

# Agricultural Risk and the Spread of Religious Communities

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## Abstract

Building on the idea that members of religious communities insure each other against some idiosyncratic risks, we argue that religious communities should be more widespread where populations face greater common risk. Our argument builds on idiosyncratic and common risks aggravating each other. This implies that individuals have a greater incentive to mutually insure against idiosyncratic risk when greater common risk makes the worst case scenario of bad realizations of common and idiosyncratic risks more likely. Our empirical analysis exploits rainfall risk as a source of common agricultural risk in the nineteenth-century United States. We show that a greater share of the population was organized in religious communities in counties with greater rainfall risk. The link between rainfall risk and membership in religious communities is stronger among more agricultural counties and counties exposed to greater rainfall risk during the growing season. We also find that among the historically more agricultural counties, more than 1/3 of nineteenth-century differences in religious membership associated with rainfall risk persist to the turn of the twenty-first century.

**Keywords:** Religious community membership, agricultural risk, informal insurance

**JEL Codes:** Z12, O13, N31

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# 1 Introduction

Most of today's major religious communities provide social assistance and access to support networks, and historically religious communities have often been the only source of support beyond the family (Bremner, 1994; Parker, 1998; Pullan, 1998, 2005; Cnaan et al., 2002; Harris and Bridgen, 2007; Gruber and Hungerman, 2007; Belcher and Tice, 2011). The social support provided by religious communities appears to be a type of informal mutual insurance especially valuable in historical agricultural societies exposed to much economic risk and without formal insurance mechanisms (McCleary and Barro, 2006a). Economic risk could therefore have contributed to the spread of today's major religious communities and beliefs in the spiritual rewards of mutual aid and charity, but empirical evidence is lacking.

Historical census data for the United States provide a rare opportunity to examine the link between economic risk and the spread of religious communities in a society with little formal insurance. In 1890, the US Census collected data on church members and seating capacity in around 2700 counties. Data on the seating capacity of churches are also available for 1870, 1860, and 1850. Agriculture was the dominant sector in more than four of five counties until 1890 (Haines, 2010). As almost all of agriculture was rainfed, output was subject to rainfall risk (USDA, 1923, 1925). The rainfall data needed to obtain proxies for rainfall risk at the county level are available starting in 1895 (PRISM, 2011). Hence, we can investigate whether a greater part of the population organized into religious communities when they faced greater economic risk by examining whether in the nineteenth-century United States churches in counties with higher rainfall risk had more total members or a greater combined seating capacity relative to population.<sup>1</sup>

Our theoretical analysis of the link between economic risk and the spread of religious communities builds on two preexisting ideas: Religious communities can sustain mutual insurance against at least some risks, and religious membership is a social activity that reduces time for other activities (Berman, 2000; McCleary and Barro, 2006a,b; Dehejia, DeLeire, and Luttmer, 2007; Glaeser and Sacerdote, 2008; Chen, 2010). These ideas are integrated into a model where

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<sup>1</sup>As we can only measure rainfall risk since 1895, our empirical analysis presumes that nineteenth-century differences in rainfall risk across counties persisted into the twentieth century. Our rainfall data for 1895-2000 indicate that county-level rainfall risk is very persistent over time.

the agricultural output of farmers in an area (a county) is subject to idiosyncratic risk and to common (county-level) rainfall risk. Idiosyncratic risk is partially insurable within a county's religious communities, while common rainfall risk is not. We then show that when relative risk aversion is in the empirically relevant range, the value of mutual insurance against idiosyncratic risk within a county's religious communities increases with common rainfall risk.<sup>2</sup> Intuitively, this is because for risk aversion in the empirically relevant range, idiosyncratic risk and common rainfall risk aggravate each other in the sense that a bad realization of one risk reduces consumption utility more, the worse the realization of the other risk. (For risk aversion outside of the empirically relevant range, idiosyncratic risk and rainfall risk can actually ameliorate each other.) As a result, individuals have more to gain from mutual insurance against idiosyncratic risk when greater common risk makes the worst case scenario of bad realizations of both idiosyncratic and common risks more probable. Individuals facing greater common risk are therefore more likely to opt into the mutual insurance sustained within religious communities rather than spending time on alternative social activities. Hence, a larger part of the population will be members of a religious community in counties with greater rainfall risk (holding expected agricultural productivity constant).

In the United States, religious communities are widely regarded as having been the main source of social assistance, especially in agricultural regions, until the rise of government social spending at the beginning of the twentieth century (McBride, 1962; Cnaan et al., 2002; Lindert, 2004; Harris and Bridgen, 2007; Gruber and Hungerman, 2007).<sup>3</sup> The available financial accounts of nineteenth-century churches indicate substantial expenditures on local relief and charity (Nemeth and Luidens, 1994). There is also extensive historical evidence that local religious community members supported each other in case of need (see, e.g., Trattner, 1974;

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<sup>2</sup>It is well understood that risk aversion alone is not sufficient for insurance demand to increase with uninsurable background risk (Gollier, 2004; Franke, Schlesinger, and Stapleton, 2006). Our theoretical analysis differs from the literature in that we focus on the incentive to insure through a social activity, while the literature focuses on the willingness to pay for insurance in financial markets.

<sup>3</sup>At the end of the nineteenth century, fraternal groups and labor unions started gaining in importance. But religious communities were the associations with by far the widest geographic spread – more than 97 percent of US counties had at least one church in 1890 – and the largest membership (Putnam, 2000). Even today, religious communities are the associations with the largest membership in the United States. More than 37 percent of respondents in the General Social Survey self-identify as a member of some church group, and 38 percent of respondents indicate that they participated more than twice in a church activity during the preceding year (Smith et al., 2013). These figures more than triple their counterparts for trade unions, fraternal groups, hobby clubs, or neighbor associations.

Bodnar, 1985; Gjerde, 1985; Overacker, 1998; Szasz, 2004; Bovee, 2010). Even today, almost 85 percent of those who attend religious services at least once a year believe that their congregation would help them in case of illness or some other difficult situation, according to the US General Social Survey (Glaeser and Sacerdote, 2008; Smith et al., 2013).

Our theoretical model implies that a greater part of the population should organize into religious communities in agricultural economies with greater rainfall risk. We evaluate this hypothesis by examining whether in the nineteenth-century United States churches in counties with greater rainfall risk had more total members or a greater combined seating capacity relative to population. To control for expected agricultural productivity, we include a range of geographic and climatic variables in our analysis. Our empirical results indicate a statistically and quantitatively significant link between membership in religious communities and rainfall risk in 1890, 1870, and 1860. A 1-standard-deviation increase in rainfall risk is associated with about a 10-percent increase in total church members and seating capacity relative to population.<sup>4</sup>

If rainfall risk affects the value of church membership through agricultural production risk, there should be a positive link between the share of the population organizing into religious communities and rainfall risk in predominately agricultural counties. Moreover, the link between membership in religious communities and rainfall risk should be stronger in more agricultural counties than less agricultural counties. We therefore undertake a separate analysis of the link between membership in religious communities and rainfall risk among counties with value added in agriculture relative to manufacturing above and below the median. Among more agricultural counties, we find a strong positive and statistically significant link between rainfall risk and total church members and seating capacity relative to population. The link among less agricultural counties is significantly weaker than among more agricultural counties and usually statistically insignificant.

The 1910, 1920, and 1930 US Census collected county-level data on the value of crops produced. Combined with historical rainfall levels, these data provide a unique opportunity to

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<sup>4</sup>For 1850, we do not find a statistically significant link between rainfall risk and membership in religious communities. We argue that the difference with our findings for 1860, 1870, and 1890 arises because of sample size and sample selection, as the number of counties with the necessary data declines as we go further back in time, and we lose mostly agricultural counties.

examine the relationship between rainfall and agricultural productivity that underlies our analysis of the link between religious membership and rainfall risk in the nineteenth-century United States. The data can also be used to assess the importance of rainfall during the growing season and the nongrowing season for agricultural productivity. Our results indicate that growing-season rainfall has a stronger effect on agricultural productivity than nongrowing-season rainfall. Hence, if rainfall risk affects the value of church membership through agricultural production risk, the link between membership in religious communities and rainfall risk should be stronger for growing-season rainfall risk than nongrowing-season rainfall risk. When we relate membership in religious communities to growing-season rainfall risk, nongrowing-season rainfall risk, and a cross-season covariance term, we find that the statistically significant link is mostly with growing-season rainfall risk.

The US Census also collected county-level data on the 1890 population's foreign birthplaces and on the foreign birthplaces of the 1880 population's parents. We use these data to control for potential effects of different national cultures on membership in religious communities. The controls for different national cultures turn out to be jointly statistically significant determinants of religious membership. The link between rainfall risk and membership in religious communities changes little however (it actually becomes somewhat stronger). We also control for the relative sizes of different religious denominations present in a county to account for potential effects of different religious cultures on membership in religious communities. The controls for different religious cultures also turn out to be jointly statistically significant determinants of religious membership. But the link between membership in religious communities and rainfall risk changes little (it again becomes somewhat stronger). Following Altonji, Elder, and Taber (2005), the finding that the link between rainfall risk and membership in religious communities becomes somewhat stronger when we control for first- and second-generation immigrants' countries of origin and for the religious denominations present in a county, suggests that the link between rainfall risk and membership in religious communities is unlikely to reflect selection on unobservables (e.g., selection of groups of people with greater attachment to their religious communities into counties with greater rainfall risk).

An alternative explanation of our finding of a positive link between rainfall risk and membership in religious communities could be the so-called coping theory of religiosity, which points

to psychological benefits of religiosity when individuals are dealing with adverse events (Pargament, 1997). This theory of religiosity is usually applied in the context of adverse events that also are unpredictable (e.g., Bentzen, 2015). Our measure of county-level rainfall variability (risk) is persistent over time. For example, the correlation coefficient between our 100-year measure of county-level rainfall variability and the same measure of county-level rainfall variability obtained for five 20-year periods is around 0.9 on average and never below 0.85; and the correlation coefficient between adjacent 20-year periods of rainfall variability is never below 0.78. As a result, individuals living in a county with greater rainfall variability are likely to have experienced periods of greater rainfall variability repeatedly during their lifetime and also likely to have had their parents and grandparents experience periods of greater rainfall variability repeatedly during their lifetimes. Individuals in counties with greater rainfall variability should therefore not be taken by surprise by rainfall variability in the same way individuals in counties with, for example, greater earthquake risk might be taken by surprise by an earthquake. Moreover, the coping theory of religiosity appears to be mostly related to religious beliefs and spirituality not to church attendance and membership (e.g., Miller et al., 2012, 2014). In fact, Bentzen (2015) finds a robust positive effect of earthquakes on religious beliefs but not on church attendance.

An interesting further question is whether the effects of agricultural production risk on nineteenth-century religious membership persist to modern times. We examine this question using county-level data on US religious membership around the turn of the twenty-first century. Our empirical results indicate that among historically more agricultural counties – the group of counties where we found an effect of rainfall risk on historical religious membership – more than 1/3 of nineteenth-century differences in religious membership associated with rainfall risk persist to the turn of the twenty-first century. The tendency to participate in religious communities therefore appears to be transmitted intergenerationally by families or local communities, maybe in the same way as families or broader communities transmit other cultural traits (e.g., Bao et al., 1999; Bisin and Verdier, 2000; Bengtson et al., 2009; Alesina and Giuliano, 2010; Fernández, 2011; Giavazzi, Petkov, and Schiantarelli, 2014).

## 2 Related Literature

Much of the theoretical economics literature views religious communities as clubs that sustain the provision of local public goods, including social insurance, with the help of social sanctions and prohibitions; see Iannaccone (1992, 1998). Berman (2000) and Abramitzky (2008) expand this framework and discuss how mutual insurance is sustained among ultra-Orthodox Jews and *kibbutzniks*, respectively. Dehejia, DeLeire, and Luttmer (2007) find that income shocks have a smaller effect on the consumption level of US households who contribute to a religious organization and a smaller effect on the self-reported happiness of households who attend religious services. Chen (2010) observes that social insurance provided by religious communities is not limited to those who participate *ex ante* (the insurance we focus on in our theoretical analysis) but also extends to those who start participating following adverse shocks. To show that individuals are more likely to start attending church following adverse shocks, Chen examines the evolution of individual income and religious intensity following the 1997-1998 Indonesian financial crisis. He finds that the crises decreased the income of government employees relative to wetland farmers and that religious intensity during the first half of 1998 moved inversely with income. Chen also finds that the presence of religious institutions in a local community is associated with more consumption smoothing. Further evidence on how religious communities are affected by adverse shocks is provided by Ager, Hansen, and Lønstrup (2016), who document a surge in church membership in counties affected by the Mississippi flood of 1927.

Our hypothesis is that partial insurance within religious communities implies a greater incentive to organize into religious communities where populations are exposed to higher levels of common risk. We therefore examine how membership in religious communities depends on the amount of common risk faced by a population, rather than specific realizations of shocks. Accordingly, individuals in our theoretical analysis decide on church membership before shocks realize, as a function of the risks they face. To capture the cost of church membership, we borrow from the literature that considers religious membership to be a social activity that reduces time for other activities (e.g., Azzi and Ehrenberg, 1975; Glaeser and Sacerdote, 2008).

