Does Religion Matter?
A Study of Regional Variations in Sex Ratios at Birth in China

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Abstract: The sex ratio at birth in China has been increasingly imbalanced since the 1970s when the government implemented a policy to reduce population growth. To explain regional variations in the ratio, existing scholarship tends to focus on economic development for its weakening effect on the Confucian tradition of son preference. However, a perspective which focuses merely on economic development without considering the local religious context yields only a limited understanding of the causes of imbalanced ratios. Considering the rapid growth of religion in China, it is of considerable interest to explore if religion shapes sex ratios at birth. This project bridges this scholarly gap by examining the association between county sex ratios at birth and the presence of each religion using data from the 2000 China Population Census and the 2004 China Economic Census. Applying a spatial error model, this study shows that ratios in counties with more Daoist organizations tend to more imbalanced, while those with more Buddhist and Islamic organizations less imbalanced.

Keywords: Sex ratio at birth, religion, spatial analysis

Introduction

The sex ratio at birth in China has been abnormally high since the 1970s. Concerned with the shortage of food for a large population size, China's government started the nation-wide birth planning campaign, also known as the "later (late marriage), longer (greater intervals between permitted births), fewer (no more than two children for urban residents and three for rural ones)" program (Whyte et al. 2015). In the reform era since 1979, the policy has become increasingly restrictive in response to a perceived national emergency concerning the economic advancement of China (Greenhalgh and Winckler 2005). In 1980 when the one-child policy took effect, married couples were permitted to have one child only. Those who violated the rule would have to pay a hefty fine in the name of social maintenance fee (Short and Zhai 1998). Later in 1984, the policy was relaxed to allow for regional variation and ethnic differences (Bhattacharjya et al. 2008; Greenhalgh 1986; Gu et al. 2007).

The one-child policy has succeeded in slowing population growth in China, but it has also unintentionally put infant girls at risk, as they were aborted or neglected at an early age, which further led to a male-biased sex ratio. Prior to the campaign in 1971, the overall sex ratio at birth, often measured by the number of registered boys under age one per 100 girls of the same age in a given year (Cai and Lavely 2003; Miller 2001), was around the natural value, 107.[1] The ratio was 107 in 1980, increased to 111 in 1985, to 114 in 1993, to 117 in 2000, and by 2010, reached 120 according to census data (Poston et al. 2014).

The increasingly imbalanced sex ratio has been a great concern of demographers. As Amartya Sen (1990) states, underlying abnormally high sex ratio is "a terrible story of inequality

[1] Note that sex ratio by this measurement may not reflect the true value of the ratio at birth, which is the number of boys born for every hundred girls born. In China, data used to calculate sex ratio at birth are mostly from census data or population sampling investigations. These data are less accurate than hospital records where doctors do not conceal the birth of any baby (Huang et al. 2016). Besides, numerating babies under age one potentially neglects those who die in their infancy. Hence, this measurement of sex ratio is the ratio of children at young ages or child sex ratio.

and neglect leading to the excess mortality of infants." A high sex ratio reflects a large number of "missing girls," and to some extent, it indicates female disadvantage in a society (Chakraborty and Kim 2010; Rallu 2006; South et al. 2014). Furthermore, on the other side of the female deficit is the male surplus, which potentially results in social problems including marriage market squeeze, sex crimes, and trafficking in women (Bien et al. 2013; Greenhalgh 2013; Zhu et al. 2009; Tucker and Van Hook 2013).

Existing scholarship has identified several determinants that have attributed to the imbalanced sex ratio at birth in China: birth planning policy, sex-selective abortion, excess female infant mortality, under-enumeration of girl babies, adoption of female infants (Banister 2004; Chu 2001; Hull 1990; Johnson 1993; Johnson et al. 1998; Li et al. 2011; Miller 2001; Shi and Kennedy 2016; Cai and Lavely 2003). From these, sex-selective abortion tends to be identified as the primary cause (Cai and Lavely 2007; Banister 2004; Ebenstein 2010; Miller 2001; Chu 2001; Dupta et al. 2003; Shi and Kennedy 2016). Additionally, Many scholars (e.g., Ebenstein 2010; Greenhalgh 2008; Gu and Roy 1995; Jiang et al. 2011; Poston 2002) believe the underlying root cause for imbalanced sex ratios is parental son preference. If the parents strongly prefer a son over a daughter under the one-child restriction, they are likely to engage in discriminatory practices including sex-selective abortion, abandonment of girl babies, and intentional neglect of girl babies, which results in a male-biased sex ratio. Hence, researchers conclude that the key to fix the "missing girls" dilemma in China is to combat son preference and norms and values that undergird it (Chung and Gupta 2007; den Boer and Hudson 2017; Diamond-Smith and Bishai 2015; Ebenstein 2011).

Demographers concluded that economic development would bring a balanced sex ratio at birth for its weakening effect on the influence of Confucian tradition which highly values sons over daughters (Croll 2000). Indeed, the rapid industrialization and urbanization since the 1970s

have brought significant social changes that undermine the Confucian heritage of son preference in China. Economic development has not only significantly improved women's education, employment, and thus social status (Li and Lavely 2003; Murphy et al. 2011; Gupta et al. 2003; Chung and Gupta 2007), but also challenged traditional family relations and gender system which placed women in a subordinate position (Chu et al. 2011; Logan et al. 1998; Xie and Zhu 2009).

However, a perspective which focuses merely on economic development without considering the local religious context yields only a limited understanding of the causes of the imbalanced sex ratio at birth. Several empirical studies (Löfstedt et al. 2004; Li and Lavely 2003) demonstrate that assumptions that discrimination against girls would diminish with economic development have proven simplistic. For example, Poston et al. (2014) found that economic development had no weakening effect when individuals held strong son preference. Some provinces such as Fujian and Guangdong are found to have highly skewed sex ratios at birth despite their advancement in economic development (Attané 2013).

We argue that including religious context, a crucial component of local culture, could provide a complete explanation for the imbalanced sex ratio at birth. First, religion influence people living in a locality by shaping local subcultures. Roozen et al. (1984) argued that churches might actively engage in advocating for their teachings and values and members of the church could influence the local subcultures through everyday interaction with people in the community. Second, religion is an important factor shaping individual values and attitudes toward son preference and abortion, the two crucial causes of the imbalanced ratio. Different religious groups influence would have different outcomes since they each have different teachings on both gender and family relations.

