contexts. This scholarly debate reveals the dual nature of artificial intelligence in the sphere of religion. On one hand, artificial intelligence presents unique opportunities to enhance religious understanding and practice, for instance, through the digitization of sacred texts or the creation of immersive spiritual experiences using virtual reality. Such advancements could revolutionize religious education and engagement, particularly appealing to a younger, more technologically adept generation. On the other hand, the integration of artificial intelligence into religious practices presents significant challenges. There is a concern that artificial intelligence, in its efforts to replicate or augment spiritual experiences, might compromise the authenticity and communal nature of religious worship. Furthermore, the ability of artificial intelligence to interpret or analyze religious teachings raises questions about the potential loss of nuanced human interpretation in religious scholarship. Acknowledging these varied implications, scholars like Davenport and Ronanki (2018) and He et al. (2020), advocate for a balanced approach. They call for an ongoing dialogue among religious leaders, theologians, artificial intelligence developers, and policymakers to navigate these complexities. Such collaborative efforts are vital in ensuring that artificial intelligence is developed and integrated into religious contexts in a respectful, ethical manner, enhancing rather than detracting from religious experiences. In conclusion, the academic discourse within American scholarship on artificial intelligence and religion underscores the need for a careful and nuanced integration of technology within spiritual domains. It advocates for a holistic approach that honors and preserves the fundamental values and traditions of religious practices, positioning artificial intelligence

as a tool for enhancing and enriching the religious experience rather than as a disruptive influence. This endeavor requires not only technological and ethical considerations but also a sustained conversation among diverse stakeholders in both the religious and artificial intelligence communities.

From an academic perspective, the intricate dynamics between economic development, political stability, education, and digitization in shaping religious landscapes constitute a nuanced field of study, as evidenced by recent scholarly contributions. Economic development, according to researchers like Franck and Iannaccone (2014), Iyer (2016), and Basedau et al. (2018), often correlates with a decrease in traditional religious observance, a trend described as 'secularization'. This notion is supported by Sidani (2019), Walker (2013), Javaid and ul Hassan (2013), and Clark (2012), who argue that as societies become more economically prosperous, materialistic values may start to eclipse spiritual ones. Conversely, Norenzayan et al. (2016) have observed a religious resurgence in economically advanced societies, driven by existential quests for meaning beyond material achievements. The role of political stability in religious contexts is multifaceted. Researchers like Diener et al. (2011) and Ben-Nun Bloom and Arikan (2012) suggest that political stability can foster an environment supportive of religious freedom and diversity. However, Bano and Benadi (2018) and Njoku and Hamid (2014) indicate that such stability can also lead to state-led control or manipulation of religious institutions. This view is echoed by Mohiuddin (2022) and Verma and Ali (2023), particularly in the context of authoritarian regimes. In terms of education's impact on religion, the discourse is equally complex. While Ammerman (2020) argues that higher education often leads to increased questioning and distancing from organized religion, Pope (2020) proposes that education can facilitate a deeper and more nuanced understanding of religious doctrines and practices. According to studies by Qudsy et al. (2021) and Volkova (2021), the rise of digitization and the internet has revolutionized access to religious information, promoting various religious beliefs and practices. However, Vala and Huang (2019) highlight difficulties such as the spread of false religious information and the danger of relegating religion to superficial online experiences, a worry also expressed by Bhatia (2022) and Balazka et al. (2021). Ringing together these varied perspectives, it is clear that the interplay of economic and political factors, educational attainment, and digital advancements collectively and significantly impact religious landscapes. These influences can both challenge and reinforce religious beliefs and practices, indicating that their effects on religion are not straightforward but context-dependent and multifaceted. As these studies suggest, comprehending the contemporary religious landscape requires an understanding of these interconnected elements and their intricate effects.