Our analysis is also related to the literature documenting that religious communities respond to the demand for social assistance. Hungerman (2005) finds that a 1996 US welfare reform

decreasing services to noncitizens was followed by increased member donations and community spending of Presbyterian congregations. Gruber and Hungerman (2007) show that the New Deal social programs crowded out charitable spending of six Christian denominations. Hungerman (2009) finds that an expansion of social security mandated by the US Supreme Court in 1991 crowded out charitable spending of United Methodist churches.

Given that religious communities provide social support, it is natural to wonder whether the decline in religious membership in many developed economies is related to rising government welfare expenditures.<sup>5</sup> Gill and Lundsgaarde (2004) find that welfare expenditures have a negative effect on church attendance across countries. Franck and Iannaccone (2014) find some (weaker) support for a negative effect of welfare spending on church attendance using retrospective panel data for eight European countries, Canada, and the United States. Scheve and Stasavage (2006) point out that church attendance and government welfare expenditures could be related, also because religiosity changes the preferences for social insurance, possibly due to the psychological benefits of religiosity when individuals are dealing with adverse events (Pargament, 1997). In their empirical work, Scheve and Stasavage show that religiosity has a negative effect on preferences for social insurance at the individual level and that this finding can account for the negative effect of religiosity on welfare expenditures across countries.<sup>6</sup>

Bentzen (2015) observes that if religiosity helps people to deal with adverse events, it may spread more easily in areas where natural disasters are more frequent. Using regional data, Bentzen finds a robust positive association between earthquakes and a range of religious beliefs when controlling for individual and country characteristics. On the other hand, Bentzen finds no robust association between earthquakes and church attendance. When she examines religious beliefs and church attendance among second-generation immigrants from regions that have suffered earthquakes, she again finds robust effects of earthquakes on religious beliefs but not on church attendance. Bentzen's findings are consistent with recent findings on the psychological benefits of religiosity. In their long-term panel study of depression risk, Miller et al. (2012, 2014) find that religiosity and spirituality, but not church attendance, are associated with

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<sup>5</sup>A main question in the literature on the determinants of religious membership is whether membership depends on income; see McCleary and Barro (2006a,b), Becker and Woessmann (2013), and Franck and Iannaccone (2014), for example.

<sup>6</sup>There is also a literature on the consequences of religious participation for economic outcomes at the individual and country level, see Barro and McCleary (2003) and Gruber (2005), for example.



greater cortical thickness and lower risk of depression.

Our work is also related to the literature on informal insurance in economies with little insurance supplied by governments or markets. The literature points to a range of insurance mechanisms, from the scattering of agricultural plots to reciprocal gift exchange; see Alderman and Paxson (1994), Townsend (1995), Dercon (2004), and Banerjee and Duflo (2011). This literature also discusses informal insurance mechanisms in response to (growing-season) rainfall risk; see Rosenzweig (1988a,b) and Rosenzweig and Stark (1989) on informal insurance and family structure; Durante (2010) on informal insurance and interpersonal trust; and Davis (2014) on informal insurance and individual versus collective responsibility.

### 3 Production Risks and Membership in Religious Communities in a Rainfed Agricultural Economy

Our theoretical analysis considers the agricultural output produced by farmers in a certain location (a county) as being subject to two types of risks. The first is uninsurable common rainfall risk. The second is idiosyncratic risk. Members of local religious communities insure each other against some idiosyncratic risks, but religious membership takes time away from alternative social activities. We show that when relative risk aversion is in the empirically relevant range, the value of mutual insurance within local religious communities is greater in counties with greater rainfall risk. As a result, a larger share of farmers organize into religious communities in counties with greater rainfall risk, holding expected agricultural productivity constant.<sup>7</sup>

**Agricultural production** Consider a nation made up of many counties. Each county is inhabited by a continuum of ex-ante identical farmers of measure 1. The output,  $Y_{fc}$ , produced by farmer  $f$  in county  $c$  by the end of a year depends on fixed county characteristics determining the productivity of agriculture,  $Z_c$ ; county-level rainfall,  $R_c$ ; and a farmer-specific input subject

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<sup>7</sup>See Gollier (2004) for the theory of decision making with multiple risks. Our theoretical analysis differs mainly in that we examine the incentive to insure through a social activity.

to idiosyncratic shocks,  $s_f$ ,

$$Y_{fc} = s_f R_c^\beta Z_c \quad (1)$$

where  $R_c$  is a weighted average of monthly rainfall levels,  $R_{mc}$ , during the year,

$$R_c = \prod_{m=1}^{12} R_{mc}^{\alpha_m} \quad (2)$$

with  $\sum_{m=1}^{12} \alpha_m = 1$ . The parameter  $\beta$  captures the percentage increase in agricultural productivity in response to a 1-percent increase in rainfall every month. The parameters  $\alpha_m$  capture that rainfall may be more important in some months than in others and allow us to accommodate the empirical evidence that rainfall matters more during growing-season months. Our empirical analysis using data on the value of crops produced from the 1910, 1920, and 1930 US Census indicates that the relationship between productivity and rainfall in equation (1) describes the data quite well; see Section 5.2 and the (binned) scatter plots in Appendix Figure A.1. Monthly rainfall levels at the county level,  $R_{mc} \geq 0$ , are taken to be random and follow a joint lognormal distribution with county-specific distribution parameters. Appendix Figure A.2 plots the standardized ln rainfall distributions at the county level for the 1895-2000 period for each month of the year.

For concreteness, we think of  $s_f \geq 0$  as the farmer's labor input and of idiosyncratic shocks to  $s_f$  as health shocks or accidents. We take  $s_f$  to be lognormally distributed with constant mean and variance and to be independent of county-level rainfall risk (it would be straightforward to allow for some correlation).

**Consumption and religious membership** We think of religious community membership as a social activity that provides insurance against idiosyncratic labor input shocks,  $s_f$ .<sup>8</sup> There is a single religious community in each county.<sup>9</sup> Farmers in a county must decide whether to

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<sup>8</sup>For simplicity, all idiosyncratic risk can be insured within religious communities in the model. It would be straightforward to add uninsurable idiosyncratic risk to capture partial insurance of idiosyncratic risk within religious communities.

<sup>9</sup>As we focus on the choice of joining or not joining a religious community, it is sufficient for there to be one religious community per county. A drawback of this simplification is that our model can be read to have implications for the size of single religious communities in a county – rather than total religious membership – which we think is unwarranted. To have a model that makes well-founded predictions about the size of single religious communities, one would have to take into account that sustaining informal insurance requires

join the local religious community before the realization of county-level rainfall shocks and labor input shocks. The utility function of farmers is

$$V_{fc} = \frac{C_{fc}^{1-\rho} - 1}{1-\rho} - q_c p_f M_{fc}. \quad (3)$$

The first term captures the utility of consumption,  $U(C_{fc})$ , using a constant relative risk aversion utility function with relative risk aversion,  $\rho > 0$ . The second term captures the disutility from the social activities required for religious membership. The indicator variable  $M_{fc}$  is equal to 1 if the farmer is a member of a religious community and 0 otherwise. The parameter  $p_f \geq 0$  captures individual heterogeneity in the disutility incurred by the social activities required for religious membership, while  $q_c > 0$  captures county-specific factors. Farmers with  $p_f = 0$  value the social activities required for religious membership as highly as the social activities they would engage in if they did not join a religious community. Hence, their utility from social activities does not change with religious membership. On the other hand, farmers with  $p_f > 0$  experience reduced utility from social activities when they join a religious community. The reason is that they value the social activities required for religious membership less than their preferred alternative activities.

**The value of insurance against idiosyncratic risk** Farmers consume their agricultural output,  $Y_{fc}$ , and their consumption levels are therefore generally subject to both rainfall and labor input risk. We assume that the religious community of county  $c$  is able to sustain perfect mutual insurance against idiosyncratic labor input risk among local members.<sup>10</sup> As a result, (1) implies that the output and consumption level of a farmer in county  $c$  who is a member of the local religious community is  $E(s)R_c^\beta Z_c$ , where  $E(s)$  is the expected labor input level.

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suppressing free riding and that this is more difficult in larger religious communities (Iannaccone, 1992). This could be incorporated in our model in a simple way by assuming that mutual insurance can only be sustained in a religious community as long as it does not exceed a certain critical size. In this case, counties where a larger share of the population organizes into religious communities would generally have more rather than larger religious communities.

<sup>10</sup>Perfect insurance of the idiosyncratic risk within religious communities is possible as long as the community has a positive measure of members. A model with a discrete number of members could capture two opposing effects absent from our analysis. On the one hand, larger religious communities can spread idiosyncratic risk better. On the other hand, larger communities may have more difficulties in avoiding free riding (Iannaccone, 1992).

The increase in the expected utility of consumption,  $\Delta EU(C_{fc})$ , that comes with religious community membership is straightforward to calculate, as  $C_{fc}^{1-\rho}$  in (3) is lognormally distributed whether farmers are members of a religious community or not,<sup>11</sup>

$$\ln \Delta EU(C_{fc}) = \mu + (1 - \rho) \ln EY_c + \frac{\rho(\rho - 1)\beta^2}{2} RVar_c \quad (4)$$

where  $EY_c$  is expected agricultural productivity in the county,  $RVar_c = Var(\ln R_c)$  captures county-level rainfall risk, and  $\mu$  depends on preference and technology parameters as well as on the amount of idiosyncratic risk. Hence, if we hold expected productivity constant, the consumption utility gain of religious membership is increasing in the amount of rainfall risk,  $RVar_c$ , farmers face if and only if their degree of relative risk aversion is strictly greater than unity,  $\rho > 1$ . Intuitively, this is because  $\rho > 1$  implies that idiosyncratic risk and rainfall risk aggravate each other in the sense that a negative realization of one risk reduces consumption utility more, the lower the realization of the other risk (Franke, Schlesinger, and Stapleton, 2006). Formally,  $\rho > 1$  implies  $\partial [\partial U(C[R, s]) / \partial R] / \partial s < 0$ , where  $U(C)$  is the utility of consumption and  $C[R, s]$  captures that productivity and, hence, consumption depends on rainfall and labor input. When the degree of relative risk aversion is smaller than unity,  $\rho < 1$ , idiosyncratic risk and rainfall risk actually ameliorate each other,  $\partial [\partial U(C) / \partial R] / \partial s > 0$ , because the complementarity between rainfall and labor in agricultural production in (1) implies that a negative realization of one risk reduces output less, the lower the realization of the other risk is. Most estimates of the coefficient of relative risk aversion in the literature exceed unity: see Attanasio and Weber (1989), Vissing-Jorgensen and Attanasio (2003), and Chiappori and Paiella (2011).<sup>12</sup>

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<sup>11</sup>When  $X \sim \ln N(\mu, \sigma^2)$ ,  $EX = \exp(\mu + \sigma^2/2)$ . Hence, the lognormality of output implies  $E \ln Y_c = \ln EY_c - Var(\ln Y_c)/2$ . Defining  $\sigma_{Rs}^2 = Var(\ln R_c)$  and  $\sigma_s^2 = Var(\ln s)$  and making use of  $C_{fc} = Y_{fc}$  and (1), this in turn implies  $C_{fc}^{1-\rho} \sim \ln N((1-\rho)(\ln EY_c - \beta^2 \sigma_{Rs}^2/2), (1-\rho)^2 \beta^2 \sigma_{Rs}^2)$  when the farmer is a member of a religious community and  $C_{fc}^{1-\rho} \sim \ln N((1-\rho)(\ln EY_c - \beta^2 \sigma_{Rs}^2/2 - \sigma_s^2), (1-\rho)^2 (\beta^2 \sigma_{Rs}^2 + \sigma_s^2))$  when the farmer is not a religious community member. The result in (4) can now be obtained by applying  $EX = \exp(\mu + \sigma^2/2)$  when  $X \sim \ln N(\mu, \sigma^2)$  to calculate the difference between  $EC_{fc}^{1-\rho}$  when the farmer is a member of a religious community and  $EC_{fc}^{1-\rho}$  when the farmer is not.

<sup>12</sup>While these estimates rely on post-World War II data, risk aversion in the late nineteenth-century United States, when incomes were closer to subsistence levels and less government insurance was available, is usually thought to have been at least as high (Kimball, 1988).