Besides, since the 1970s, China has experienced rapid revivals of institutional religions, namely Buddhism, Daoism, Catholicism, Protestantism, and Islam.[2] According to the official documentation, the total number of the religious population in China totals exceed 200 million (2018), including 100 million Buddhism followers (Buddhist 2012), 58 million Protestants as estimated by Pew Research Center (2011), about 6 to 12 million Catholics (Jin and Qiu 2010, 107), and 21 million Muslims (Islamic 2012).[3] The fact that the revival of religion coincides with the implementation of the family planning policy makes it worthwhile to examine how and to what degree religion plays a role in shaping demographic trends.

Studies in Western and other Asian countries show that religion affects sex ratio. For instance, Kim and Song (2007) notice that high sex ratios are found in south-eastern South Korea, an area with a long history of Confucian cultural traditions but few Protestant and Catholic churches. Due to their religious teachings that denounce abortion, normal sex ratios of children are found among Christian or Muslim families in India (Bhat and Zavier 2007; Guilmoto 2005), and among Asian immigrants in Canada (Almond et al. 2013). Demographic studies in China, however, have largely ignored the role of religion shaping the sex ratio of a locality.

This study bridges this gap by examining the relationship between religious geography and county sex ratio at birth. In the current study, we first mapped out the geographical distribution of county sex ratios and then applied spatial regression to examine the effect of the number of

[2] Confucianism is not considered as a religion. It is seen as a core component of Chinese culture that is embedded in people's lives. See Kim and Song (2007) for a similar statement about Confucianism in South Korea.
[3] The government statistics (e.g., State Council Information Office 2018) show that the number of Catholics and Protestants in China is 6 million and 38 million respectively, much lower than the estimation by Pew Research Center and scholars such as Jin and Qiu (2010). It is difficult to estimate the number of Daoists as there are no set registration procedures which ordinary believers must follow as part of their religion (State Council Information Office 2018).

religious sites on the ratio. We find religious presence together well economic development in a county has substantial influence on sex ratio at birth.

LITERATURE REVIEW

Imbalanced sex ratios, son preference, and parents' intervention in child-bearing

Scholars (e.g., Li and Lavely 2003; Dupta et al. 2003; Ebenstein and Leung 2010) agree that the root cause for the imbalanced sex ratio is son preference which has been an integral part of Confucian values (Poston et al. 1997). In Confucian tradition, male offspring is considered to be important for economic, cultural, and religious reasons (Li and Lavely 2003; Dupta et al. 2003; Ebenstein and Leung 2010; Arnold and Kuo 1984). Economically, sons are important manual labor force in the agricultural context. Culturally, they are the primary provider of old-age support for parents. In Confucian tradition, grown children, especially male offspring, should live with their elderly parents or grandparents to provide old age support as their filial obligation (Whyte and Ikels 2004; Chu and Yu 2010). Most importantly, sons are wanted for religious reasons, continuing the family lineage and performing ancestor worship ceremonies (Pande et al. 2006; Johnson 1993). The desire of having male offspring manifests itself in parents' intervention in childbearing, further leading to a skewed sex ratio on an aggregate level.

The majority of the scientific community agrees that the imbalanced sex ratio results from the deliberate actions to control the sex composition of offspring (see Attané 2013). This is true especially when there is fertility restriction and prenatal sex determination is available. In such a society, one major intervention in parents' childbearing is sex-selective abortion. Studies in China show that the availability of ultrasound B-machines, a technology of detecting the sex of the fetus before birth, is associated with a rise in sex ratio at birth (Chen et al. 2013; Chu 2001). The government officially banned prenatal sex detection in 1989 and made it illegal to use ultrasound to reveal the sex of a fetus to parents (Shi and Kennedy 2016). However, it did not put

an end to prenatal sex selection. Based on the in-depth interviews conducted by Chu (2001) in 2000, women in several villages of central China could learn the sex of a fetus in private clinics or hospitals through bribing service providers.

The technology of sex determination itself does not skew the ratio, but it does when combined with abortion practice. Parents with strong son preference in China (Chu 2001) and India (Kishwar 1993; Lingam 1991; Manmeet 1993) are reported to practice prenatal sex determination and abort female fetuses to ensure the birth of a boy or avoid the birth of a girl. [4] Chu (2001) collected data among women in rural villages in 2000 and found that half of the survey respondents who reported pregnancy had used sex determination, and nine out of ten of the female fetus in second pregnancies were aborted if their firstborn was a girl.[5] Drawing data from Chinese Children Survey and Local Chronicles, Chen et al. (2013) found that increased local access to ultrasound technology was followed by a dramatic increase in sex ratio, demonstrating that sex-selective abortion was practiced ensuring the birth of a baby boy.[6] Zhu et al. (2009) estimated that an excess of one million boys were born in the past 12 months using data from the National Intercensus Survey of 2005 and stated the combination of abortion and prenatal sex determination accounted for almost all excess males.

In a summary, son preference relates to fertility intervention which would further lead to a high sex ratio when there is fertility restriction and sex selection. Since the year 2011, China

[4] Since the implementation of the one-child policy in 1980, abortion became an essential component of the birth-control campaign. Consequently, the government removed virtually all restrictions on induced abortion (Rigdon 1996; Savage 1988), and abortion laws in China are among the least restrictive in the world (Rahman et al. 1998; Guilmoto and Tovey 2015). Abortion is authorized up to the 28th week of pregnancy (Guilmoto and Tovey 2015).
[5] In some rural areas, if the first child was a girl, the married couple was allowed to have another birth, which was the 1.5 policy. Therefore, it is imperative to have a son as the second child. Otherwise, the couple may not have a son, or may not legally have the third birth.
[6] Specifically, Chen et al. (2013) showed that the sex ratio at parity one was 107.2 when ultrasound technology was unavailable, compared with 108.7 when the technology is available. The gap in the ratio for the second- and higher-order births is much broader. With the adoption of ultrasound technology, the average ratio increased from 113.2 to 121.2 for second births, and from 118.6 to 132.4 for third- and higher- order births.

relaxed the birth policy to allow certain couples to have two children.[7] With this change, one may expect a balanced sex ratio since people with strong son preference may choose to have a second birth of having a son. However, Jiang et al. (2016) analyzed data from the 2013 Survey of Fertility Intentions and Behaviors in Shaanxi Province and found that women with a preference for sons had turned to sex-selective abortion to ensure that their first child was a son instead of having a second birth.[8] In other words, the relaxation of birth policy does not necessarily bring a normal sex ratio. There has been a tendency for smaller family size, "fewer and healthier births," especially among educated couples in China (Basten and Jiang 2014; Nie and Wyman 2005). Park and Cho (1995) demonstrate, when family size norm has become small, son preference distorts sex ratios at birth through parental discrimination against daughters. Thus, it is likely that sex ratios would remain imbalanced with the level of son preference among Chinese couples unchanged (Basten and Jiang 2014).