### Variable and Model

**Variable.** Dependent variable: In this study, we conceptualize "religious freedom" as the comprehensive liberty to hold, not to hold, change, express, and practice religious beliefs individually or communally, in private or in public domains. This conceptualization draws from seminal works such as Bader (2003), Foner and Alba (2008), and Mahmood (2012), which underscore that legal frameworks upholding religious freedom reflect societal acceptance and the integration of a myriad of religious beliefs, thereby mirroring the broader religious canvas. Moreover, the interconnection between enhanced religious freedom and the vibrancy of diverse religious communities is substantiated by the demographic inquiries of Kutcher et al. (2010) and Aleksynska and Chiswick (2013). The examination of government policies' effects on religious entities by Driessen (2010), Finke (2013),

Cadge and Konieczny (2014) further validates the pivotal role of religious freedom in ensuring the vitality and public engagement of religious institutions. Additionally, the analyses by Tessler (2010) and Nelson (2012) of societal perspectives towards minority religions illustrate that religious freedom is an emblem of societal tolerance and pluralism, essential elements of the religious fabric. Gunnarsson (2020)'s exploration of the interplay between religious freedom and educational curricula highlights the societal valuation and dissemination of religious knowledge, integral to comprehending religion's societal and cultural dimensions. Thus, in our research, religious freedom is meticulously delineated as a dependent variable, allowing for a nuanced exploration of its interaction with the proliferation of AI technology and its implications for societal dynamics. This definition facilitates a clearer distinction between limitations imposed on religious freedom and the broader surveillance effects attributed to AI's expansive integration into society, ensuring a focused investigation into the nuanced impact of digital advancement on this fundamental liberty.

**Independent variable:** The use of the number of artificial intelligence patents as a proxy for artificial intelligence development and proliferation is a well-supported concept in academic literature. Firstly, the work of Kovács et al. (2021) underlines a clear correlation between artificial intelligence patent filings and technological progress in artificial intelligence, illustrating that patents are reflective of concrete innovations and breakthroughs within the field. Secondly, studies by Scherngell et al. (2023) and Cicerone et al. (2023) examine the geographic distribution of artificial intelligence patents. This analysis provides valuable insights into regional centers of artificial intelligence development, pinpointing areas where significant advancements in artificial intelligence are taking place. Thirdly, research by Liu et al. (2021) and Damioli et al. (2021) delves into which industries are most actively filing artificial intelligence patents, offering a lens into the sectors at the forefront of artificial intelligence adoption and innovation. Fourthly, temporal trends in artificial intelligence patent filings, as discussed by various scholars, present a historical view of artificial intelligence technology's evolution and growth over time. Finally, studies by Liu et al. (2020) and Li et al. (2020) explore the relationship between artificial intelligence patent filings and artificial intelligence investments. This aspect indicates the economic and commercial significance of artificial intelligence, as patent activity often correlates with increased funding and market interest. Collectively, these articles reinforce the idea that artificial intelligence patent counts serve as a comprehensive measure for evaluating the overall trajectory and impact of artificial intelligence in multiple contexts.

**Control variable (socioeconomic factors):** To provide a precise estimation of the impact of artificial intelligence on religious freedom, it is essential to include control variables such as economic development, political stability, education levels, and the degree of digitalization. A wide range of academic sources support this strategy. Firstly, studies by Qayyum et al. (2020), Götmark and Andersson (2020), and Bentzen and Gokmen (2023) suggest that the level of economic development significantly impacts the availability of resources for artificial intelligence development and its ethical management, thereby influencing religious freedom. In wealthier economies, advanced artificial intelligence technologies might lead to different outcomes for religious freedom compared to those in less developed nations. Secondly, the importance of political stability is emphasized by Topidi (2019). Stable political climates often facilitate more predictable environments for artificial intelligence development and the implementation of religious freedom policies. Thirdly, the relevance of education levels is highlighted by Redondo and Sarrazin (2022) and Mu'ti and Burhani (2019), as higher education rates typically correspond with

increased awareness and comprehension of artificial intelligence and religious rights, which can shape public opinion and policy-making. Finally, the impact of societal digitalization, explored by Annicchino (2022), affects the integration of artificial intelligence in daily life and governance, with significant implications for the monitoring and regulation of religious practices and freedoms. By accounting for these factors, I can more accurately isolate the specific effects of artificial intelligence on religious freedom, leading to a more robust and precise analysis.