**Rainfall risk and membership in religious communities** Farmers with  $p_f = 0$  always join religious communities. After all, they enjoy the social activities required for religious membership as much as the preferred alternatives, and religious communities provide insurance against idiosyncratic shocks. Farmers with  $p_f > 0$  face a trade-off because religious membership decreases their utility from other social activities but provides insurance against idiosyncratic shocks. Combining (3) and (4) yields that farmers join a religious community if and only if the insurance gain exceeds the cost of religious membership,

$$\mu + (1 - \rho) \ln EY_c + \frac{\rho(\rho - 1)\beta^2}{2} RV ar_c \geq \ln q_c + \ln p_f. \quad (5)$$

County-specific determinants of the disutility of religious membership can be accounted for by allowing  $\ln q_c$  to depend on such variables as expected income, for example,

$$\ln q_c = \theta \ln EY_c. \quad (6)$$

We assume that the individual-specific element of the disutility of religious membership,  $\ln p_f$ , is distributed according to some cumulative distribution function,  $H(x)$ . Combined with (5) and (6), this implies that membership in religious communities in county  $c$ ,  $M_c = \int_f M_{fc}$ , is

$$M_c = H \left( \mu - (\theta + \rho - 1) \ln EY_c + \frac{\rho(\rho - 1)\beta^2}{2} RV ar_c \right). \quad (7)$$

Hence, if we hold expected agricultural income  $EY_c$  constant, membership in religious communities is larger in counties with greater rainfall risk if  $\rho > 1$ .

**Rainfall risk during the growing and nongrowing seasons** The agricultural production function in (1) and (2) allows for heterogeneous effects of monthly rainfall. According to the literature on the effect of weather on crop yields, rainfall matters more in growing-season months than in nongrowing-season months (Schlenker and Roberts, 2009). We now examine how such heterogeneity affects the link between membership in religious communities and rainfall risk.

The US nongrowing season varies by crop and state; see Covert (1912) and USDA (2007)

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<sup>13</sup>For example, churches in richer counties may be easier to get to or equipped more comfortably.

for historical and modern data, respectively, but it typically includes the months of November, December, and January.<sup>14</sup> Define  $N = \{\text{December, January, February}\}$  and  $G = \{\text{March, } \dots, \text{November}\}$  and express the sum of the monthly rainfall effects in (2) over the growing season and the nongrowing season as

$$a_N = \sum_{m \in N} \alpha_m \quad \text{and} \quad a_G = \sum_{m \in G} \alpha_m. \quad (8)$$

Using this notation, rainfall risk,  $RVar_c = Var(\ln R_c)$ , can be written in terms of rainfall risk during the growing season, rainfall risk during the nongrowing season, and a covariance term,

$$RVar_c = a_G^2 RVar_c^G + a_N^2 RVar_c^N + a_G a_N RCov_c \quad (9)$$

where  $RVar_c^G$  and  $RVar_c^N$  capture growing-season and nongrowing-season rainfall risk,

$$RVar_c^G = Var \left( \sum_{m \in G} \alpha_{Gm} \ln R_{mc} \right) \quad (10)$$

$$RVar_c^N = Var \left( \sum_{m \in N} \alpha_{Nm} \ln R_{mc} \right) \quad (11)$$

with  $\alpha_{Gm} = \alpha_m/a_G$  and  $\alpha_{Nm} = \alpha_m/a_N$ .  $RCov_c$  in (9) is twice the covariance between growing-season and nongrowing-season rainfall,

$$RCov_c = 2Cov \left( \sum_{m \in G} \alpha_{Gm} \ln R_{mc}, \sum_{m \in N} \alpha_{Nm} \ln R_{mc} \right). \quad (12)$$

From (7) and (9) it follows that the strength of the effect of nongrowing-season rainfall risk on membership in religious communities relative to the effect of growing-season rainfall risk is  $(a_N/a_G)^2$ . From (1) and (8) it follows that the effects of nongrowing-season and growing-season rainfall on agricultural productivity are  $\beta_N = \beta a_N$  and  $\beta_G = \beta a_G$ , respectively. Hence, our theoretical model implies that the strength of the effect of nongrowing-season rainfall risk on membership in religious communities relative to the effect of growing-season rainfall risk is determined by the effect of nongrowing-season rainfall on agricultural productivity relative to

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<sup>14</sup>Covert (1912) records the growing season for corn, wheat, and cotton as March through November.

the effect of growing-season rainfall,  $(a_N/a_G)^2 = (\beta_N/\beta_G)^2$ .

## 4 Estimating the Effect of Rainfall Risk on Membership in Religious Communities

Our empirical investigation of the link between membership in religious communities and rainfall risk across US counties in the late nineteenth century begins with a log-linearized version of (7),

$$\ln \left( \frac{\text{Church members or seatings}_c}{\text{Population}_c} \right) = \varphi + \lambda RVar_c + \gamma \ln EY_c \quad (13)$$

where  $RVar_c$  is rainfall risk,  $EY_c$  is expected agricultural productivity, and we measure the share of the population organizing into religious communities as total church members or combined church seating capacity relative to population.<sup>15</sup> The parameter of interest is the link between membership in religious communities and rainfall risk,  $\lambda$ . To estimate (13) we need proxies for rainfall risk and expected agricultural productivity, which in turn requires county-level rainfall data for a sufficiently long period of time as well as values for the parameters  $\beta$  and  $\alpha_m$  in the agricultural production function in (1) and (2). Our main analysis is for the case where monthly rainfall enters the agricultural production function symmetrically. However, we also examine the case where the effect of rainfall on productivity is smaller in growing-season months than in nongrowing-season months.

**Symmetric effects of monthly rainfall** When monthly rainfall enters the agricultural production function in (1) and (2) symmetrically,  $\alpha_m = \alpha$ , the rainfall risk measure becomes

$$RVar_c = Var \left( \frac{1}{12} \sum_{m=1}^{12} \ln R_{mc} \right) \quad (14)$$

and (1) implies that expected agricultural productivity can be written as

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<sup>15</sup>The log-formulation has the usual advantages (e.g., Wooldridge, 2012), as the variable  $(\text{Church members or seatings}_c)/\text{Population}_c$  takes positive values only, is very positively skewed, and has some large values that probably reflect measurement error. The formulation in (13) implies that the dependent variable takes positive and negative values, that the distribution is unskewed, and that extreme observations are curtailed.

$$\ln EY_c = \delta + \ln E \left( \prod_{m=1}^{12} R_{mc}^{\beta/12} \right) + \ln Z_c = \delta + \ln RY_c + \ln Z_c \quad (15)$$

where  $RY_c = E \left( \prod_m R_{mc}^{\beta/12} \right)$  captures the effect of rainfall on expected productivity and  $\delta = \ln E(s)$ . We can estimate  $\beta$ , the average effect of rainfall on agricultural productivity in the late nineteenth-century United States, using county-level data on the value of crops from the US Census in 1910, 1920, and 1930. The availability of multiple observations for each county allows us to take a within-county approach. The estimating equation based on (1) and  $\alpha_m = \alpha$  is

$$\ln Y_{ct} = \text{county FE \& time effects} + \beta \left( \frac{1}{12} \sum_{m=1}^{12} \ln R_{mct} \right) \quad (16)$$

where  $Y_{ct}$  is the value of crops per unit of farmland. The county fixed effects (FE) capture all fixed county characteristics. The time effects capture changes over time and are allowed to vary by state. We also control for the amount of farmland and estimate specifications with controls for contemporaneous temperature and lagged rainfall and temperature.

Substituting (15) into (13) yields our estimating equation for the link between membership in religious communities and rainfall risk

$$\ln \left( \frac{\text{Church members or seatings}_c}{\text{Population}_c} \right) = \varphi + \lambda RVar_c + \gamma \ln RY_c + \sum_{i=1}^I \phi_i X_{ic} \quad (17)$$

where  $RVar_c$  is defined in (14),  $RY_c = E \left( \prod_m R_{mc}^{\beta/12} \right)$  with  $\beta$  estimated using (16), and  $X_{ic}$  stands for county characteristics like soil quality or ruggedness of the terrain that may affect agricultural productivity,  $Z_c$ . The rainfall data we use are for the 1895-2000 period (the county rainfall data are only available from 1895 onwards).<sup>16</sup>

**Rainfall during the growing and nongrowing seasons** To assess the link between membership in religious communities and rainfall risk during the growing and nongrowing seasons,

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<sup>16</sup>Our empirical analysis therefore presumes that county-level rainfall risk during the nineteenth century was similar to rainfall risk over the 1895-2000 period. Or, to put it differently, that county-level rainfall risk is persistent over time. Our data suggest this to be the case as the correlation coefficient between county-level rainfall risk over the 1895-1947 period and over the 1948-2000 period is 0.94.



we reestimate (17) after replacing the term for rainfall risk by

$$\lambda_G RV ar_c^G + \lambda_N RV ar_c^N + \tau Cov_c. \quad (18)$$

The variances and the covariance are defined in (10)-(12) and are calculated as the corresponding moments over the 1895-2000 period, assuming symmetric effects of monthly rainfall within each season.

As shown above, our theoretical model implies that  $\lambda_N/\lambda_G$ , the effect of nongrowing-season rainfall risk on membership in religious communities relative to the effect of growing-season rainfall risk, should be equal to  $(\beta_N/\beta_G)^2$ , where  $\beta_N/\beta_G$  is the effect of nongrowing-season rainfall on agricultural productivity relative to the effect of growing-season rainfall. We can therefore assess the importance of nongrowing-season rainfall risk relative to growing-season rainfall risk for membership in religious communities by reestimating the agricultural production function in (16) after splitting the rainfall effect into a growing-season effect and a nongrowing-season effect

$$\text{Rainfall effect} = \beta_G \left( \frac{1}{9} \sum_{m \in G} \ln R_{mct} \right) + \beta_N \left( \frac{1}{3} \sum_{m \in N} \ln R_{mct} \right). \quad (19)$$

## 5 Data and Empirical Results

### 5.1 Data

**Membership in religious communities 1850-1890** The decennial censuses of the United States during the period 1850-1890 collected information on churches at the county level. The data allow us to obtain two proxies for membership in religious communities in a county, namely the combined seating capacity of churches in the county relative to population in 1850, 1860, 1870, and 1890 (the 1880 data were never published) and the total number of members of churches in the county relative to population in 1890. Our data refer to all religious denominations listed in the US Census. These data are retrieved from ICPSR file 2896 (Haines, 2010). For summary statistics and maps that illustrate the spatial variation in the main data we use,

see the appendix.<sup>17</sup>

**Climate data** Our rainfall data come from PRISM (2011), which provides monthly rainfall data on a 4 times 4 km grid from 1895 onward. PRISM was developed for the National Oceanic and Atmospheric Administration and is also used by the US Department of Agriculture, NASA, and several professional weather channels.<sup>18</sup> We map the data into counties to obtain monthly rainfall at the county level. Appendix Figure A.2 plots the standardized distributions of ln rainfall at the county level for the 1895-2000 period for each month of the year. We also use PRISM data on monthly average temperature, which we process analogously to the rainfall data.

**Soil and elevation data** We control for 53 soil types using the US Department of Agriculture’s SSURGO database.<sup>19</sup> We use these data to calculate the fraction of each county’s land area that falls into the different soil categories. The source of our elevation data is the Environmental System Research Institute.<sup>20</sup> We calculate the fraction of each county’s land area falling into the following 11 elevation bins: below 200 meters, 200 to 400 meters, 400 to 600 meters, and so on up to 2000 meters; and above 2000 meters.

**Other data** The data on land area, population, literacy, value added in agriculture and in manufacturing, total farmland, value of crops produced, and the birthplace of foreign-born individuals come from the US Census and are retrieved from ICPSR file 2896 and IPUMS (Haines, 2010; Ruggles et al., 2010). Value added in manufacturing is calculated as manufacturing output minus the cost of materials. Value added in agriculture is calculated as output minus the cost of fertilizers in 1890; in 1860 and 1870, value added in agriculture is obtained as output in agriculture since there is no information on fertilizer purchases. Modern county-level data on US religious membership around the turn of the twenty-first century are retrieved from the Association of Religion Data Archives ([www.theARDA.com](http://www.theARDA.com)).

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<sup>17</sup>In a supplementary Appendix available on our websites, we also present maps with the within-state variation in our main data, as our empirical results control for state fixed effects.

<sup>18</sup>See Deschenes and Greenstone (2007), who also use the PRISM data.

<sup>19</sup><http://soils.usda.gov/surveys/geography/ssurgo/>.

<sup>20</sup>[www.esri.com](http://www.esri.com).