Religious geography and the imbalanced sex ratio

Existing research focuses on economic development to explain the imbalanced sex ratio at birth in China. In the current study, we bring in religion as a key factor to offer a complete explanation for the regional variations of the ratios. Kim and Song (2007) argued that a causal relationship between regional characteristics and regional level of sex ratios could be established in that local religious culture shapes individual values and attitudes towards son preference and

[7] In the year of 2011, the government started allowing those couples both of whom are single children to have two children. In 2013, couples could have a second child if either husband or wife was an only child, and entering 2015, the government decided to loosen the birth planning policy and implement the Two Children policy (Goodkind 2016). However, the relaxation turned to be insufficient to boost up fertility rate. Goodkind (2016) found that by the year of 2015, although 11 million couples met the criterion of having a second child, only 1.5 million applied, indicating tepid desire for more children.

[8] You may notice abortion attitude is absent from the study of imbalanced sex ratios at birth in China. This is perhaps because people practice abortion driven by the desiring of having a son regardless of their disapproval attitude. For instance, when interviewed their attitudes toward abortion, 92 percent of women in rural China said it was not right to abort female fetuses, and considered it to be unfair for girls. Nevertheless, they practiced abortion under pressure from husband or parents-in-law (Chu 2001). However, it is reasonable to believe that people who strongly oppose abortion is less likely to practice it than those who do not.

abortion, as presented in Figure 1. Previous research suggests that factors at both micro- and macro- levels that affect sex ratios should be examined systematically with empirical data. First, macro-level factors such as cultural norms and economic development may shape individual gender ideology, son preference, and abortion attitude (see Lu and Tao 2015; Bianchi et al. 2000; Fuwa 2004; Karsten and Jürges 2005; Blumberg 1984). Second, individual characteristics such as education, income, and religious identity contribute to diminished/perpetuated son preference and abortion attitude (see Hu and Tian 2018; Karsten and Jürges 2005; Murphy et al. 2011; Gaudin 2011). Therefore, religion, an important factor shaping not only local subcultures but also individual values and attitudes, should be included in understanding imbalanced sex ratios in China.

Various religions have revived and are thriving over the past several decades despite the regulative environment (Yang 2011). Religion in China was seriously suppressed during the Cultural Revolution (1966–1976). The government then regarded religion as feudal and reactionary worldviews that should be eradicated (Yang 2011). All religious activities were banned, and churches and temples were torn down, statues of gods smashed (Yang 2011). Since the launch of economic reforms in the late 1970s, the government has shifted its perspective from ideological Marxism to moderate pragmatism and given up the idea of eliminating religion completely (Ng 2000; Morrison 1984). In 1982, the Chinese Communist Party (CCP) issued the Document No.19 which stated that religious belief should be respected and protected, yet insisted that religion would disappear in the future (Potter 2003). Contrary to what the government had expected – namely that continued modernization would gradually replace people's "feudal" thoughts with modern values, the power of these "feudal remnants" has become stronger during the recent era of modernization (Johnson 1996). In 1982, six years after the Cultural Revolution, the number of religious sites was 40,000 and increased to 83,000 in

2001 (Feng and Hu 2002). According to the 2004 China Economic Census, 2,231 out of 2,873 counties reported having at least one officially-registered religious organization.[9]

Meanwhile, the religious population has been on a steady rise. The total number of Muslims and Christians increased from 10 million in 1982 to 60 million in 2001, and that of Daoists and Buddhists increased by 10 million (Feng and Hu 2002). According to the white paper entitled: *China's Policies and Practices on Protecting Freedom of Religious Belief* and issued by the State Council Information Office (State Council Information Office 2018), the religious population increased to nearly 200 million in 2018. This is rapid growth as compared to the total number of religious believers, 8 million, in 1966 (Feng and Hu 2002). Among all five religions, the growth of Protestantism in China has been particularly eye-catching. According to government statistics, there were about 3 million Chinese Christians in 1982, and there were about 16 million Christians who belonged to officially registered Christian groups between 2004 and 2006, implying a rapid increase (Ying 2009). Additionally, it is believed that there are tens of thousands of Christian house churches in China are that are not registered, indicating a much higher number of Christians in China (Stark and Liu 2011).

Therefore, considering the rapid growth of religion, it is of considerable interest to examine whether it helps to shape county sex ratio at birth. There are several reasons to expect a significant influence. Firstly, different religious groups may hold different attitudes toward son preference and abortion. For instance, studies show that in India, Muslims hold stronger son preference than Christians – measured by the ideal number of sons over the ideal number of daughters (Gaudin 2011; Bharati et al. 2011). In Canada, Almond et al. (2013) find that Christian and Muslim Asian immigrant families do prefer sons in that they tend to continue having

[9] Note these statistics numerate officially-registered religious organizations that are in the red market only. According to Yang (2006)'s triple religious markets, whereas those in the grey and black markets such as house churches and underground Catholic churches remain hidden from official statistics.

children in the absence of male offspring. They further point out that the prohibition of abortion in Christianity and Islam explains why the sex ratio of children among Asian immigrants who are Christians or Muslims is balanced despite parental son preference (Almond et al. 2013).