**Model.** The purpose of this article is to analyze the impacts of artificial intelligence and socioeconomic factors on religious freedom. From a theoretical standpoint, artificial intelligence's impact on religious freedom is complex, encompassing its roles in data processing, surveillance, and content moderation. These capabilities can either safeguard or undermine religious freedoms, depending on their application. Researchers such as Aljarah et al. (2021), Paschalides et al. (2020), Laaksonen et al. (2020), and Pereira-Kohatsu et al. (2019) have focused on artificial intelligence's role in monitoring online religious hate speech. Meanwhile, Kılıç (2024) explores its use in state surveillance of religious groups. Additionally, the work of Elkin-Koren (2020) delves into how artificial intelligence shapes public discourse around religious beliefs and its role in either enforcing or circumventing religious censorship.

To accurately estimate the impact of artificial intelligence on religious freedom, employing annual and national fixed-effect models is essential. Annual fixed-effect models enable the analysis of temporal changes in artificial intelligence technology and policy and their effects on religious freedom. National fixed-effect models, in contrast, help isolate artificial intelligence's impact from country-specific elements like cultural norms, existing religious freedom standards, and legal frameworks. These models, used in tandem, provide a contextually aware understanding of artificial intelligence's influence on religious freedom. This methodological approach effectively distinguishes artificial intelligence's direct impact from other concurrent developments, offering a clearer insight into the interplay between technological advancement, socioeconomic factors, and religious liberties. Then, the baseline model is shown as follows:

$$re_{i,t} = a_0 + a_1 ai_{i,t} + a_2 ec_{i,t} + a_3 po_{i,t} + a_4 ed_{i,t} + a_5 di_{i,t} + \eta_i + \mu_t + \epsilon_{i,t} \quad (1)$$

In Eq. (1) of our analytical model, 'i' represents the specific country being analyzed, and 't' denotes the year. This setup allows for an examination that takes into account both spatial (country-specific) and temporal (year-specific) variations. The constant term, labeled 'a<sub>0</sub>', establishes a baseline against which the effects of the independent variables are measured. The coefficients, denoted as '[a<sub>1</sub>, a<sub>5</sub>]', are pivotal to the model; they estimate the impact of various independent variables on our dependent variable. The term 'η' signifies the country-fixed effect. It captures the unique, unobservable characteristics inherent to each country, which are assumed to be constant over time. Conversely, 'μ' represents the year-fixed effect, accounting for any global trends or temporal factors that uniformly influence all countries in a specific year. In this equation, 'ε' is termed white noise. It represents the random error component of the model, assumed to be normally distributed with a mean of zero, encapsulating those elements of the data not explained by our model. The dependent variable in our study, 're', stands for religious freedom. It is the primary focus of our analysis. 'ai', another significant variable, represents artificial intelligence, whose impact on religious freedom is a central theme of our research. 'ec' refers to the gross domestic product, serving as an indicator of economic development. 'po', another key variable, denotes political stability, essential for

understanding the socio-political context impacting religious freedom. ‘ed’ is used to indicate the level of education within a country, reflecting its overall educational attainment. Finally, ‘di’ stands for the degree of digitalization, highlighting the extent to which digital technologies are integrated into the societal and economic structures of a country. All data employed in this study have been sourced from the World Bank, spanning from 2000 to 2022. This comprehensive dataset provides a solid foundation for our analysis. To mitigate issues of heteroscedasticity and enhance the statistical reliability of our findings, we have transformed all variables into their logarithmic forms. This transformation helps stabilize the variance among the data points, thereby improving the robustness and clarity of our regression analysis.