## 5.2 Main Empirical Results

**Agricultural production and rainfall** Table 1 reports our results on the effect of rainfall on the value of crops produced per unit of farmland from the US Census in 1910, 1920, and 1930 using the within-county estimation approach in (16). Our method of estimation is weighted least squares. We weight counties by their average farmland over the period, as within-county changes in the value of crops per unit of farmland should be more closely related to county-level average rainfall when more land is under cultivation.<sup>21</sup> The value of crops reported in the US Census corresponds to the year preceding the census years, and  $\ln Y_{ct}$  on the left-hand side of (16) therefore refers to the value of crops per acre of farmland in 1909, 1919, and 1929. The corresponding rainfall in year  $t$  on the right-hand side of (16) refers to the 12 months from December of year  $t - 1$  to November of year  $t$ . That is, the rainfall in year  $t$  encompasses the growing season (March through November) of year  $t$  and the preceding nongrowing season (December of year  $t - 1$  and January and February of year  $t$ ).<sup>22</sup> Column (2) adds a control for the rainfall in year  $t - 1$ , which is defined analogously to the rainfall in year  $t$  and refers to the 12 months from December  $t - 2$  to November  $t - 1$ . The results in columns (1) and (2) indicate that rainfall in year  $t$  enters positively and statistically significantly at the 1-percent level, while the effect of rainfall in year  $t - 1$  is statistically insignificant. The effect of rainfall in year  $t$  implies that a 1-percent increase in average monthly rainfall in year  $t$  raised the value of crops by around 0.5 percent in 1909-1929. In column (3) we add controls for average

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<sup>21</sup>Deschenes and Greenstone (2007) use the same weights in a similar context. One reason for weighting is that idiosyncratic shocks to the output of different units of farmland are more likely to average out when more land is under cultivation. Another reason is that our measure of average rainfall refers to the average in a county as a whole, not the average on cultivated land. The discrepancy between these two averages should tend to be smaller in counties with more farmland when holding the share of land under cultivation constant. Moreover, the discrepancy should also tend to be smaller in counties with a larger share of land under cultivation, and counties with more farmland tend to have a larger share of land under cultivation in our data. To see these last two points in a concrete example, let  $F$  be the acres of farmland in a county and  $\phi \in (0, 1)$  the share of land under cultivation. Take rainfall on acre  $i$  to be  $R_i = R + \varepsilon_i$  with  $\varepsilon_i$  identically and independently distributed with mean zero and variance  $\sigma^2$ . Then the variance of the difference between rainfall per acre in the whole county and rainfall per acre on cultivated land is  $\sigma^2(1 - \phi)/F$ . This means that average rainfall in the county is a better proxy for average rainfall on cultivated land in counties with more farmland and/or with a greater share of land under cultivation. In any case, the unweighted least-squares results are similar to those in Table 1 in that all effects other than rainfall at  $t$  are statistically insignificant. The effect of rainfall at  $t$  is statistically significant at the 1-percent level but smaller than in Table 1, 0.27 as compared to 0.52 in the specification in column (3). Using the value of 0.27 in equation (17) does not affect any of our findings on the link between rainfall risk and the size of religious organizations (point estimates change by very little).

<sup>22</sup>Defining rainfall years in this way facilitates comparisons when we estimate separate effects for rainfall during the growing and nongrowing seasons.

temperature in year  $t$  (December  $t - 1$  to November  $t$ ) and  $t - 1$  (December  $t - 2$  to November  $t - 1$ ). The average temperature effects are statistically insignificant, which probably reflects that average annual temperature is not a good way of capturing the effect of temperature on agricultural productivity (Deschenes and Greenstone, 2007; Schlenker and Roberts, 2009). The (binned) scatter plots in Appendix Figure A.1 illustrate that the relationship between agricultural productivity and rainfall in (16) appears to describe the data quite well.

**Rainfall risk and membership in religious communities** Tables 2 and 3 present our results on the link between membership in religious communities and rainfall risk in 1890.<sup>23</sup> The estimating equation is (17) and the estimation method is least squares. Religious membership in a county is measured as total church members in the county relative to population or as combined church seating capacity relative to population. The main parameter of interest is the coefficient on rainfall risk,  $RVar_c$ , defined in (14). The control variable capturing the effect of rainfall on expected agricultural productivity,  $RY_c = E\left(\prod_m R_{mc}^{\beta/12}\right)$ , is calculated using a value for  $\beta$  of 0.52 based on the results in Table 1. Other controls are the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, longitude and latitude, average temperature over the period 1895-2000, ln land area, and state fixed effects.

We start by measuring 1890 membership in religious communities using total church members relative to population. A first impression of the association between religious membership and rainfall risk in the data can be obtained from a binned scatter plot once all controls have been partialled out. As can be seen from Appendix Figure A.3, the association between religious membership and rainfall risk appears to be positive. Table 2, column (1) summarizes our regression results using (17). The link between membership in religious communities and rainfall risk is statistically significant at the 1-percent level. A useful way to get a sense of the quantitative implications of the point estimate on rainfall risk is to calculate the increase in religious membership associated with a 1-standard-deviation increase in rainfall risk, which would be an increase in rainfall risk of 0.05 (see Appendix Table 1). Such an increase in rainfall

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<sup>23</sup>For additional robustness checks to those in the main text further below, see the supplementary Appendix. There we use alternative methods to calculate standard errors, examine “placebo” specifications that randomly reshuffle rainfall risk within states, estimate the effect in the 13 former British colonies that founded the United States and other groups of older states, and implement alternative sample splits.

risk is associated with an increase in religious membership of about 11 percent.<sup>24</sup>

Table 2, columns (2) and (3) split the full 1890 sample into counties with value added in agriculture relative to manufacturing above and below the median. The median share of agriculture over agriculture plus manufacturing is 0.87 and the average share of agriculture in counties above the median is 0.95. Counties with agricultural value added above the median are therefore almost entirely agricultural and quite uniformly so, as the difference between the share of agriculture in the most and the least agricultural county in this group is only 12 percentage points. Hence, if rainfall risk affects church membership through agricultural production risk, there should be a positive link between rainfall risk and membership in religious communities among these counties. The result in column (2) shows that the link is in fact positive and statistically significant at the 5-percent level. The point estimate implies that a 1-standard-deviation increase in rainfall risk, which amounts to an increase in rainfall risk of 0.05 (see Appendix Table 1), is associated with an increase in membership in religious communities of about 14 percent among counties with agricultural value added above the median. On the other hand, there is no statistically significant link between rainfall risk and religious membership among counties with agricultural value added below the median in column (3). In this group of counties, the agricultural sector is smaller than the manufacturing sector on average and the group is very heterogenous in terms of the share of agriculture (it contains all urban US counties). The link between membership in religious communities and rainfall risk is stronger among more agricultural counties in column (2) than among less agricultural counties in column (3), and the difference is statistically significant at the 5-percent level.<sup>25</sup>

Our second measure of 1890 membership in religious communities in a county is combined church seating capacity relative to population. A first impression of the association between religious membership and rainfall risk using this alternative measure can again be obtained from a binned scatter plot once all controls have been partialled out. As can be seen from Appendix

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<sup>24</sup>Our findings on the link between rainfall risk and religious membership are not affected when we also control for the variance in annual average temperature over the 1895–2000 period. The temperature variance is always statistically insignificant. This could be because annual average temperature does not capture the effect of temperature on agricultural productivity well. In fact, annual average temperature is never a statistically significant determinant of the value of crops in Table 1.

<sup>25</sup>This result is based on a model where we consider the full sample but interact all right-hand-side variables in the regression with an indicator variable that takes the value 1 if and only if counties have value added in agriculture relative to manufacturing above the median.

Figure A.4, the association again appears to be positive. Table 2, column (4) summarizes our regression results using (17). The link between membership in religious communities and rainfall risk in 1890 is statistically significant at the 5-percent level. The point estimate implies that a 1-standard-deviation increase in rainfall risk is associated with an increase in membership in religious communities of about 10 percent, which is very similar to the result we obtained using church members relative to population as a measure of religious membership. Columns (5) and (6) split the sample into counties with value added in agriculture relative to manufacturing above and below the median. Among counties with agricultural value added above the median in column (5), the link between membership in religious communities and rainfall risk is statistically significant at the 1-percent level. The point estimate implies that a 1-standard-deviation increase in rainfall risk is associated with an increase in membership in religious communities of about 30 percent. Among counties with agricultural value added below the median in column (6), there is no statistically significant link between rainfall risk and religious membership. The link between membership in religious communities and rainfall risk is stronger among more agricultural counties than among less agricultural counties, and the difference is statistically significant at the 5-percent level.

Table 3 summarizes our results on the link between membership in religious communities and rainfall risk in 1870 and in 1860. The only measure of membership in religious communities available for these years is combined church seating capacity relative to population. Column (1) summarizes our results for 1870. The sample is around 20 percent smaller than the 1890 sample. Even so, the results are similar to the ones for membership in religious communities in 1890. A 1-standard-deviation increase in rainfall risk is associated with a statistically significant increase in membership in religious communities of about 12 percent. Columns (2) and (3) split the 1870 sample according to agricultural value added below and above the median. The median agricultural share in 1870 is 0.89, and counties with agricultural value added above the median are therefore almost entirely agricultural and homogenous in terms of the share of agriculture. The link between membership in religious communities and rainfall risk among more agricultural counties in column (2) is statistically significant at the 5-percent level. A 1-standard-deviation increase in rainfall risk is associated with an increase in religious membership of about 40 percent. Rainfall risk shows a weaker link with membership in religious communities among

less agricultural counties in column (3), but the link is still statistically significant at the 10-percent level. The link between membership in religious communities and rainfall risk among more agricultural counties is stronger than among less agricultural counties, and the difference is statistically significant at the 10-percent level.

Table 3, column (4) reports our results on the link between membership in religious communities and rainfall risk in 1860. This sample is nearly 30 percent smaller than the 1890 sample and about 10 percent smaller than the 1870 sample. But again, results are similar to the ones we obtained for membership in religious communities in 1870 and 1890. The link between membership in religious communities and rainfall risk is statistically significant at the 5-percent level. A 1-standard-deviation increase in rainfall risk is associated with an increase in membership in religious communities of about 10 percent. Columns (5) and (6) present the results when we split the sample by agricultural value added below and above the median. In 1860, the median share of agriculture was 0.91, and the difference between the most and least agricultural county in the group with above-median agricultural shares was 8 percentage points. Hence, counties with agricultural value added above the median were homogeneously agricultural. The link between membership in religious communities and rainfall risk among more agricultural counties in column (5) is statistically significant at the 5-percent level, and the point estimate implies that a 1-standard-deviation increase in rainfall risk is associated with an increase in religious membership of around 40 percent. On the other hand, rainfall risk does not show a statistically significant link with membership in religious communities among counties with agricultural value added below the median in column (6). The link between membership in religious communities and rainfall risk among more agricultural counties is stronger than among less agricultural counties, and the difference is statistically significant at the 5-percent level.

We do not find a statistically significant link between membership in religious communities and rainfall risk in 1850. We attribute this to the smaller number of counties and sample selection. The necessary data are available for approximately 1450 counties in 1850 compared to about 1820 counties in 1860; 2070 counties in 1870; and 2650 counties in 1890. Moreover, most of the counties missing in 1850 compared to 1860, 1870, or 1890 are agricultural. The consequence of the drop in sample size and sample selection between 1860 and 1850 can be

illustrated by reestimating the link between membership in religious communities and rainfall risk in the 1860 subsample of counties for which there are data in 1850. This always yields statistically insignificant estimates, whereas in the full 1860 sample results were similar to those for 1870 and 1890.

**Agricultural production and seasonal rainfall** Table 4 examines how the effect of rainfall on the value of crops per unit of farmland in Table 1 changes when we distinguish between rainfall during the growing season and the nongrowing season. In the early twentieth-century United States, the nongrowing season went from December to February and the growing season from March to November (Covert, 1912). Column (1) reproduces the specification of Table 1 that controls for rainfall in year  $t$  and year  $t - 1$ . In column (2) we split rainfall in year  $t$  and year  $t - 1$  into growing-season rainfall and nongrowing-season rainfall as in (19). The estimates can be interpreted as, respectively, the effects on agricultural productivity of a 1-percent increase in monthly rainfall during the growing season and the nongrowing season in year  $t$  and year  $t - 1$ . We find positive and statistically significant effects of growing-season and nongrowing-season rainfall in year  $t$ . A 1-percent increase in growing-season rainfall raises agricultural productivity by 0.33 percent and a 1-percent increase in nongrowing-season rainfall raises productivity by 0.15 percent. Only growing-season rainfall is statistically significant in year  $t - 1$ , with a 1-percent increase in growing-season rainfall raising agricultural productivity by 0.28 percent. The results in column (4) show that the effects of rainfall on agricultural productivity change little when we control for average growing season and nongrowing season temperatures in years  $t$  and  $t - 1$ .<sup>26</sup>

**Seasonal rainfall risk and membership in religious communities** Table 5 summarizes our results on the link between membership in religious communities and rainfall risk during the growing and nongrowing seasons. The estimating equation is (17) with the rainfall risk term being replaced by (18). The control variables are the same as in Tables 2 and 3. Because rainfall during the growing season is a significant determinant of agricultural productivity in

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<sup>26</sup>It is worth noting that the effect of year  $t - 1$  growing-season average temperature is positive and statistically significant. However, the effect is small in the sense that it implies a small effect of growing-season temperature risk on membership in religious communities relative to the effect of growing-season rainfall risk. We elaborate on this point in the next footnote.