More importantly, effects of religious teachings on abortion and son preference may spill over to local culture, potentially affecting not just the religious but also others living in areas dominated by these religious traditions (see Adamczyk et al. 2016; Adamczyk and Valdimarsdóttir 2017; Glass and Levchak 2014). Glass and Levchak (2014) point out that conservative Protestant attitudes and values on marriage, birth control, and abortion could help to foster local norms and institutions that encourage early transition to adulthood. This explains that higher divorce rates are found in counties with a higher percentage of conservative Protestants. In the United States, in areas with dominant conservative religious groups, there may not be any abortion clinics nearby, and local churches may take on roles of advocating for life while denouncing abortion as murder (Adamczyk et al. 2016; Adamczyk and Valdimarsdóttir 2017). Similarly, Dingemans and Ingen (2015) confirmed that effect of religious context on individual social trust by finding that people in a country with a higher percentage of Protestants are more likely to trust others, irrespective of their religious affiliation. These studies demonstrate that religious presence could influence the values and attitudes of people living in that locality.

Due to the tight control over religious activities in China, especially those of Christianity and Islam (Yang 2011), the influence of these two religions on local subcultures may be limited. Nevertheless, religious groups in mainland China still manage to influence the general public through non-institutional means, including social media and evangelical activities. For example, it is reported that members of Early Rain Reformed Church in Chengdu of Sichuan Province went out to streets and distributed anti-abortion leaflets to people on Children's Day, advocating for the pro-life teaching of Christianity (Xue 2018).

Additionally, different religious groups differ in the extent to which they are embedded in Chinese culture. Among the five religions, Daoism and Buddhism are believed to be Chinese religion, whereas Islam and Christianity (Protestantism and Catholicism) are referred to as "foreign" religion (Thompson 1996). Islam and Christianity may challenge certain values of Confucian tradition such as ancestor worship (Cao 2010). By contrast, Buddhism, despite its foreign origin, has been much more intertwined with Confucianism than Christianity or Islam (Perrett 2000; Petersen 2001). It has long been viewed as an integral part of Chinese culture.[10] The difference between Buddhism, Daoism, and Confucianism is vague, which is evident in the formation of Chinese folk religion. As Tamney (1998) summarizes, Chinese folk religion includes elements from Buddhism (belief in Karma and rebirth and meditational techniques), Daoism (multiple gods are organized into a hierarchy headed by Jade Emperor), and Confucianism (the idea of filial piety and ancestor worship). It is understood not as a specific type of religion, but as a type of culture by Chinese people which has been embedded in Chinese society for hundreds of years and rooted in the life of Chinese people (Yang 1961). According to C. K. Yang, folk religion fits into the category of "diffused religion," whose beliefs and rituals are integral to social life, functioning as a pervasive influence in every aspect of social life (Yang 1961). As a result, Buddhism and Daoism may perpetuate son preference and skew sex ratios at birth as Confucian tradition does.

Based on the literature review, we would like to test the following hypotheses:

H1: Sex ratios at birth in counties with a greater presence of Chinese religion (Buddhism/ Daoism) are more imbalanced.

[10] Chinese culture is considered as a harmonious aggregate of Confucianism, Daoism, and Buddhism (Lou 1994). All of them are important parts of Chinese culture, and they together are often referred to as "*Rushidao* 儒释道 (Tian 2015)."

H2: Sex ratios at birth in counties with a greater presence of western religion (Islam/Catholicism/Protestantism) are less imbalanced.

Data and Methods

To test these hypotheses, we use data from the 2004 China Economic Census (CEC) and the 2000 China Population Census (CPC). The population census includes information including sex ratios, education, urbanization, and age of each county. As the first national economic census in China (excluding Hong Kong, Macau, and Taiwan), the CEC 2004 enumerated and included information for 72,887 officially registered religious sites in 2,873 counties, including name, street address, year of establishment, along with some other information.[11] From the recorded names, the Center on Religion and Chinese Society at Purdue University differentiated the sites into five religions: Buddhism, Daoism (including Folk Religions), Islam, Catholicism, and Protestantism.

We combined the CEC 2004 and the CPC 2000 to obtain both the religious and demographic information of each county based on GB (*Guobiao* 国标) codes from two datasets. We aggregated the data with county-level GDP information from the *Statistic Materials of Public Finance of Cities and Counties* (2004), in accordance with the county name in specific city and province.[12] We successfully matched 2,677 counties with CPC 2000. GDP per capita is calculated by dividing the county-level population in 2000 using its GDP. We also obtained county-level geographic data from the China Data Center at the University of Michigan in order to map county sex ratio and religious geography.

[11] This includes 72,849 religious sites and 38 religious administrative offices. This study included religious sites only.

[12] The book includes province names, city names, and county names but not their GB codes. We did some work in identifying these counties and assign them with the right GB code in CPC 2000. Some counties and districts were renamed after 2000, thus were excluded from analyses.

Note that the State Administration for Religious Affairs (SARA) of China, in 2014 there was a total of 139,000 religious venues (SARA 2014). Yet, our dataset only includes 72,849 religious sites. It is unlikely that between 2004 and 2014 more than 66,000 religious organizations were newly registered. In China, local government officials are known to underreporting the number of religious organizations or followers for political consideration – the government desires for reducing religion (Yang 2011). Such underreporting affect Christianity and Islam particularly severely for the government highly cautions the growth of so-called "western" religions (Leung 2005). Also, there are 649 counties with zero count on the number of religious organizations. It is unlikely that no temple was present in these counties in the year of 2004. Folk religion has revived and been thriving since the 1980s, and it receives support from local government who hope to profit from temple activities (Chau 2010). The zero count is likely to due to the failure of lower-level local officials to report religious organizations. Thus, we excluded counties with zero counts on the total number of religious organizations in our analyses. The total number of counties became 2,080. Despite these issues in the dataset, the CEC 2004 is the first ever available census dataset of religious organizations in China that allows us to explore the relationship between religious geography and county sex ratio.

Dependent variables

The dependent variable is sex ratio at birth. It is measured as the number of boys between age 0 and 4 per 100 girls of the same age. We use the age range of 0 to 4 (or the child sex ratio) because existing studies have identified several issues in the validity of sex ratio calculations that only include infants under one year old, including delayed-registration, underreporting, and adoption (Cai and Lavely 2003; Goodkind 2004; Johnson et al. 1998; Merli and Raftery 2000). By comparing census data over time, Cai and Lavely (2003) found that a portion of girls that were missing in an earlier census reappeared in a later one. Using this measurement of sex ratio

not only address the underreporting issue in the census data, but also take sex-selective abortion and early childhood mortality due to parental son preference into account. By including five annual cohorts, this measurement reduces the effects of short term fluctuations and thus is more robust and statistically stable (Cai and Lavely 2007).