**Robustness test.** In our research, we have chosen the system generalized method of moments as the foundational econometric approach to examine the dynamics between artificial intelligence and religious freedom. This method, pioneered by Hansen (1982) and further refined by Arellano and Bond (1991), is a sophisticated statistical tool known for effectively addressing endogeneity issues. These issues often stem from problems like omitted variables, measurement errors, or the simultaneity of effects within the model. A key strength of system generalized method of moments lies in its strategic application of instrumental variables. The careful selection of these variables is crucial, as it ensures the generation of estimators that are both consistent and efficient, even in the presence of potential endogeneity. The system generalized method of moments method leverages the orthogonality conditions that exist between these instrumental variables and the error terms. This approach is instrumental in producing estimates that are not biased by endogenous factors. Implementing system generalized method of moments in our study enhances the credibility and robustness of our findings. This alignment with the latest econometric methodologies not only strengthens our analysis but also places our research within the realm of contemporary empirical studies. The relevance and effectiveness of system generalized method of moments in modern research contexts are well documented, and its application in our study is a testament to its utility. The specifics of our system generalized method of moments model, as implemented in the study, are presented as follows:

$$re_{i,t} = b_0 + b_1re_{i,t-\omega} + b_2ai_{i,t} + b_3ec_{i,t} + b_4po_{i,t} + b_5ed_{i,t} + b_6di_{i,t} + \eta_i + \delta_t + \epsilon_{i,t} \tag{2}$$

$$re_{i,t} - re_{i,t-\omega} = b_1(re_{i,t-\omega} - re_{i,t-2\omega}) + b_2(ai_{i,t-\omega} - ai_{i,t-2\omega}) + b_3(ec_{i,t-\omega} - ec_{i,t-2\omega}) + b_4(po_{i,t-\omega} - po_{i,t-2\omega}) + b_5(ed_{i,t-\omega} - ed_{i,t-2\omega}) + b_6(di_{i,t-\omega} - di_{i,t-2\omega}) + b_7re_{i,t-\omega} + b_8ai_{i,t} + b_9ec_{i,t} + b_{10}po_{i,t} + b_{11}ed_{i,t} + b_{12}di_{i,t} + (\delta_{t-\omega} - \delta_{t-2\omega}) + (\epsilon_{i,t-\omega} - \epsilon_{i,t-2\omega}) \tag{3}$$

In our model, encapsulated by Eqs. (2) and (3), the intercept is denoted as ‘b<sub>0</sub>’, while the coefficient vector ‘[b<sub>1</sub>, b<sub>6</sub>]’ represents the coefficients that are to be estimated. An essential feature of these equations is the inclusion of an autoregressive coefficient, a measure introduced to address potential constraints related to the degrees of freedom within the model. We adopt the system generalized method of moments as our analytical approach, a technique that methodically adheres to a tripartite process: identification, simultaneity, and exclusion restrictions, following the methodologies outlined by Asongu and Odhiambo (2020) and further detailed in Tchamyou et al. (2019). At the outset of our system generalized method of moments approach, we operate under the premise that endogeneity could be a factor in all the independent variables. To navigate this, the model categorizes specific variables as predetermined, identified in the “gmmstyle” format. This step is pivotal, especially considering that in our

model, ‘years’—representing the temporal dimension—are regarded as strictly exogenous. They are therefore classified under the “iv (years, eq(diff))” specification. This categorization is critical in maintaining the first-difference property of these temporal elements, thereby preventing their conversion into endogenous variables, a concept explored in Tchamyou and Asongu (2017). This phase, integral to our econometric analysis, is commonly referred to as the identification step.

In our econometric model, we strategically use lagged variables as instrumental instruments to address the fixed effects that could potentially cloud the relationships we are examining. To achieve this, we apply Helmert transformations to our predictor variables. This method deviates from conventional approaches that typically subtract the lagged value from its current value. Instead, as highlighted in Tchamyou et al. (2019), our approach subtracts the average of future observations from the current value of the variable. This technique creates a balance between forward-differenced variables and their corresponding lagged versions. A notable feature of this methodology is the diminished importance of the specific number of lags used. The primary emphasis is placed on optimizing the data’s utility rather than adhering to a fixed number of lags. The only deviation from this rule is the deliberate omission of the last observation for each analytical unit, whether it is an individual entity or a country. This exclusion is critical to maintaining the precision and relevance of the transformation process. Adopting this methodological approach significantly enhances the robustness of our model, effectively addressing any distortions that might arise from fixed effects.