Table 4, we expect a positive link between membership in religious communities and growing-season rainfall risk. Nongrowing-season rainfall mattered less for agricultural productivity than growing-season rainfall, and we therefore expect nongrowing-season rainfall risk to matter less for membership in religious communities than growing-season rainfall risk. To get an idea of how much less important nongrowing-season rainfall risk should be according to our theoretical analysis, recall that equations (7)-(9) and (19) imply that the importance of nongrowing-season rainfall risk relative to growing-season rainfall risk for membership in religious communities is  $(\beta_N/\beta_G)^2$ , where  $\beta_N$  and  $\beta_G$  are the (contemporaneous) effects of nongrowing-season and growing-season rainfall on agricultural productivity. The formula changes somewhat when agricultural productivity also depends on lagged rainfall. In this case, the lagged effect of rainfall and the correlation between rainfall in different years play a role, too. In our data, the correlation between rainfall in different years is approximately zero. In this case, the formula for the relative importance of nongrowing-season rainfall risk for membership in religious communities relative to growing-season rainfall risk is  $(\beta_{N,t}^2 + \beta_{N,t-1}^2) / (\beta_{G,t}^2 + \beta_{G,t-1}^2)$ , where subscripts  $t$  and  $t - 1$  denote the year  $t$  and  $t - 1$  effects of (nongrowing- and growing-season) rainfall on agricultural productivity. Substituting the statistically significant rainfall effects in column (4) of Table 4 into this formula yields a value of 0.11.<sup>27</sup> Hence, the effect of nongrowing-season rainfall risk on membership in religious communities should be approximately 1/10 of the effect of growing-season rainfall risk.

Table 5, column (1) reports our results on the link between membership in religious communities in 1890 measured as total church members relative to population and rainfall risk during the growing and nongrowing seasons. The link between membership in religious communities and growing-season rainfall risk is positive and statistically significant at the 1-percent level, while the link between religious membership and nongrowing-season rainfall risk is statistically insignificant. Column (2) examines the link between rainfall risk during the growing and

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<sup>27</sup>The same approach can be used to calibrate the importance of growing-season temperature risk (the variance over time of average growing-season temperature) for religious membership relative to the importance of growing-season rainfall risk. In this case, the appropriate formula is  $(\omega_{G,t}^2 + \omega_{G,t-1}^2) / (\beta_{G,t}^2 + \beta_{G,t-1}^2)$ , where  $\omega_{G,t}$  is the effect of year  $t$  growing-season temperature on agricultural output. Substituting the statistically significant estimates in column (4) of Table 4 yields 0.056, which indicates that temperature risk should be substantially less important for religious membership than rainfall risk. When we add the growing-season temperature variance over the 1895-2000 period as a right-hand-side variable in our regressions, it is always statistically insignificant (other findings are unaffected).

nongrowing seasons and membership in religious communities in 1890 measured as combined church seating capacity relative to population. We continue to find a positive and statistically significant link between membership in religious communities and growing-season rainfall risk, whereas the link between religious membership and nongrowing-season rainfall risk is statistically insignificant. The results for membership in religious communities in 1870 and 1860 are shown in columns (3) and (4). The link between membership in religious communities and growing-season rainfall risk is statistically significant at the 1-percent level, while the link between religious membership and nongrowing-season rainfall risk remains statistically insignificant. The covariance term is statistically insignificant in all cases except for 1870.

**Accounting for differences in national cultures, population density, literacy, and religious cultures** The US Census collected county-level data on the foreign birthplaces of the population in 1890 and the foreign birthplaces of the population’s parents in 1880 (the data on birthplaces of foreign-born parents are not available for 1890). These data allow us to account for potential effects of national cultures on membership in religious communities in 1890. To do so, we first calculate for each county the share of the 1890 population born in 33 different foreign places and the share of the 1880 population’s parents born in these places.<sup>28</sup> We then include these shares as additional control variables in our empirical analysis of membership in religious communities.

Table 6 presents the results when we measure membership in religious communities using total church members relative to population. The controls for first- and second-generation immigrants’ countries of origin are jointly statistically significant determinants of religious membership at the 0.001-percent significance level in all specifications. The link between rainfall risk and membership in religious communities in column (1) is somewhat stronger than in Table 2, column (1) where we estimated the same specification without controls for first- and second-generation immigrants’ countries of origin. Using the methodology of Altonji, Elder, and Taber (2005), this suggests that our results are unlikely to be biased upward by selection on unobserv-

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<sup>28</sup>The European foreign birthplaces listed in the census are Austria, Belgium, Bohemia, Canada, Denmark, France, Germany, Greece, Holland, Hungary, Ireland, Italy, Luxembourg, Norway, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and "other European countries". For the Americas, the list includes Atlantic Islands, Central America, Cuba, Mexico, and South America. The remaining categories are Africa, Asia, Australia, India, and Pacific Islands.

ables (e.g., selection of groups of people with greater attachment to their religious communities into counties with greater rainfall risk). This is because for the link between rainfall risk and membership in religious communities to be upward biased, selection on unobservables would have to have the opposite effect on the link between rainfall risk and membership in religious communities than selection on observables (e.g., selection by first- and second-generation immigrants' countries of origin; see Nunn and Wantchekon, 2011, for a recent application of this methodology). Results also change little in columns (2) and (3) where we control for  $\ln$  population in 1890 and the literacy rate in 1880 (the literacy rate is not available for 1890) to account for potential effects of population density and literacy on church membership.<sup>29</sup> Columns (4) and (5) split the sample into counties with value added in agriculture relative to manufacturing above and below the median. We find a positive and statistically significant link between membership in religious communities and rainfall risk among more agricultural counties but a statistically insignificant link among less agricultural counties. Moreover, the difference between more and less agricultural counties is statistically significant at the 5-percent level. Finally, we consider the link between membership in religious communities and rainfall risk during the growing and nongrowing seasons in column (6). We continue to find a stronger link of membership in religious communities with growing-season rainfall risk than with nongrowing-season rainfall risk. Table 7 reports the results when we measure membership in religious communities using combined church seating capacity relative to population. Again, the controls for first- and second-generation immigrants' countries of origin are jointly statistically significant determinants of religious membership at the 0.001-percent significance level in all specifications. The link between rainfall risk and membership in religious communities in column (1) is somewhat stronger than in Table 2, column (4) where we estimated the same specification without controls for first- and second-generation immigrants' countries of origin. Results change little in columns (2) and (3) where we control for  $\ln$  population in 1890 and the literacy rate in 1880. Columns (4) and (5) show a positive and statistically significant link between membership in religious communities and rainfall risk among more agricultural counties but a statistically insignificant link among less agricultural counties. Moreover, the difference between more and

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<sup>29</sup>See Glaeser and Sacerdote (2008) and Becker and Woessmann (2013) on the link between education and church attendance.

less agricultural counties is statistically significant at the 1-percent level. Finally, in column (6) we continue to find a stronger link of membership in religious communities with growing-season rainfall risk than with nongrowing-season rainfall risk.

The US Census also collected county-level data on religious membership by denomination. These data allow us to account for potential effects of denominational differences in religious culture on membership in religious communities in 1890 by controlling for the relative size of different religious denominations. To do so, we first calculate the share of total church members in each county belonging to 12 different denominations and proceed analogously with combined church seating capacity.<sup>30</sup> We then include these denomination shares as additional controls when we examine the link between rainfall risk and membership in religious communities.<sup>31</sup> Table 8, Panel A, reports results when we measure membership in religious communities and the relative size of denominations using total church members. The set of controls for first- and second-generation immigrants' countries of origin and the set of controls for the religious denominations present in a county are both jointly statistically significant determinants of religious membership at the 0.001-percent significance level in all specifications. The link between rainfall risk and membership in religious communities in column (1) is somewhat stronger than in Table 2, column (1) where we estimated the same specification without controls for immigrants' countries of origin and for denominations present in a county. Hence, the methodology of Altonji, Elder, and Taber (2005) again suggests that our results are unlikely to be biased upward by selection on unobservables. Results change little in column (2) where we control for ln population in 1890 and the literacy rate in 1880. When we split the sample into counties with value added in agriculture relative to manufacturing above and below the median, the link between membership in religious communities and rainfall risk is positive and statistically sig-

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<sup>30</sup>The denominations are taken from Gutmann's (2007) classification of nineteenth-century religious denominations into Baptists, Congregationalists, Conservatives, Disciples of Christ, Episcopalians, Jews, Lutherans, Methodists, Mormons, Presbyterians, Reformed, and Roman Catholics.

<sup>31</sup>We do not examine the effect of rainfall risk on the size of specific denominations, as there is no information on denominational differences in insurance provision and substitutability among denominations. For example, the size of denominations does not seem a useful proxy for insurance provision, as sustaining informal insurance requires suppressing free riding, which is more difficult to accomplish in larger religious communities (Iannaccone, 1992). When we use the US General Social Survey data mentioned in the introduction to check for denominational differences in the help individuals expect from their congregation in case of illness or some other difficult situation, we find that differences are statistically insignificant for all denominations in the previous footnote except Conservatives (mainly Mennonites and Quakers, who are more likely to expect help from congregants).

nificant among more agricultural counties in column (3) but not among less agricultural counties in column (4). Moreover, the difference between more and less agricultural counties is statistically significant at the 5-percent level. When we consider the link between growing-season and nongrowing-season rainfall risk on the one hand and membership in religious communities on the other in column (5), the link continues to be stronger for growing-season rainfall risk.

Table 8, Panel B, presents results when we measure membership in religious communities and the relative size of denominations using combined church seating capacity. Again, the set of controls for first- and second-generation immigrants' countries of origin and the set of controls for religious denominations present in a county are both jointly statistically significant determinants of religious membership at the 0.001-percent significance level in all specifications. The link between rainfall risk and membership in religious communities in column (1) is somewhat stronger than in Table 2, column (4) where we estimated the same specification without controls for immigrants' countries of origin and religious denominations. Results change little in column (2) where we control for ln population in 1890 and the literacy rate in 1880. When we split the sample into counties with value added in agriculture relative to manufacturing above and below the median, the link between membership in religious communities and rainfall risk is positive and statistically significant among more agricultural counties in column (3) but not among less agricultural counties in column (4), and the difference is statistically significant at the 5-percent level. Finally, in column (5) we find that the link with religious membership is stronger for growing-season rainfall risk.

### **5.3 The Persistent Effects of Rainfall Risk on Modern Religious Communities**

An interesting issue is whether the effects of agricultural production risk on nineteenth-century religious membership persist to the turn of the twenty-first century. County-level data on US religious membership around the turn of the twenty-first century are collected by the Glenmary Research Center and distributed by the Association of Religion Data Archives ([www.thearda.com](http://www.thearda.com)). The data archive has information on church *members* according to each denomination's membership definition for 1980 and 1990 and on church *adherents* for 1980, 1990, 2000, and 2010.

Church adherents include members and other regular attendants to religious services.<sup>32</sup> Our measures of modern county-level religious membership only count denominations that we could classify as belonging to meta-denominations present in our nineteenth-century data.<sup>33</sup>

Our empirical analysis is based on the following estimating equation:

$$\ln \left( \frac{\text{Modern church members or adherents}_c}{\text{Population}_c} \right) = \varphi + \gamma \ln RY_c + \sum_{i=1}^I \phi_i X_{ic} \quad (20)$$

$$+ \rho \ln \left( \frac{\text{1890 church members}_c}{\text{Population}_c} \right)$$

where  $RY_c = E \left( \prod_m R_{mc}^{\beta/12} \right)$  with  $\beta$  being estimated using (16), and  $X_c$  stands for county characteristics like soil quality or ruggedness of the terrain. Our main interest is in the parameter  $\rho$  – the extent to which differences in historical church membership across counties persist to around the turn of the twenty-first century – when historical church membership is instrumented with rainfall risk,  $RVar_c$ . The resulting estimate indicates the extent to which cross-county differences in historical church membership associated with rainfall risk persist.

Table 9, Panel A, columns (1)-(3) report our results for the degree of persistence,  $\rho$ , when modern church membership in (20) is measured as average adherents over the 1980-2010 period and historical membership in 1890 is instrumented with rainfall risk. We only consider counties with an above-median agricultural share in 1890, as our empirical analysis using historical data yielded an effect of rainfall risk on religious membership for counties with agricultural shares above the median but not for below-median agricultural counties. Column (1) reports results with the controls of Table 2. Column (2) adds the controls for countries of origin of immigrants of Table 6 and column (3) the controls for the size of different religious denominations of Table 8. In addition to point estimates and standard errors, the table reports the Kleibergen-Paap F-statistic of instrument strength. As the instrument appears sometimes weak, we also report the Anderson-Rubin test of statistical significance for  $\rho$ , which is robust to weak instruments

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<sup>32</sup>The ARDA database for members does not have information on Roman Catholics, and we therefore use adherents instead.

<sup>33</sup>As these meta-denominations constitute the vast majority of modern US church members and adherents, we get almost identical results when we use all denominations (available upon request). The meta-denominations are Baptists, Congregationalists, Conservatives, Disciples of Christ, Episcopalians, Jews, Lutherans, Methodists, Mormons, Presbyterians, Reformed, and Roman Catholics; see Gutmann (2007).

(e.g., Andrews and Stock, 2005). It can be seen that the point estimates of  $\rho$  are between 0.36 and 0.5 and statistically significant at standard levels. The 0.36 point estimate, for example, implies that slightly above 1/3 of the historical church membership associated with rainfall risk persists to around the turn of the twenty-first century.