Independent Variables

Our focal independent variable is religious presence. A frequently-used measurement of religious presence in existing research is the proportion of adherents of a particular religion (or denomination) in a locality (Olson and Li 2015; Olson and Perl 2011). Due to the lack of data on religious adherents in China, we used the number of officially-registered organizations of one religion as an approximate estimator of influence of that religion in an area. Kim and Song (2007) adopted the same measurement to examine religious effects on sex ratio at birth in South Korea and found that the prevalence of Buddhism, the number of Buddhist temples, was positively associated with sex ratio at birth, while that of Protestantism was negatively.

We create five variables separately for five religions representing the number of Buddhist, Daoist, Protestant, Catholic, and Islamic organizations in each county. Note that temples related to folk religious practices are classified as Daoist organizations. Considering the considerable variations of the population across all counties, the number of religious sites is coded as the number of sites per 10,000 people. We further take the log to of it to reduce skewedness.

Control Variables

We control for county-level economic development, urbanization, immigration, and the proportion of Han population. GDP per capita is a measurement of economic development. We use logged GDP per capita in the analyses due to its skewedness. Existing research suggests that the influence of Confucian tradition and son preference tend to be stronger in rural areas than in urban cities (Cooney et al. 1991; Li and Cooney 1993; Zhang and Sturm 1994). Female infant

mortality tends to higher in rural than in urban areas, so does county sex ratio (Huang et al. 2016; Attané 2013). Thus, we expect to find higher ratios in areas with a lower level of urbanization. Urbanization is measured by the percentage of the non-agricultural population in a county. Other socio-economic indicators such as family structure (the percentage of households with two or more generations) and education are not controlled for, though both of them may affect county sex ratio (see Attané 2009; Pande and Astone 2007; Huang et al. 2016). A preliminary analysis of data shows that both variables are strongly correlated with urbanization/economic development, thus adding them may bring collinearity and over-specification issues.

The level of migration/immigration is controlled for. Lu and Tao (2015a) found that out-migration flow of population in an area was associated with diminished son preference. We use net migration rate, calculated as (1 – hukou population/census enumeration) ×100, following the practice made by Cai (2010) and Wang and Chi (2017).[13] The county-level net migration rate captures the proportion of people without local hukou registration to the total population in that county. A positive value of net migration rate indicates migration inflow, while a negative value suggests migration outflow (see Cai 2010). The proportion of Han ethnic population is measured by 100 – the percentage of ethnic minority population in each county. Son preference and Confucian tradition of ancestor worship are primary characteristics of Han Chinese. Thus they are more likely to hold son preference than non-Han Chinese (Skinner 1997). Consequently, high sex ratios tend to be in areas with dominantly Han populations than those with ethnic minorities (Lavely et al. 2001; Cai and Lavely 2007). Besides, China's government relaxed birth planning policy on ethnic minorities, and ethnic minorities are allowed to have at least two births legally (Poston et al. 2006; Greenhalgh 1986).

[13] Hukou refers to household registration. All citizens have to be registered in the locale where they reside, rural or non-rural regions.

Analytic Strategy

This study examines the relationship between county sex ratio at birth and religious presence. The first phase explores the spatial pattern of the sex ratio which provides an overall picture of its regional variations. Second, we use two spatial statistics, global Moran's I and local Moran's I, to determine the spatial clustering of sex ratio at birth. They are the most widely accepted measure for spatial clustering (Cliff and Ord 1973; Ver Hoef and Cressie 1993; Upton and Fingleton 1985). Values of Moran's tests range between -1 and 1, indicating negatively/positively correlation, and the absolute value indicates the strength of correlation. When on average higher/low values of sex ratios cluster together in space, Global Moran's I will be positive. If the ratio of a particular county and that of its neighboring counties are both highly skewed, Local Moran's I for this particular county will yield a positive value. If spatial dependence is detected, geographically weighted regression (GWR) instead of ordinary least squares (OLS) regression is favored to control for spatial autocorrelation.

Note there are two types of spatial processes that may cause the spatial pattern of clustering: spatial dependence and spatial heterogeneity. The effects of these two types of spatial processes are impossible to be empirically disentangled in cross-sectional data but need to be determined based on some a priori assumptions (Anselin 2001, 1988). Spatial dependence refers to a contagion-type effect where the sex ratio in one region proliferates into the neighboring regions, therefore resulting in clusters. On the other hand, spatial heterogeneity results from the contextual variation over space, due to some exogenous factors such as climate, topography, culture, or demographic diversity across areas (Anselin 2001). To decide the appropriate specification in this context, we follow the classical approach adopted in the spatial econometrics literature, the Lagrange Multiplier (LM) test. The LM test is designed to distinguish between spatial dependence as a nuisance and a substantive spatial process, and they guide the choice

between spatial error autocorrelation and a spatial lag (Anselin and Rey 1991). Regarding weight matrix W, we use a first order contiguity spatial weight matrix that identifies contiguous counties that share common boundaries (often known as queen contiguity).

The third phase is to examine associations between county sex ratio and the number of religious sites. Previous researches show sex ratio often is spatially dependent and highly imbalanced values tend to cluster in space (Cai and Lavely 2007; Echávarri and Ezcurra 2010).[14] The clustering potential in county sex ratio suggests that spatial dimension needs to be taken into account in examining its relationship with religion. All analyses and models are run in ArcGIS 10.3 and *Geoda*^{TM}.

Results

Table 1 presents descriptive statistics of variables used in analyses. The table shows county sex ratio, measured by the number of boys aged between 0 and 4 per 100 girls of the same age, is 116 on average based on the 2000 census. It is slightly lower than the value 120, measured by the number of boys aged 0 per 100 girls of the same age in the year 2000. This discrepancy between the two numbers suggests the potential under-enumeration of female births in census collection. Map.1 presents regional variations in county sex ratio in China. The map shows that less imbalanced ratio is found in the northwestern part of China, whereas highly imbalanced ratio in the southcentral and east China. Provinces in southcentral China, such as Guangxi, Guangdong, and Henan, and those in the east, Fujian, Anhui, Jiangxi, and Jiangsu are home to high ratio, above 110. Balanced ratios are found in regions with dominant non-Han population, such as Xinjiang and Tibet. Besides, the map suggests a clustering pattern of county sex ratio, similar values, high or low, tend to cluster in space.