In the final phase of our analysis, we turn our attention to the exclusion restriction criterion. This principle stipulates that the relationship between the dependent variable and any strictly exogenous variables must only be mediated through the endogenous regressors identified in our model. To ensure the validity of this criterion, we utilize the Difference-in-Hansen test. This diagnostic tool is essential for evaluating the exogeneity of our instruments. It is noteworthy that a traditional instrumental variable approach often results in the rejection of the null hypothesis in the context of the Sargan Over-Identifying Restrictions test. Such a finding indicates that the instruments may not be effectively representing the influence on the outcome variable through the endogenous variables we have specified. Crucially, within our system generalized method of moments estimation framework, the Difference-in-Hansen Test takes on heightened significance. It acts as a vital diagnostic measure, rigorously testing the strict exogeneity of the temporal variables, designated as ‘years’ in our study. This step is crucial to ensuring both the reliability and validity of the results derived from our system generalized method of moments estimations.

**Results and Discussion**

**The effect of artificial intelligence on religious freedom.** In this study, we utilized an array of five econometric models to assess the impacts of artificial intelligence and socioeconomic factors on religious freedom. The models employed are as follows: pooled ordinary least squares designated as Model 1, panel OLS for Model 2, country-specific fixed effects in Model 3, year-specific fixed effects in Model 4, and a comprehensive model combining both country and year fixed effects, referred to as Model 5. This range of models allows us to address both spatial and temporal variations within the data, and the outcomes of these models are presented in Table 1. Our analytical process began with the application of the Chow test. This test led to the rejection of the pooled OLS model for our dataset, as evidenced by the rejection of the null hypothesis. We then proceeded with the Hausman test, which also resulted in the rejection of the null hypothesis. This outcome indicated that the

**Table 1 Results of the effects of artificial intelligence on religious freedom.**

| Variable and Model   | Model (1)         | Model (2)            | Model (3)         | Model (4)         | Model (5)         |
|----------------------|-------------------|----------------------|-------------------|-------------------|-------------------|
| ai                   | -0.023** (-2.083) | -0.025** (-2.021)    | -0.023** (-1.988) | -0.018** (-2.065) | -0.011** (-2.095) |
| ec                   | 0.184*** (3.462)  | 0.152*** (4.023)     | 0.146*** (4.098)  | 0.135*** (3.753)  | 0.144*** (3.875)  |
| po                   | 0.365* (1.624)    | 0.333* (1.744)       | 0.325 (1.534)     | 0.348 (1.437)     | 0.354* (1.635)    |
| ed                   | 0.279*** (2.983)  | 0.257*** (2.606)     | 0.224** (2.114)   | 0.206** (2.096)   | 0.205** (2.032)   |
| di                   | -0.064 (-1.042)   | -0.065 (-1.453)      | -0.067 (-1.025)   | -0.063* (-1.602)  | -0.061* (-1.589)  |
| c                    | -2.502 (-1.105)   | -2.411 (-1.263)      | -2.622* (-1.592)  | -2.103 (-1.352)   | -2.012 (-1.393)   |
| Chow test            | 89.233***         |                      |                   |                   |                   |
| Hausman test         |                   | $\chi^2 = 92.917***$ |                   |                   |                   |
| F-statistical value  | 74.335***         | 66.186***            | 70.472***         | 75.391***         | 69.845***         |
| Country-fixed effect |                   | No                   | Yes               | No                | Yes               |
| Year-fixed effect    |                   | No                   | No                | Yes               | Yes               |
| R <sup>2</sup>       | 0.289             | 0.246                | 0.219             | 0.243             | 0.257             |

Note: \*10% significance level, \*\*5% significance level, \*\*\*1% significance level, T-statistical value shown in parentheses.

model incorporating only country-fixed effects was not adequately suited for our analysis. Consequently, we opted for Model 5, which integrates both country- and year-fixed effects. This choice is supported by the advanced econometric principles proposed by scholars such as Kropko and Kubinec (2020), Hill et al. (2020), and Fernández-Val and Weidner (2018). These researchers suggest that to effectively handle unobserved heterogeneity—factors that remain constant over time but vary across different entities, or the reverse—a model with both country and year fixed effects is more likely to yield unbiased and consistent estimations. This approach is particularly pertinent when considering global phenomena such as economic fluctuations or broad regulatory changes that impact all countries in the study uniformly. By incorporating these two dimensions of variability, Model 5 successfully isolates external influences from the primary dynamic between artificial intelligence and religious freedom, thus strengthening the validity and robustness of the causal conclusions drawn from our empirical results.