It is interesting to compare our estimate of the persistence of cross-county differences in historical church membership associated with rainfall risk and the persistence of historical church membership no matter what the source of historical cross-county differences in church membership is. This “average” degree of persistence can in principle be obtained by estimating (20) with least squares. However, in our case this approach clearly does not work, as 1890 membership is certainly measured with error and least-squares estimation yields (downward) biased results in this case. To address this issue we estimate the “average” degree of persistence,  $\rho$ , in (20) by instrumenting church membership in 1890 with church seatings in 1870.<sup>34</sup> This yields a consistent estimate when measurement error in 1890 membership is unrelated to measurement error in 1870 seatings, which does not seem unreasonable as these data were collected a generation apart. Table 9, Panel A, columns (4)-(6) report our results. Overall, the degree of persistence we estimate is similar to what we obtained in columns (1)-(3), which indicates that historical differences in cross-county church membership associated with rainfall risk persist about as much as historical differences in church membership associated with other sources.

Table 9, Panel A, columns (7)-(9) augment the specifications in columns (4)-(6) with a direct effect of rainfall risk. This allows us to capture any effects of rainfall risk on modern religious membership conditional on 1890 membership. Our results indicate that the direct effect of rainfall risk is statistically insignificant. Hence, rainfall risk appears to affect modern church membership through persistent effects on nineteenth-century church membership rather than any direct effect during the twentieth century.

Table 9, Panel B reports our results when using average members over the 1980-1990 period as the proxy for modern religious membership. This yields qualitatively similar results as

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<sup>34</sup>Using 1890 church seatings as an instrument is most likely not a good alternative, as 1890 seatings and members were collected at the same time and are likely to reflect the same measurement errors. When there are no data for 1870 seatings in a county we use the average of 1870 seatings in directly neighboring counties (if available).

our analysis based on adherents but stronger persistence of historical membership to modern times. Hence, overall our empirical analysis indicates considerable persistence of the effect of rainfall risk on membership in religious communities. This is consistent with recent evidence on the persistence of various cultural traits transmitted either within families or within broader communities (e.g., Bao et al., 1999; Bisin and Verdier, 2000; Bengtson et al., 2009; Alesina and Giuliano, 2010; Fernández, 2011; Giavazzi, Petkov, and Schiantarelli, 2014).

## 6 Conclusion

Is the spread of religious communities related to economic risks faced by individuals? The available microeconomic evidence indicates that religious communities provide some informal insurance against idiosyncratic risk to their members. We argued that, as a result, membership in religious communities should be more prevalent where populations face greater common risk. Intuitively, this is because we found that for individual risk aversion in the empirically relevant range, idiosyncratic risk and rainfall risk aggravate each other in the sense that a bad realization of one risk reduces consumption utility more, the worse the realization of the other risk. Hence, individuals gain more from mutual insurance against idiosyncratic risk when greater common risk makes the worst case scenario of bad realizations of both idiosyncratic and common risks more probable.

In our empirical analysis, we used rainfall risk as a driver of agricultural production risk in the nineteenth-century United States. We found that in counties with greater rainfall risk, a larger share of the population was organized into religious communities. The link between rainfall risk and membership in religious communities became somewhat stronger when we controlled for first- and second-generation immigrants' countries of origin and for the religious denominations present in a county. This suggests that our finding of a positive link between rainfall risk and religious community membership is unlikely to reflect the selection of groups of people with greater attachment to their religious communities into counties with greater rainfall risk. We also argued that our finding is unlikely to reflect the coping theory of religiosity, which points to psychological benefits of religiosity when individuals are dealing with adverse events that are unpredictable. This is because we found cross-county differences in rainfall risk to be



persistent over time and because the coping theory of religiosity has been found to apply to religious beliefs rather than church attendance.

If rainfall risk affects the value of church membership through agricultural production risk, there should be a positive link between the share of the population organizing into religious communities and rainfall risk in predominately agricultural counties. Moreover, the link between membership in religious communities and rainfall risk should be stronger in more agricultural counties than less agricultural counties. We found empirical support for both of these implications of our model. In line with our model, we also found the link between membership in religious communities and rainfall risk to be stronger for rainfall risk during the growing season. Our estimates of the effect of rainfall risk on membership in religious communities imply that a 1-standard-deviation increase in rainfall risk was associated with an increase in membership in religious communities of around 10 percent across all counties. Among more agricultural counties, a 1-standard-deviation increase in rainfall risk was associated with an increase in membership in religious communities between 20 percent (in 1890) and 50 percent (in 1860).

We also investigated whether the effects of agricultural production risk on nineteenth-century religious membership persisted to modern times. Our empirical results indicate that among historically more agricultural counties – the group of counties where we found an effect of rainfall risk on historical religious membership – more than 1/3 of nineteenth-century differences in religious membership associated with rainfall risk persist to the turn of the twenty-first century.

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## Tables

**Table 1: The Effect of Rainfall on Agricultural Productivity at the Turn of the Twentieth Century**

	(1)	(2)	(3)
Rainfall t	0.515*** (0.183)	0.511*** (0.178)	0.516*** (0.181)
Rainfall t-1		0.177 (0.144)	0.178 (0.144)
Temperature t			0.0246 (0.0377)
Temperature t-1			0.0212 (0.0438)
County FE	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
Farmland	Yes	Yes	Yes
R2	0.633	0.634	0.634
Number of counties	8,787	8,787	8,787

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Notes: The left-hand-side variable is the natural logarithm (ln) of the value of crops produced per acre at the county level in 1909, 1919, and 1929. The results in column (1) are for the estimating equation in (16); see Sections 4 and 5.2 (pages 18-19) for more details on the specification. Columns (2)-(3) add controls for lagged rainfall and for contemporaneous and lagged temperature. Temperature refers to average temperature. The method of estimation is weighted least squares with weights equal to the farmland of counties. All specifications control for ln farmland, time effects, and county fixed effects; time effects are allowed to vary by state. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the county level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 2: The Effect of Rainfall Risk on Religious Community Size in 1890**

	Church members/population			Church seatings/population		
	Baseline	Agriculture above median	Agriculture below median	Baseline	Agriculture above median	Agriculture below median
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall risk	1.962*** (0.471)	2.519** (1.065)	-0.917 (0.986)	1.888** (0.801)	5.431*** (1.823)	-1.331 (1.095)
ln RY	0.270 (0.210)	0.323 (0.390)	-0.092 (0.174)	0.799** (0.355)	1.575** (0.633)	0.186 (0.159)
Soil shares	Yes	Yes	Yes	Yes	Yes	Yes
Elevation shares	Yes	Yes	Yes	Yes	Yes	Yes
Average elevation	Yes	Yes	Yes	Yes	Yes	Yes
Average temperature	Yes	Yes	Yes	Yes	Yes	Yes
Longitude and latitude	Yes	Yes	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.463	0.515	0.512	0.576	0.620	0.612
Number of counties	2,693	1,341	1,341	2,651	1,322	1,323

Notes: For columns (1)-(3) the left-hand-side variable is the natural logarithm (ln) of total church members over population at the county level in 1890. For columns (4)-(6) the left-hand-side variable is ln combined church seating capacity over population at the county level in 1890. The estimating equation employed is (17). Rainfall risk is defined in equation (14) and calculated using 1895-2000 rainfall data. The RY variable is defined just after equation (17) and is calculated using the same rainfall data and a value  $\beta = 0.52$ . See Section 4 for more details on the specification and Section 5.1 for data sources. Other controls are ln land area of the county (area), the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, average temperature over the period 1895-2000, longitude and latitude, and state fixed effects. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 3: The Effect of Rainfall Risk on Religious Community Size in 1860 and 1870**

	Church seatings/population 1870			Church seatings/population 1860		
	Baseline	Agriculture above median	Agriculture below median	Baseline	Agriculture above median	Agriculture below median
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall risk	2.310** (1.036)	8.011** (3.391)	1.735 (0.890)	1.892** (0.898)	7.710** (3.480)	-0.496 (1.034)
ln RY	0.354 (0.270)	1.259** (0.502)	0.220 (0.356)	-0.016 (0.468)	1.396* (0.752)	-0.331 (0.267)
Soil shares	Yes	Yes	Yes	Yes	Yes	Yes
Elevation shares	Yes	Yes	Yes	Yes	Yes	Yes
Average elevation	Yes	Yes	Yes	Yes	Yes	Yes
Average temperature	Yes	Yes	Yes	Yes	Yes	Yes
Longitude and latitude	Yes	Yes	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.390	0.384	0.509	0.351	0.339	0.476
Number of counties	2,068	1,033	1,034	1,822	909	909

Notes: The left-hand-side variable is the natural logarithm (ln) of combined church seating capacity over population at the county level in 1870 (columns (1)-(3)) and in 1860 (columns (4)-(6)). The estimating equation employed is (17). Rainfall risk is defined in equation (14) and calculated using 1895-2000 rainfall data. The RY variable is defined just after equation (17) and is calculated using the same rainfall data and a value  $\beta = 0.52$ . See Section 4 for more details on the specification and Section 5.1 for data sources. Other controls are ln land area of the county (area), the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, average temperature over the period 1895-2000, longitude and latitude, and state fixed effects. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 4: The Effect of Seasonal Rainfall on Agricultural Productivity at the Turn of the Twentieth Century**

	(1)	(2)	(3)	(4)
Rainfall t	0.511*** (0.178)		0.516*** (0.181)	
-- Rainfall t, Growing season		0.326* (0.186)		0.325* (0.194)
-- Rainfall t, Nongrowing season		0.148*** (0.0363)		0.147*** (0.0382)
Rainfall t-1	0.177 (0.144)		0.178 (0.144)	
-- Rainfall t-1, Growing season		0.279*** (0.0837)		0.314*** (0.0837)
-- Rainfall t-1, Nongrowing season		-0.0482 (0.0666)		-0.0497 (0.0644)
Temperature t			0.0246 (0.0377)	
-- Temperature t, Growing season				-0.0203 (0.0459)
-- Temperature t, Nongrowing season				-0.00891 (0.0214)
Temperature t-1			0.0212 (0.0438)	
-- Temperature t-1, Growing season				0.107** (0.0453)
-- Temperature t-1, Nongrowing season				-0.0208 (0.017)
County FE	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Farmland	Yes	Yes	Yes	Yes
R2	0.634	0.638	0.634	0.639
Number of counties	8,787	8,787	8,787	8,787

Notes: The left-hand-side variable is the natural logarithm (ln) of the value of crops produced per acre at the county level in 1909, 1919, and 1929. The estimating equation is (16) with the rainfall term being split into rainfall over the growing season and nongrowing season as in equation (19): see Section 4 and Section 5.2 (pages 18-19 and 23) for more details on the specification. Temperature refers to average temperature. The growing season is March-November, and the nongrowing season is December-February following Covert (1912), see pages 12-13. The data sources are in Section 5.1. Columns (1) and (3) are reproduced from Table 1. The method of estimation is weighted least squares with weights equal to the farmland of counties. All specifications control for ln farmland, time effects, and county fixed effects. The time effects are allowed to vary by state. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the county level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 5: The Effect of Seasonal Rainfall Risk on Religious Community Size in 1860, 1870, and 1890**

	Church members/population	Church seatings/population		
	1890	1890	1870	1860
	(1)	(2)	(3)	(4)
Growing-season rainfall risk	1.134*** (0.300)	1.273** (0.580)	1.318*** (0.422)	1.554*** (0.528)
Nongrowing-season rainfall risk	0.199 (0.129)	0.156 (0.147)	-0.118 (0.351)	-0.547 (0.477)
RCov(Growing-season, Nongrowing-season rainfall)	-0.493 (0.915)	-1.336 (1.040)	5.026* (2.576)	1.026 (3.356)
In RY control	Yes	Yes	Yes	Yes
Soil shares	Yes	Yes	Yes	Yes
Elevation shares	Yes	Yes	Yes	Yes
Average elevation	Yes	Yes	Yes	Yes
Average temperature	Yes	Yes	Yes	Yes
Longitude and latitude	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
R2	0.464	0.577	0.392	0.352
Number of counties	2,693	2,651	2,068	1,822

Notes: The left-hand-side variable is the natural logarithm (ln) of total church members over population or combined church seating capacity over population at the county level from the US Census in 1890, 1870, or 1860. The estimating equation employed is (17) with the rainfall risk term replaced by equation (18) and calculated using 1895-2000 rainfall data. The RY variable is defined just after equation (17) and is calculated using the same rainfall data and a value  $\beta = 0.52$ . The growing season is March-November and the nongrowing season is December-February following Covert (1912), see pages 12-13. See Section 5.1 data sources and Sections 4 and 5.2 for more details on the specification. Other controls are ln land area of the county (area), the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, average temperature over the period 1895-2000, longitude and latitude, and state fixed effects. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 6: The Effect of Rainfall Risk on Church Members in 1890: Controlling for First- and Second-Generation Immigrants' Countries of Ancestry**