[14] You may suggest that multi-level modeling would be an appropriate modeling strategy given the local variation in birth planning policy. However, the analyses on child sex ratio (age 0–4) by Cai and Lavely (2007) show that high or low ratios do not correspond to provincial boundaries. Thus, we believe that spatial regression is a better modeling strategy.

We further conducted the diagnostics of spatial dependence to decide whether spatial dependence is a concern in the dataset and which spatial autoregressive model to apply. Table 2 presents the results of spatial dependence diagnostics for the OLS model (with all predictors included). The table shows that Moran's I is positive and statistically significant ($p < 0.001$), indicating the presence of spatial dependence; thus spatial autoregressive model is needed. Furthermore, the LMLAG (for spatial lag) and the LMERR (for spatial error) are both significant, but the Robust LM (for spatial lag) is not significant. According to Anselin (2004), the diagnostics results (shown in Table 2) suggest the use of the spatial error model (SEM), meaning that the clustering pattern of county sex ratio is more a nuisance than a substantive spatial process. The equation of SEM is presented below:

$$Y_{ij} = \beta_0 + X\beta + \lambda W\varepsilon + \varepsilon;$$

λ is the spatial autoregressive coefficient, W is an N by N spatial weight matrix, and ε is an N by one vector of i.i.d errors. The spatial matrix W expresses the strength of potential interaction between each observation and its neighbors (Anselin and Rey 1991).

Table 3 presents regression estimates predicting county sex ratio. This first model (GDP) is the OLS model which includes only logged GDP per capita. It shows economic development is negatively significantly associated with county sex ratio, which is consistent with previous research. Specifically, one unit increase in logged GDP per capita is associated with 1.53 decrease in the ratio ($p < 0.001$), meaning that a ten percent increase in GDP per capita is associated with 0.14 decrease in the ratio.

The second Model (+Religion) includes all religious predictors. Including religious factor significantly improves R-square, from 0.007 to 0.131. The results show that the logged number of religious sites is significantly associated with county sex ratio for all five religion, Buddhism, Catholicism, Daoism, Protestantism, and Islam. Ratios in counties with more Buddhist, Catholic,

and Islamic sites are predicted to be less imbalanced ($p < 0.001$), whereas those in counties with more Daoist ($p < 0.001$) and Protestant ($p < 0.05$) sites more imbalanced. Specifically, one unit increase in logged Buddhist temple per 100,000 people in a county decreases the ratio by -3.47 ($p < 0.001$) controlling for logged GDP per capita. It means that a 10 percent increase in the number of Buddhist temples decreases the predicted ratio by 0.31 (= 3.25*log(1.1)). A 10 percent increase in the number of Daoist temples predicts 0.68 (= 7.11*log(1.1)) increase in the ratio ($p < 0.001$).

The third model (+ Control) includes all control variables.[15] The model results show that with control for these variables, the presence of all types of religion except for Protestantism remains significantly associated with county sex ratio at birth. Logged GDP per capita, urbanization, and immigration is negatively associated with the ratio ($p < 0.01$), whereas the percentage of Han population is positively ($p < 0.001$). A 10 percent increase in the GDP per capita predicts 0.2 (=2.06*log(1.1)) decrease in the ratio. Note that the logged number of Protestant sites became statistically insignificantly after including demographic controls. The effect size of Buddhism, Catholicism, Daoism, and Islam all shrank after controlling for socio-economic factors.

The final model (+ Spatial) is the spatial error model which adds a spatial dimension in county sex ratio at birth. The model results show there is a significant spatial dependence in the ratio. The correlation between sex ratio at birth of one county and that of its neighboring counties is 0.76, statistically significant ($p < 0.001$). Accounting for the spatial dependence yields a great

[15] There may be multi-collinearity issue adding in all religious predictors in one model at the same time. We conducted collinearity diagnostics on all predictors using Stata 15. The test results show that VIFs are below 2, suggesting that multi-collinearity is not a concern according to the rule of thumb by Paul Allison (2012). He claims that multi-collinearity is a concern when a VIF is higher than 2.50, which corresponds to an R^2 of .60 with the other variables.

improvement of the model fit. The R-square became 0.658 as compared to 0. 242 in the previous model.

Compared with results from the previous model, the effect size of logged GDP per capita shrank by nearly half, and the percentage of net immigrants became statistically insignificant. The logged number of religious sites for Buddhism, Daoism, and Islam remain significantly associated with the ratio ($p < 0.001$), while no significant relationship is found for that of Protestant/Catholic churches. With accounting for a spatial dependence, a 10 percent increase in the number of Daoist sites per 100,000 people in a county is expected to increase the ratio by 0.16 (=1.71*log(1.1)), whereas the same increase in the number of Buddhist sites is associated with a decrease of 0.11 (=1.20*log(1.1)) in the ratio. A 10 percent increase in GDP per capita is expected to lower the ratio by 0.11 (=1.18*log(1.1)). The comparison of the effect size of religious presence and economic development suggests that religion has substantial impact on county sex ratio.

In summary, several findings are worth noting. First, county sex ratio at birth is spatially dependent. Similar ratios (imbalanced or balanced) tend to cluster together geographically. Second, as the literature suggests, economic development has a significant mitigating effect on county sex ratio. Less imbalanced ratios tend to be in counties that are economically advanced. Third, religious presence in a county plays a significant role shaping its ratio and the association differs for different religions. The number of Buddhist ($p < 0.001$) and Islamic ($p < 0.001$) sites are negatively associated with county sex ratio, while that of Daoist temples positively ($p < 0.001$). No statistically significant effect is found for Protestantism or Catholicism.