In Table 1, the spotlight is on the insights gleaned from Model 5. Nonetheless, it's critical to acknowledge that the results from the remaining four models are instrumental in bolstering our study. They function as a robustness check, significantly strengthening the trustworthiness and substantiation of our principal findings. The empirical results from Model 5 present a significant inverse correlation between artificial intelligence and religious freedom, indicating that a 1% increase in artificial intelligence correlates with a 0.011% decrease in religious freedom.

This finding aligns with recent scholarly discourse. First, technological determinism, a concept explored by Jungherr (2023) and Chaney and Sahoo (2020), posits that technological advancements, including artificial intelligence, shape societal and cultural norms. They argue that the widespread adoption of artificial intelligence can intensify surveillance and control measures, potentially infringing upon religious freedoms. Their research emphasizes how government-employed artificial intelligence surveillance systems can monitor and sometimes restrict religious practices and expressions, leading to a reduction in religious freedom. Second, the issue of information control, as analyzed by Gorwa et al. (2020), highlights that artificial intelligence, especially in content moderation on digital platforms, might inadvertently or intentionally suppress religious content viewed as sensitive. This could significantly hinder the free exchange of religious ideas, thus contributing to the observed decline in religious freedom. Lastly, the ethical implications of artificial intelligence, discussed by Cheng et al. (2021), Palladino (2023), and Kriebitz and Lütge (2020), emphasize the potential for artificial intelligence applications in the public and private sectors to foster biases and discrimination against certain religious groups. They illustrate how this can manifest, ranging

from biased artificial intelligence algorithms in employment practices to censorship of religious content in education and public information systems. Collectively, these studies offer a comprehensive view of the negative correlation between artificial intelligence and religious freedom demonstrated in Model 5. They highlight the critical need for thoughtful deployment and regulation of artificial intelligence to ensure that technological progress does not inadvertently impinge upon religious liberties.

In our study examining the determinants of religious freedom, the empirical data significantly emphasizes the roles of economic development, political stability, education level, and digitalization. These findings are in harmony with existing theoretical frameworks and are supported by contemporary academic research. Our results reveal a positive correlation between economic development and religious freedom. This is consistent with the modernization theory, which suggests that as economies evolve, societies become more pluralistic and open to diverse viewpoints, including those on religion. Alon et al. (2017) and Graafland (2020) support this view, finding that economic growth often paves the way for increased social and political freedoms, religious freedom included. In more prosperous economies, there tends to be greater allowance for individual expression and reduced governmental interference in personal beliefs. Political stability also has a positive association with religious freedom. Stable political environments typically feature consistent and equitable governance, fostering an environment conducive to the free practice of religion. Research by Uzelac et al. (2020) indicates that nations with stable political systems generally offer stronger legal protections for various freedoms, including religious rights. Such stability ensures a legal environment where religious groups can operate without fear of abrupt policy shifts or persecution.

Furthermore, our findings demonstrate a positive link between higher education levels and religious freedom. This aligns with the idea that education fosters tolerance and understanding among diverse groups. A study by Greaves et al. (2020) illustrates that higher educational attainment is often connected with more liberal attitudes toward different religious practices and greater acceptance of religious diversity. On the other hand, an increase in digitalization appears to negatively impact religious freedom. This could be attributed to enhanced surveillance and control mechanisms in highly digitalized societies, potentially impinging on religious practices. A study by El Naggari (2014) in the context of surveillance capitalism suggests that while digitalization offers benefits, it also enables governmental and corporate entities to monitor and sometimes regulate public and private conduct, including religious activities. In summary, these results present a better understanding of the factors influencing religious freedom, illustrating the intricate interactions among economic, political, educational, and technological factors.