	<u>FG/SG</u>	<u>+ Pop</u>	<u>+ Literacy</u>	<u>Agriculture above median</u>	<u>Agriculture below median</u>	<u>Growing and nongrowing season</u>
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall risk	2.060*** (0.667)	2.178*** (0.767)	2.134*** (0.766)	2.889** (1.316)	-0.264 (0.741)	
Growing-season rainfall risk						0.893* (0.496)
Nongrowing-season rainfall risk						0.320** (0.143)
RCov(Growing-season, Nongrowing-season rainfall)						0.363 (1.477)
In RY control	Yes	Yes	Yes	Yes	Yes	Yes
FG national cultures	Yes	Yes	Yes	Yes	Yes	Yes
SG national cultures	Yes	Yes	Yes	Yes	Yes	Yes
Soil shares	Yes	Yes	Yes	Yes	Yes	Yes
Elevation shares	Yes	Yes	Yes	Yes	Yes	Yes
Average elevation	Yes	Yes	Yes	Yes	Yes	Yes
Average temperature	Yes	Yes	Yes	Yes	Yes	Yes
Longitude and latitude	Yes	Yes	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.495	0.514	0.515	0.603	0.568	0.516
Number of counties	2,520	2,520	2,482	1,239	1,239	2,482

Notes: The left-hand-side variable is the natural logarithm (ln) of total church members over population at the county level in 1890. The estimating equation employed is (17); in column (6) the rainfall risk term is replaced by equation (18). Rainfall risk is calculated using 1895-2000 rainfall data. The RY variable is defined just after equation (17) and is calculated using the same rainfall data and a value  $\beta = 0.52$ . The growing season is March-November and the nongrowing season is December-February following Covert (1912), see pages 12-13. See Section 4 for more details on the specification and Section 5.1 for data sources. First-generation (FG) national cultures refer to the shares of foreign-born county residents in 1890 by foreign birthplace. Second-generation (SG) national cultures refer to the shares of foreign-born parents of county residents in 1880 by foreign birthplace. The data identifies 33 different foreign birthplaces listed in footnote 28. We control for ln population in 1890 (from column (2) on) and the literacy rate in 1880 (from column (3) on). Other controls are ln land area of the county (area), the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, average temperature over the period 1895-2000, longitude and latitude, and state fixed effects. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 7: The Effect of Rainfall Risk on Church Seatings in 1890: Controlling for First- and Second-Generation Immigrants' Countries of Ancestry**

	<u>+ FG/SG</u>	<u>+ Pop</u>	<u>+ Literacy</u>	<u>Agriculture above median</u>	<u>Agriculture below median</u>	<u>Growing and nongrowing season</u>
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall risk	2.394*** (0.676)	2.394*** (0.677)	2.000*** (0.504)	4.423*** (1.217)	0.269 (0.540)	
Growing-season rainfall risk						1.383*** (0.458)
Nongrowing-season rainfall risk						-0.0107 (0.0975)
RCov(Growing-season, Nongrowing-season rainfall)						0.718 (0.753)
In RY control	Yes	Yes	Yes	Yes	Yes	Yes
FG national cultures	Yes	Yes	Yes	Yes	Yes	Yes
SG national cultures	Yes	Yes	Yes	Yes	Yes	Yes
Soil shares	Yes	Yes	Yes	Yes	Yes	Yes
Elevation shares	Yes	Yes	Yes	Yes	Yes	Yes
Average elevation	Yes	Yes	Yes	Yes	Yes	Yes
Average temperature	Yes	Yes	Yes	Yes	Yes	Yes
Longitude and latitude	Yes	Yes	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.609	0.609	0.617	0.656	0.698	0.617
Number of counties	2,520	2,502	2,471	1,234	1,234	2,471

Notes: The left-hand-side variable is the natural logarithm (ln) of combined church seating capacity over population at the county level in 1890. The estimating equation employed is (17); in column (6) the rainfall risk term is replaced by equation (18). Rainfall risk is calculated using 1895-2000 rainfall data. The RY variable is defined just after equation (17) and is calculated using the same rainfall data and a value  $\beta = 0.52$ . The growing season is March-November and the nongrowing season is December-February following Covert (1912), see pages 12-13. See Section 4 for more details on the specification and Section 5.1 for data sources. First-generation (FG) national cultures refer to the shares of foreign-born county residents in 1890 by foreign birthplace. Second-generation (SG) national cultures refer to the shares of foreign-born parents of county residents in 1880 by foreign birthplace. The data identifies 33 different foreign birthplaces listed in footnote 28. We control for ln population in 1890 (from column (2) on) and the literacy rate in 1880 (from column (3) on). Other controls are ln land area of the county (area), the share of land of a given soil type using a 53-category soil classification system, the share of land at a given elevation using 11 elevation bins, average elevation, average temperature over the period 1895-2000, longitude and latitude, and state fixed effects. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

**Table 8: The Effect of Rainfall Risk on Religious Community Size: Controlling for Religious Denominations**

**Panel A: Church Members/Population**

	Baseline	+ Pop and Literacy	Agriculture above median	Agriculture below median	Growing and nongrowing season
	(1)	(2)	(3)	(4)	(5)
Rainfall risk	2.244*** (0.602)	2.201*** (0.648)	2.854** (1.169)	0.411 (0.768)	
Growing-season rainfall risk					1.044** (0.494)
Nongrowing-season rainfall risk					0.276* (0.148)
RCov(Growing-season, Nongrowing-season rainfall)					0.238 (1.256)
Denomination shares	Yes	Yes	Yes	Yes	Yes
All Controls Tables 6/7 (column 1)	Yes	Yes	Yes	Yes	Yes
Population and Literacy	No	Yes	Yes	Yes	Yes
R2	0.547	0.567	0.647	0.603	0.568
Number of counties	2,482	2,482	1,239	1,239	2,482

**Panel B: Church Seatings/Population**

	(1)	(2)	(3)	(4)	(5)
Rainfall risk	2.216*** (0.586)	2.143*** (0.580)	4.206*** (1.308)	0.450 (0.583)	
Growing-season rainfall risk					1.358*** (0.461)
Nongrowing-season rainfall risk					0.0448 (0.112)
RCov(Growing-season, Nongrowing-season rainfall)					0.925 (0.723)
Denomination shares	Yes	Yes	Yes	Yes	Yes
All Controls Tables 6/7 (column 1)	Yes	Yes	Yes	Yes	Yes
Population and Literacy	No	Yes	Yes	Yes	Yes
R2	0.629	0.633	0.672	0.712	0.633
Number of counties	2,471	2,471	1,234	1,234	2,471

Notes: The left-hand-side variable is the natural logarithm (ln) of total church members over population (Panel A) or combined church seating capacity over population (Panel B) at the county level in 1890. See Section 4 for more details on the specification and Section 5.1 for data sources. Denomination shares refer to either church members of 12 different denominations divided by the total church members (Panel A) or church seating capacity of these denominations divided by total church seating capacity (Panel B); the denominations are listed in footnote 30. See the notes to Table 7 for a description of the first-generation (FG) and second-generation (SG) national cultures variables as well as the other controls. The method of estimation is least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.



**Table 9: Persistence of Religious Membership****Panel A: Church Adherents/Population 1980-2010**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Church members per capita in 1890	0.501*** (0.140)	0.437** (0.214)	0.363* (0.201)	0.501*** (0.178)	0.459*** (0.156)	0.457*** (0.169)	0.488*** (0.185)	0.453*** (0.167)	0.452** (0.181)
Rainfall risk							0.999 (0.864)	0.387 (0.807)	0.301 (0.858)
Number of counties	1,333	1,235	1,235	1,188	1,154	1,154	1,188	1,154	1,154
Kleibergen-Paap F-Statistic	6.90	5.05	6.12	7.45	11.41	12.27	7.51	10.88	11.57
Anderson-Rubin Wald Test (p-val)	0.01	0.02	0.04	0.07	0.04	0.05	0.08	0.06	0.07

**Panel B: Church Members/Population 1980-1990**

Church members per capita in 1890	0.605*** (0.183)	0.667** (0.328)	0.577* (0.312)	0.584** (0.230)	0.574*** (0.180)	0.561*** (0.192)	0.572** (0.235)	0.564*** (0.190)	0.551*** (0.203)
Rainfall risk							0.930 (0.931)	0.579 (0.937)	0.569 (0.930)
Number of counties	1,333	1,235	1,235	1,188	1,154	1,154	1,188	1,154	1,154
Kleibergen-Paap F-Statistic	6.90	5.05	6.12	7.45	11.41	12.27	7.51	10.88	11.57
Anderson-Rubin Wald Test (p-val)	0.02	0.03	0.04	0.06	0.02	0.02	0.07	0.02	0.03
All Controls Table 2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FG national cultures	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
SG national cultures	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Population	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Literacy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Denomination shares	No	No	Yes	No	No	Yes	No	No	Yes

Notes: The left-hand-side variable is the average of the natural logarithm (ln) of total church adherents over population for the years 1980-2010 in Panel A and the average of the natural logarithm (ln) of total church members over population for the years 1980 and 1990 in Panel B. In columns (1)-(3) the excluded instrument is rainfall risk; in columns (4)-(9) the excluded instrument is the natural logarithm (ln) of church seating/population at the county level in 1870). The method of estimation is two-stage least squares. Standard errors (in parentheses) account for arbitrary heteroskedasticity and are clustered at the state level. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level, respectively.

## Appendix Table 1: Summary Statistics

### Panel A: Full sample

Variable	1890			1870			1860			1850		
	Obs	Mean	StdDev	Obs	Mean	StdDev	Obs	Mean	StdDev	Obs	Mean	StdDev
ln Church members/population	2,693	-1.33	0.56	-	-	-	-	-	-	-	-	-
ln Church seatings/population	2,651	-0.45	0.63	2,068	-0.79	0.69	1,822	-0.68	0.69	1,448	-0.75	0.73
Rainfall risk	2,693	0.06	0.05	2,068	0.05	0.04	1,822	0.04	0.04	1,448	0.04	0.03
Growing-season rainfall risk	2,693	0.07	0.07	2,068	0.06	0.07	1,822	0.06	0.06	1,448	0.05	0.05
Nongrowing-season rainfall risk	2,693	0.22	0.24	2,068	0.15	0.12	1,822	0.14	0.10	1,448	0.12	0.06
Cov (Growing-season, Nongrowing-season rainfall)	2,693	0.01	0.02	2,068	0.01	0.02	1,822	0.01	0.01	1,448	0.01	0.01
Average temperature	2,693	12.29	4.47	2,068	12.78	4.10	1,822	13.01	3.94	1,448	13.13	3.71
ln Population	2,693	9.47	1.06	2,068	9.32	0.97	1,822	9.28	0.94	1,448	9.23	0.90
ln Area	2,693	6.49	0.76	2,068	6.37	0.71	1,822	6.31	0.65	1,448	6.26	0.58
Population per square mile	2,693	73.1	669.65	2,068	74.5	1128	1,822	67.2	1010	1,448	58.45	729.4
Agricultural value added relative to agriculture plus manufacturing	2,682	0.76	0.26	2,067	0.81	0.21	1,818	0.84	0.21	1,446	0.78	0.23

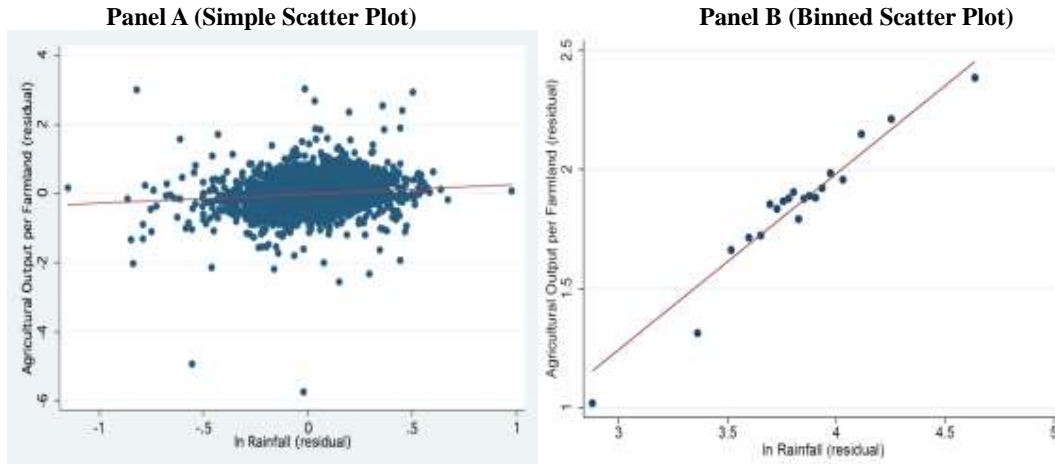
**Panel B.1: Counties with agricultural share above the median**

Variable	1890			1870			1860		
	Obs	Mean	StdDev	Obs	Mean	StdDev	Obs	Mean	StdDev
ln Church members/population	1,341	-1.39	0.59	-	-	-	-	-	-
ln Church seatings/population	1,322	-0.49	0.69	1,033	-0.82	0.74	909	-0.72	0.71
Rainfall risk	1,341	0.07	0.05	1,033	0.05	0.03	909	0.04	0.03
Average temperature	1,341	13.12	4.52	1,033	14.34	3.63	909	14.54	3.56
ln Population	1,341	9.10	0.95	1,033	9.05	0.75	909	9.03	0.75
ln Area	1,341	6.52	0.76	1,033	6.33	0.58	909	6.30	0.54
Population per square mile	1,341	22.34	15.47	1,033	20.90	14.12	909	20.62	13.49
Agricultural value added relative to agriculture plus manufacturing	1,341	0.95	0.04	1,033	0.95	0.03	909	0.96	0.03