Discussion and Conclusion

Religion in China has survived and been reviving since the 1970s. With the increasing presence of religious organizations and faithful population, it is of scholarly consideration to

explore whether religious geography plays a role in shaping demographic trends in China. This current study shows that religious presence in a county influences its sex ratio, measured by the number of boys aged between 0 and 4 per 100 girls. Besides, the effect size of religious presence on county sex ratio is not neglectable. It is even greater than that of economic development. For instance, we may observe highly imbalanced ratio in a county with a great presence of Daoist temples despite its advancement in economy. In other words, bringing religion as a key factor could provide a complete understanding of sex ratios at birth.

Note that different religion affects county ratio differently. First, Daoist presence tends to worsen the ratio. This is likely due to the embeddedness of Daoism in the Confucian tradition. The tradition of having sons to continue the family line could lead to parental discriminatory practices against female fetuses and infant girls which further results in a male-biased sex ratio on an aggregate level. On the contrary, Islamic presence helps to mitigate the imbalanced ratio. The reason may be that people living in those areas would abide by or are greatly influenced by the Islam teachings of denouncing abortion which protect unborn daughters (Almond et al. 2013).

Second, the speculation that Buddhist presence may worsen county ratios is not supported. Our analyses show that ratios in counties with a greater Buddhist presence tend to be less imbalanced as opposed to balanced based on theoretic speculations on the closeness between Buddhism and Confucian tradition.[16] Perhaps, Buddhism could effectively foster a disapproval attitude toward abortion among people living in the county.

[16] Some may suspect this negative relationship between the number of Buddhist temples in a county and its sex ratio is caused by the uniqueness of Tibet, a province dominant with non-Han population and Tibetan Buddhism. It is possible that the relationship between the ratio and the presence of Buddhism was hugely inflated by the particular case of Tibet for the family planning policy is loose in non-Han regions. Such concern also applies to Xinjiang, a province with dominant ethnic minorities as Muslims. To address this concern, we reassessed the model excluding the two provinces, Tibet and Xinjiang. The finding still holds. Both Buddhism ($p < 0.01$) and Islam ($p < 0.001$), measured by the logged number of religious organizations, are negatively associated with county sex ratio. The coefficient of Buddhism shrank a little bit, became 1.1, whereas that of Islam increased to 2.0. In summary, Buddhism and Islam have a balancing effect on the highly skewed sex ratio.

Third, our analyses lend no support to the mitigating effect of Christianity (Protestantism/Catholicism) on county ratio. There are several reasons why we failed to find any association between the two. It might be a measurement issue. In the current study, our data included officially registered religious organizations only, with no information on the number of underground Catholic churches and that of house churches of Protestantism. It is likely that the number of officially-registered churches fails to capture the influence of Christianity in a county. It might be that Christian influence has not grown strong enough to challenge the Confucian tradition of son preference that has been deeply embedded in Chinese society. This is evident in the study by Cao (2010). He observed that devout Christians in Wenzhou, so-called China's Jerusalem, though they would intentionally distance themselves from ancestor worship, held strong son preference and some of them even chose to violate the policy in order to have another birth of having a son (Cao 2010). The finding that Christianity has no effect on county sex ratio may suggest that the influence of Confucian tradition still remain strong and pervasive.

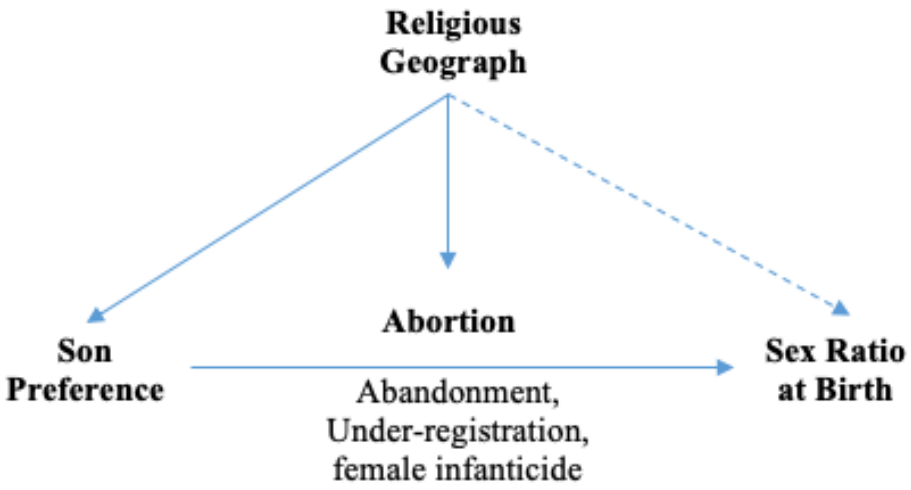
Some limitations need to be mentioned. First, the measurement of religious presence may fail to capture the true influence of some religions, especially that of Catholicism and Protestantism. However, data on religious organizations employed in the current study are the most recent and available in China. More detailed information on religious population, e.g., the percentage of adherents for different religious groups, and religious presence, e.g., the size of the temple/church, is needed to probe into the relationship between religious presence and county sex ratio. Second, this study did not account for the presence of Confucian tradition, due to the lack of data. Future research is needed to examine the interaction between religious presence and local Confucian tradition in affecting county sex ratio at birth.

Despite these limitations, this study contributes to a better understanding of regional variations in sex ratios at birth by highlighting the influence of religious presence. It suggests the