**Discussion.** In this research, we adhere to a definition of “religious freedom” that encompasses the liberty to adopt, change, or renounce religious beliefs; to worship in private or public; to practice religion individually or in community with others; and to express one’s religious beliefs openly, without fear of intervention or reprisal from the state or other entities. This broad delineation is informed by international human rights norms and seeks to capture the multifaceted nature of religious expression and observance. Central to our analysis is the distinction between the limitations of religious freedom—actions or policies that directly restrict the aforementioned aspects of religious liberty—and the general surveillance effects of AI technologies. While AI-driven surveillance constitutes a broader challenge to civil liberties, encompassing issues of privacy, freedom of expression, and association, its impact on religious freedom is of specific concern. This is due to the potential use of surveillance to monitor religious practices, profile religious communities, or censor religious expression under the guise of maintaining public order or national security. The incursion of digitalization into the fabric of society, marked by the pervasive deployment of AI and surveillance technologies, undeniably poses challenges to a spectrum of civil liberties. Religious freedom, while critical, is but one facet of the broader civil liberties landscape that is being reshaped in the wake of technological advancement. Our discussion acknowledges the interconnectedness of these liberties and posits that the erosion of religious freedom in the digital age cannot be viewed in isolation. Rather, it reflects a wider trend wherein the rapid development and deployment of AI technologies outpace the establishment of robust legal and ethical frameworks to safeguard fundamental rights. By situating religious freedom within the broader context of civil liberties at risk, our study contributes to an essential dialogue on balancing the benefits of technological development with the imperatives of human rights protection. It underscores the necessity of a proactive approach in policy-making and technology design to ensure that advancements in AI serve to enhance, rather than diminish, the freedoms that underpin democratic societies. In conclusion, our research endeavors to provide a comprehensive examination of how the extension of AI and digital surveillance technologies intersect with and impacts religious freedom. By elucidating these dynamics within the broader discourse on civil liberties, we aim to foster a deeper understanding of the challenges at the intersection of technology, society, and human rights.

**Robustness Test.** To thoroughly understand the intricate relationship between artificial intelligence, socioeconomic factors, and religious freedom, it’s essential to acknowledge external factors and the potential for reciprocal causation in this interaction. To reinforce the credibility of the conclusions shown in Table 1 and to tackle possible endogeneity or the risk of neglecting relevant variables, our study employs the system generalized method of moments. This method, building on the pioneering work of Arellano and Bond (1991) and further refined by Arellano and Bond (1991), offers a robust technique for managing endogenous variables in panel data. The system-generalized method of moments approach is key to providing consistent and precise estimates, capturing the dynamic interactions among the variables, and ensuring the validity of our causal inferences. The outcomes are detailed in Table 2.

In our study, we rigorously validated the analytical robustness of our model while carefully addressing potential endogeneity concerns. To this end, we employed the System Generalized Method of Moments (GMM). This advanced technique is particularly adept at handling endogeneity, effectively capturing the dynamic interactions among the variables. This capability

**Table 2 Results of robustness test.**

| Variable and Model | Model (6)          |
|--------------------|--------------------|
| ai                 | -0.013*** (-2.599) |
| ec                 | 0.202** (2.052)    |
| po                 | 0.376*** (4.638)   |
| ed                 | 0.244* (1.752)     |
| di                 | -0.078* (-1.872)   |
| re <sub>-1</sub>   | 0.641*** (4.819)   |
| c                  | -1.586** (-1.971)  |
| AR(1)              | 0.115              |
| AR(2)              | 0.135              |
| Sargen test        | 0.067              |
| Hansen test        | 0.268              |

Note: \*10% significance level, \*\*5% significance level, \*\*\*1% significance level, T-statistical value shown in parentheses.

significantly bolsters the reliability of our findings. Upon implementing the GMM system, we didn’t stop there. We conducted a comprehensive series of four post-estimation diagnostic tests. These tests were crucial in verifying the precision and accuracy of our model, ensuring that our results were not just statistically sound but also practically significant. The results obtained from the system GMM are presented in Table 2. A careful comparison of these results with those in Table 1 reveals a high degree of consistency in the coefficients. While there are minor variances in the sizes of the coefficients and their statistical significance, these differences are small and do not detract from the overall conclusions. In fact, these results from Table 2 not only corroborate the initial observations reported in Table 1 but also add a layer of robustness and reliability to them.