**Panel B.2: Counties with agricultural share below the median**

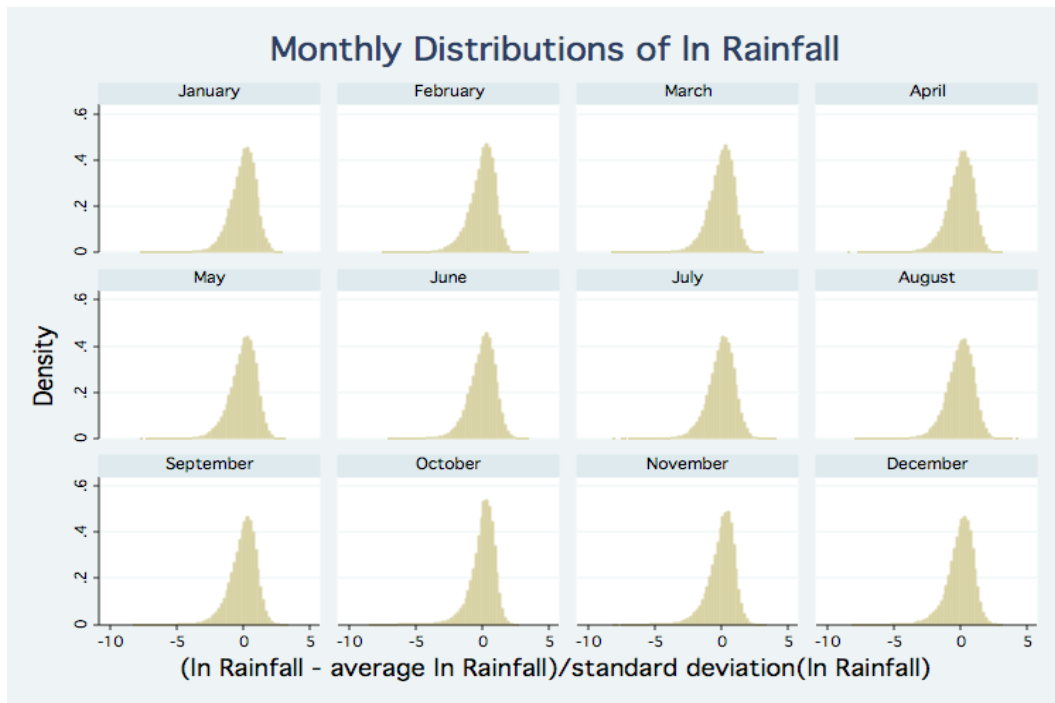
Variable	1890			1870			1860		
	Obs	Mean	StdDev	Obs	Mean	StdDev	Obs	Mean	StdDev
ln Church members/population	1,341	-1.27	0.52	-	-	-	-	-	-
ln Church seatings/population	1,323	-0.41	0.56	1,034	-0.76	0.64	909	-0.64	0.65
Rainfall risk	1,341	0.05	0.05	1,034	0.05	0.05	909	0.04	0.05
Average temperature	1,341	11.45	4.24	1,034	11.21	3.95	909	11.48	3.68
ln Population	1,341	9.87	0.99	1,034	9.59	1.07	909	9.54	1.03
ln Area	1,341	6.45	0.77	1,034	6.41	0.82	909	6.33	0.74
Population per square mile	1,341	124.4	946.25	1,034	128	1594	909	114.1	1428
Agricultural value added relative to agriculture plus manufacturing	1,341	0.43	0.25	1,034	0.67	0.22	909	0.71	0.23

## Appendix Figure A.1



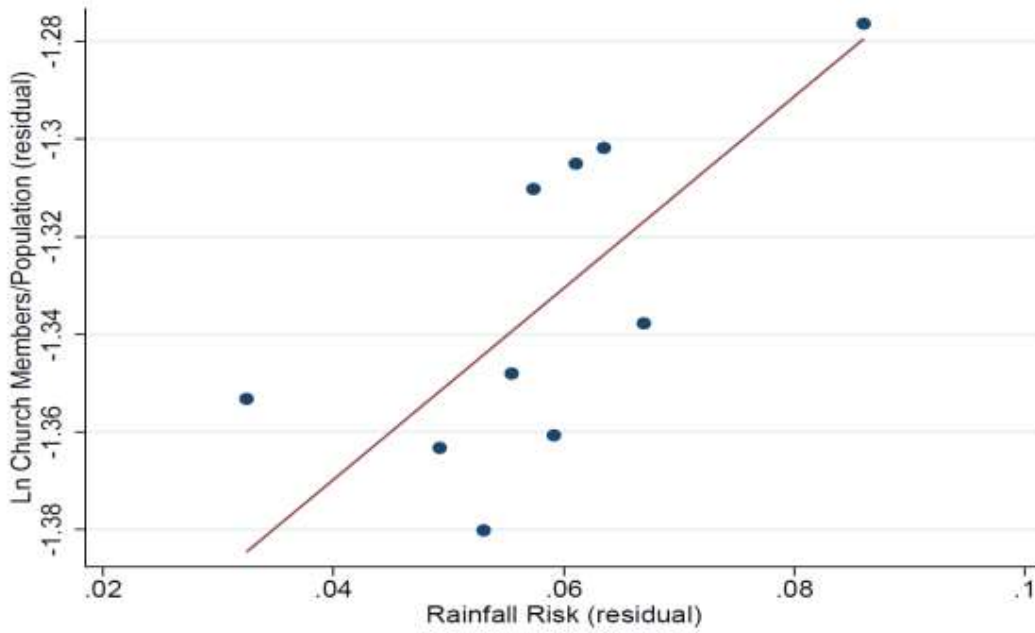
Notes: Panel A is a simple scatter plot and Panel B a binned scatter plot. Both are based on the residuals from a regression of the county-level natural logarithm (ln) of the value of crops produced per acre (horizontal axis) and of rainfall (vertical axis) in 1909, 1919, and 1929 on county fixed effects, time effects that vary by state, and ln farmland. See Section 5.1 for the data sources and Section 4 as well as Section 5.2 (pages 18-19) for more details on the specification.

## Appendix Figure A.2



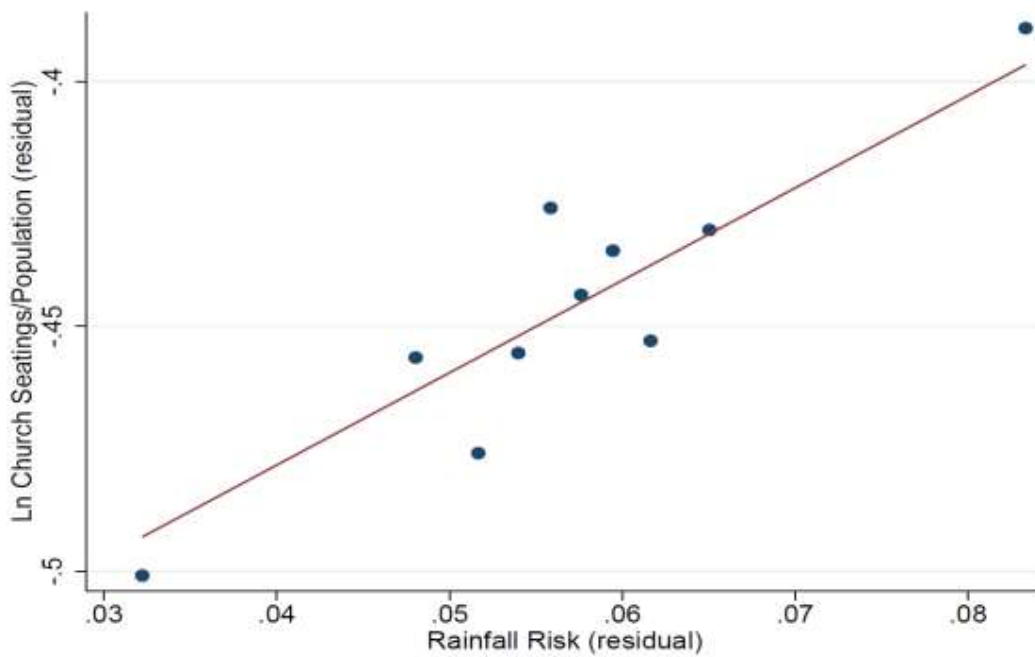
Notes: Standardized distributions of the natural logarithm (ln) of rainfall 1895-2000 at the county level by month.

### Appendix Figure A.3



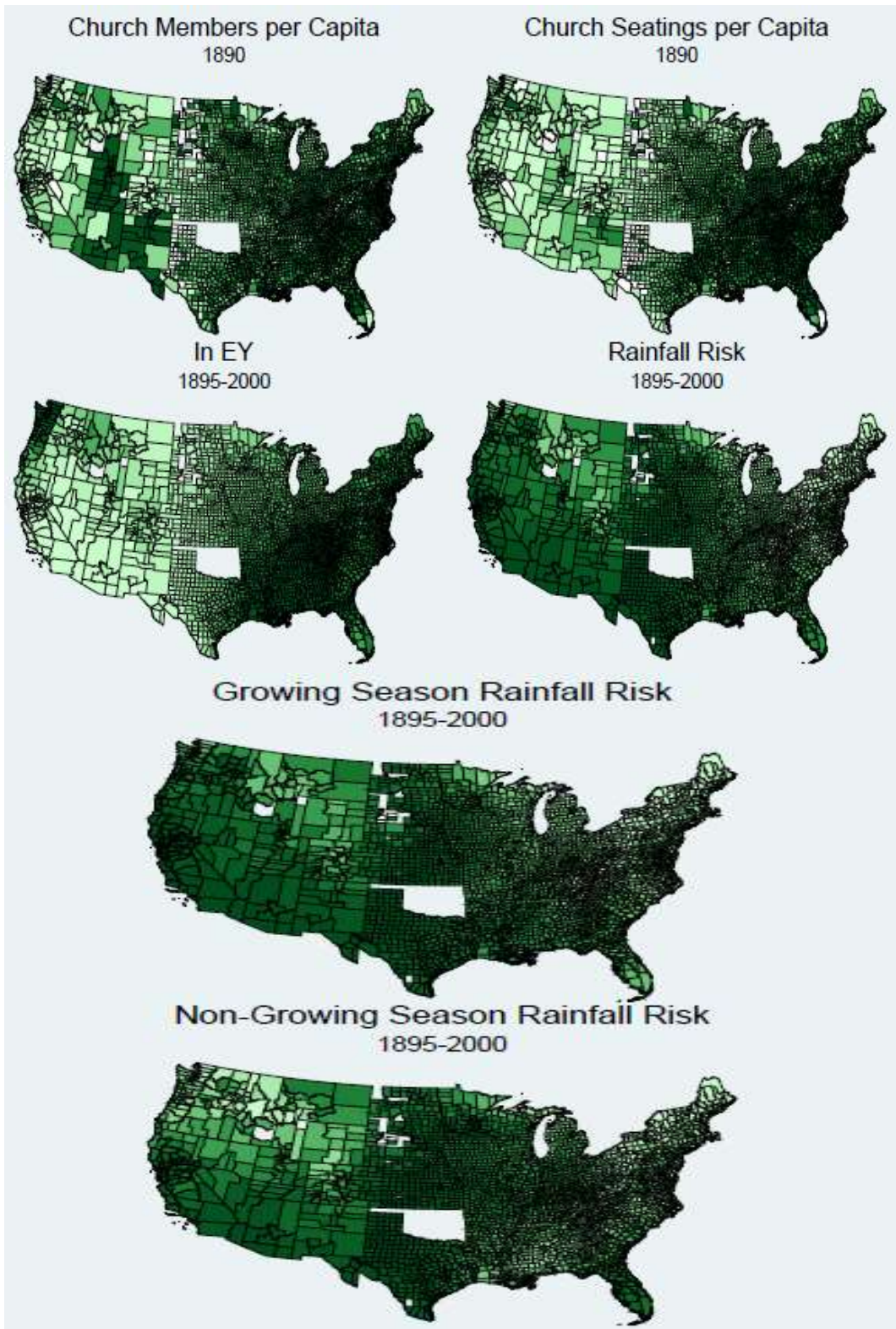
Notes: Binned scatter plot based on the residuals from a regression of the county-level natural logarithm (ln) of total church members over population (horizontal axis) and of rainfall risk (vertical axis) in 1890 on state fixed effects and all other controls included in Table 2, column (1). See the note to Table 2 for a list of controls.

### Appendix Figure A.4



Notes: Binned scatter plot based on the residuals from a regression of the county-level natural logarithm (ln) of combined church seating capacity over population (horizontal axis) and of rainfall risk (vertical axis) in 1890 on state fixed effects and all other controls included in Table 2, column (1). See the note to Table 2 for a list of controls.

## Appendix Figure A.5



Notes: A darker color refers to higher values of church members per capita, church seatings per capita, lnEY, and (growing/nongrowing) rainfall risk. White polygons denote missing observations.