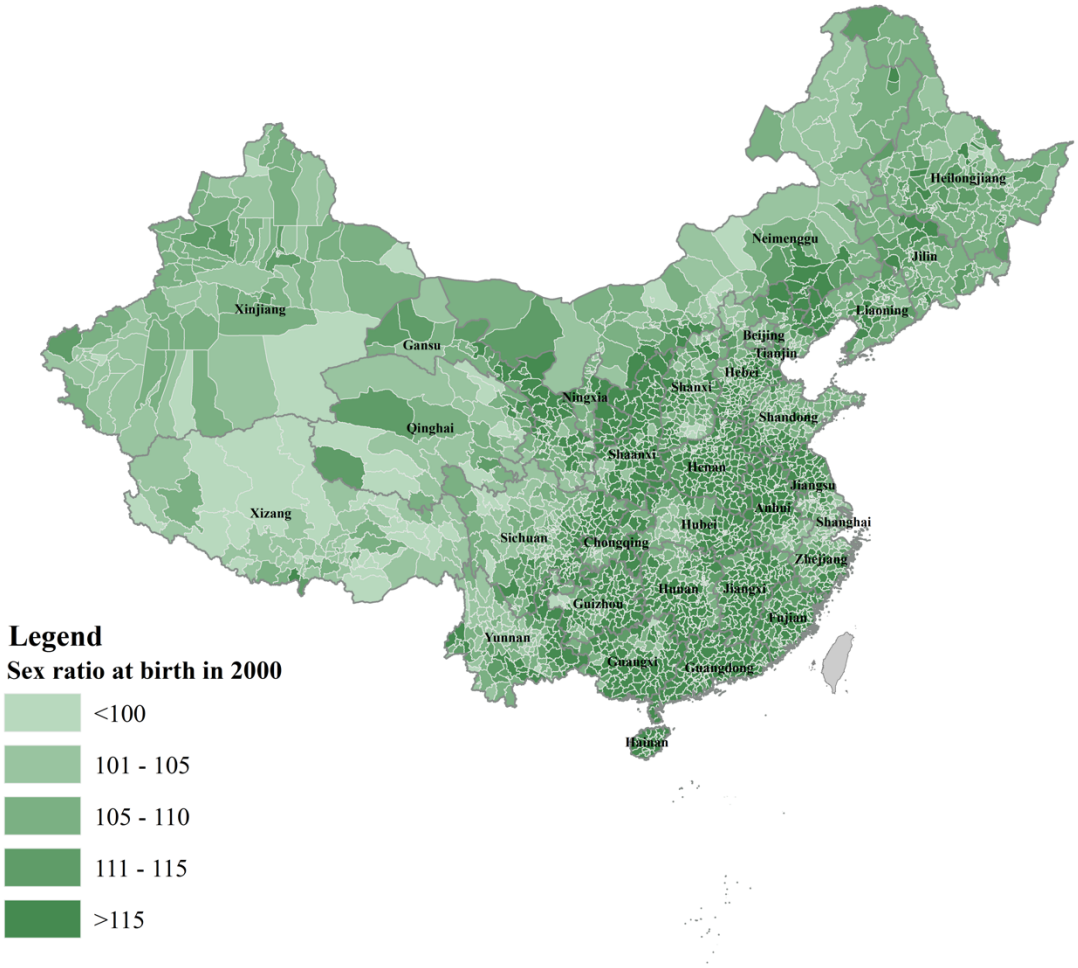
importance of bringing religion as a key factor in demographic studies. Indeed, economic development strongly affects sex ratio. And religion plays an equivalently important (or even stronger) role in shaping the ratio. Future research is needed in order to provide a detailed picture of how religion shapes demographic trends via influencing individual attitudes and values on son preference and abortion.

Appendix:

Figure 1: A causal relationship between religious geography and sex ratio at birth



Map 1. County-level Sex Ratio in 2000



Note: Sex ratio is measured by the number of boys aged between 0 and 4 per 100 girls.

Table 1. Variable Definitions and Sample Descriptive Statistics (N=2,080)

Variable	Definition	Mean	SD
County sex ratio	Number of boys aged at 0 and 4 per 100 girls of the same age	115.97	13.87
GDP per capita	GDP per capita (in 1,000 *yuan*)	10.08	10.43
Logged GDP	Logged GDP per capita	1.99	0.78
Buddhist temples	Logged number of Buddhist sites per 10,000 people	0.75	1.03
Catholic churches	Logged number of Catholic sites per 10,000 people	0.15	0.31
Daoist temples	Logged number of Daoist sites per 10,000 people	0.17	0.45
Protestant churches	Logged number of Buddhist sites per 10,000 people	0.45	1.08
Islamic mosques	Logged number of Buddhist sites per 10,000 people	0.51	0.69
Urbanization	Percentage of non-agricultural population	28.17	24.90
% Han	Percentage of Han population	83.64	29.30
Net migration	Percentage of immigrants	0.24	11.90

Table 2. Diagnostics of Spatial Dependence for OLS Model

Test	MI/DF	Value	Prob.
Moran's I	0.5959	38.9214	0.0000
LM (lag)	1	383.4416	0.0000
Robust LM (lag)	1	0.3339	0.5634
LM (error)	1	1486.9992	0.0000
Robust LM (error)	1	1103.8915	0.0000

Note: Calculated by the *Geoda*^{TM} software. The aforementioned spatial weight matrix has been used in these diagnostics.

Table 3. Regression Estimates for County Sex Ratios, N=2,080

	GDP	+ Religion	+ Control	+ Spatial
Logged GDP per capita	-1.525***	-2.420***	-2.058***	-1.183***
	(0.389)	(0.370)	(0.371)	(0.329)
Buddhist		-3.472***	-1.788***	-1.201***
		(0.293)	(0.347)	(0.352)
Catholic		-3.000***	-4.120***	-0.221
		(0.933)	(0.875)	(0.663)
Daoist		7.108***	4.131***	1.714***
		(0.699)	(0.692)	(0.580)
Protestant		0.918**	0.554	0.053
		(0.429)	(0.406)	(0.332)
Islamic		-2.915***	-1.251***	-1.216***
		(0.267)	(0.288)	(0.337)
Urbanization			-0.146***	-0.106***
			(0.012)	(0.011)
% Han population			0.145***	0.090***
			(0.013)	(0.015)
Net migration			-0.063**	-0.017
			(0.026)	(0.020)
Spatial error of Sex Ratio (λ)				0.737
				(0.015)
Constant	119.001***	123.499***	113.625***	115.634***
	(0.831)	(0.869)	(1.381)	(1.543)
R-square	0.007	0.131	0.242	0.658
Log Likelihood	-8413.132	-8274.641	-8132.81	-7,484.002
Akaike's Information. Criterion	16830.300	16563.300	16285.600	14,992.000
Wald Test $\lambda = 0$				2,369.704***
LR Test $\lambda = 0$				1,297.617***

Note: The dependent variable is county sex ratio at birth, measured by the number of boys aged between 0 and 4 per 100 girls. Religious presence is calculated as the logged number of sites per 10,000 people. Standard errors are in parentheses.
* p <0.05; ** p <0.01; *** p <0.001

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