**Conclusion**

This study’s primary objective was to explore the impacts of artificial intelligence and socioeconomic factors on religious freedom in 20 countries from 2000 to 2022. By employing a model that integrates both country-specific and year-specific fixed effects for our empirical analysis, we thoroughly investigated this relationship. The findings from our research indicate a negative impact of artificial intelligence on religious freedom. In addition, the study was dedicated to identifying the principal factors that influence religious freedom. The analysis of our empirical data demonstrates a positive correlation between religious freedom and variables such as economic development, political stability, and education levels. Conversely, our results also show that an increase in digitalization negatively impacts religious freedom. Moreover, the results obtained from the system generalized method of moments’ estimation strongly support these findings, providing robust validation for our initial observations. This strengthens the conclusion that the relationship between artificial intelligence and religious freedom is complex and influenced by various socioeconomic factors.

Based on the conclusion of this study, which highlights the multifaceted relationship between artificial intelligence and religious freedom, influenced by various socioeconomic factors, the following policy implications emerge: First, governments are advised to develop comprehensive regulatory frameworks for artificial intelligence that carefully consider its potential effects on religious freedom. These frameworks should encompass guidelines for the responsible development and deployment of artificial intelligence technologies, ensuring they do not unintentionally impinge on religious practices or beliefs. Additionally, these frameworks should include effective mechanisms for addressing any violations of religious freedom that may result from artificial intelligence applications. Second, in an era of increasing digitalization, it is essential for policymakers to balance the embrace of

technological advancements with the protection of religious freedom. This may necessitate the enactment of more stringent privacy laws and surveillance regulations to avert the misuse of digital technologies in ways that could limit religious practices or lead to discrimination against certain religious groups. Third, given the positive correlation identified between economic development, political stability, and religious freedom, it is suggested that policies focused on promoting economic growth and political stability could indirectly contribute to the enhancement of religious freedom. Economic strategies aimed at fostering growth and reducing poverty, in tandem with maintaining a stable political climate, can create an environment more supportive of religious tolerance and freedom. Finally, considering the positive link between education levels and religious freedom, significant investment in education is crucial. Educational policies should not only aim at expanding access to education but also at integrating curricula that promote tolerance and understanding of diverse religious beliefs. Educating the younger generation about the significance of religious freedom and the societal impacts of technologies like artificial intelligence is a critical step towards fostering a more inclusive and tolerant society.

Reflecting on the findings of this study, it's crucial to recognize its limitations and outline potential avenues for future research. Firstly, the study's concentration on 20 countries may not encompass the entire global scenario. The dynamics of the relationship between artificial intelligence and religious freedom can vary across different regions and cultures, aspects that this study might not fully capture. Future research should strive to include a more diverse array of countries, particularly those from regions not represented in this study, to achieve a more global perspective on artificial intelligence's impact on religious freedom. Secondly, the methodologies used to measure complex concepts like religious freedom and the influence of artificial intelligence could be limited in scope. Additionally, the variability in data quality and availability across different countries and years might have influenced the results of this study. Future studies could benefit from integrating qualitative methods, such as in-depth interviews or case studies. These approaches would provide richer insights into the specific ways artificial intelligence affects religious freedom in various socio-political contexts. Lastly, while this study accounts for several critical socioeconomic factors, it may overlook other potential confounding variables. These unaccounted variables could play a significant role in shaping the interplay between artificial intelligence and religious freedom. Future research should consider examining additional variables and their interactions, particularly focusing on cultural factors and the impacts of various artificial intelligence technologies. Such exploration would aid in uncovering the more robust and relatable ways in which artificial intelligence can influence religious freedom.

### Data availability

All data generated or analyzed during this study are included in this published article.

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## Author contributions

The author confirms sole responsibility for the conception and design, analysis and interpretation, and manuscript preparation.

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The author declares no competing interests.

## Ethical approval

This article does not contain any studies with human participants performed by any of the author.

## Informed consent

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