LETTER: Pathogen Prevalence is Associated with Cultural Changes in Gender Equality

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Gender equality has varied across time, with dramatic shifts occurring in countries like the US in the past several decades. Although differences across societies and changes within societies in gender equality have been well documented, the causes of changes in levels of gender equality remain poorly understood. Scholars have posited that such shifts have been driven by specific events (i.e. Title IX, Roe v. Wade), broader social movements (i.e. Feminism, Women's Liberation), or general levels of social development (e.g., Modernization Theory 1). Although these factors likely are in part responsible for temporal variations in gender equality, they provide fairly intermediate explanations void of a comprehensive framework. In the present research, we use an ecological framework to explore the role of key ecological dimensions on change in gender equality over time. We focus on four key types of ecological threats/affordances that have previously been linked to cultural variations in human behavior as potential explanations for cultural change in gender equality: infectious disease, resource scarcity, warfare, and climatic stress. Here we show that decreases in pathogen prevalence in the US over 6 decades (1951-2013) are linked to reductions in gender inequality and that such shifts in rates of infectious disease *precede* shifts in gender inequality. Results were robust, holding when controlling for other ecological dimensions and for collectivism and conservative ideological identification (indicators of more broadly traditional cultural norms and attitudes). Further the effects were partially mediated by reduced rates of teen births (a sign that people are adopting slower life history strategies), suggesting that life history strategies statistically account for the relationship between pathogen prevalence and gender inequality over time. Finally, we replicated our key effects in a different society, using comparable data from the UK over a period of 7 decades (1945-2014).

There is a growing view in the behavioral sciences that the ultimate sources of cultural variations in psychology, behavior, and institutions may lie in systematic variations in ecology across societies (e.g., 2, 3, 4, 5). Ecological frameworks have provided theory-driven, novel explanations for cultural variations in phenomena ranging from collectivism (5), to homicide (6). Ecology has also been used to explain not only patterns of cultural variation, but more recently *change* in various cultural practices and values such as individualism and contempt (7). Here we apply this approach to cultural changes in gender equality, focusing on four dimensions of ecology: pathogen prevalence, resource scarcity, external threat, and climatic stress.

The threat posed by infectious disease have been implicated in a host of cross-cultural differences in phenomena (4). These cultural variations have been conceptualized as adaptive responses to varying pathogen loads, part of a behavioral immune system that reduces the chance of individuals becoming ill (9). Higher levels of infectious disease seem to lead societies and individuals to adopt more traditional attitudes and norms. Higher levels of pathogen prevalence are associated with greater conformity (10, 11, 12), greater authoritarianism (13), less openness (14), and tighter social norms (15). Given that most human societies have relatively patriarchal traditions, it seems possible that higher pathogen prevalence might also promote behaviors, norms, and values that foster gender inequality. That is, as men have traditionally held more power in most societies, if pathogens push people toward more traditional values than one might expect individuals and institutions to accord women fewer rights and opportunities when pathogen loads are higher. Further, cross-sectional research suggests that in countries where infectious disease is more prevalent men and women tend to diverge more in the qualities they seek in potential mates, with women showing relatively greater preference for intelligence and status in a potential mate and men showing relatively greater preference for physical attractiveness (16). This also suggests higher pathogen prevalence might increase inequality among the sexes by increasing pressure on men and women to emphasize and develop more traditional attributes and skills. In fact, previous empirical work has shown that cross-cultural differences in gender inequality are associated with higher pathogen levels (16, 17). Such cross-sectional observations (for an independent replication, also see Figure S1) raise the question whether *changes* in levels of infectious disease may lead to *changes* in gender equality.

Testing longitudinal associations between pathogens and gender inequality can also help to address the question of possible underlying mechanisms. Pathogens may impact gender inequality due to generally more conservative orientations (4). Another possibility is that pathogens impact gender inequality because higher levels of infectious disease cue people to adopt faster life history strategies (16, 18) -- mating earlier, having more children, focusing on short term goals as opposed to long-term personal investments like education (19). For example, a recent study found that people higher in perceived vulnerability to disease show more impulsivity, greater delay discounting, and reduced ability to delay gratification (18) and other work has documented found that in US States with higher levels of pathogen prevalence teen birth rates are higher (20). Thus, because higher levels of pathogens cue people to adopt fast life history strategies, in times where infectious disease is more prevalent women may be less likely to pursue or attain positions of economic, social, and political power as earlier mating reduces one's ability to pursue education, career, and status. Conversely, when levels of infectious disease are low, people are more likely to adopt slower life history strategies. For women this might mean delaying reproduction in favor of pursuing education and careers, thus one might expect when pathogen levels decrease that gender inequality would as well.

Resource scarcity has also been linked to more anti-egalitarian values (1) and promotes faster strategies (21). Thus in times when economic hardship is more prevalent one might expect more gender inequality.

Predictions for the impact of climatic stress and external threats such as wars on gender inequality are less straightforward than those for pathogen prevalence and resouce scarcity. According to Climato-Economic theory, more demanding climates should lead to *less* broadly egalitarian norms and values in places where resources are scarce, but to *more* broadly egalitarian norms and values where resources are abundant (5). This might lead one to predict that in affluent Western societies (e.g., the US or the UK) , higher levels of climatic stress would be associated with *less* gender inequality.

Finally, external threats such as wars may also affect levels of gender inequality, yet there are competing predictions. One the one hand, male members of society typically fight wars and women take on more diverse societal roles during such times, especially in the case of prolonged conflict. Thus, one might expect war to be negatively associated with gender inequality. On the other hand, external threats (including armed conflicts) have been linked to tighter social norms in previous cross-cultural work (15), suggesting that prevalence of armed conflicts might be associated with an increase in gender inequality.

Using archival data from over 6 decades, in Study 1 we tested the role of these four types of ecological threats/affordances in variations over time within US society in levels of gender inequality. We did so using cultural-level indices of gender inequality in the social and political domains, in temporal linguistic trends, and in attitudes, as well as a range of archive-based indicators of (social) ecology: pathogen prevalence, resource scarcity, warfare, and climatic stress. Subsequently, in Study 2, we aimed to replicate the main patterns from Study 1 in another society, using comparable archival data.

In Study 1, we observed that gender inequality declined dramatically over time, $r = -.92$, $p < .001$ (Figure 1). To test the role of ecology we first examined zero-order correlations between our 4 ecological predictors and our gender inequality index. Pathogen prevalence was positively correlated with gender inequality over time, $r = .77$, $p < .001$, and unemployment was negatively correlated with gender inequality, $r = -.29$, $p = .05$. Neither war, $r = -.18$, ns, nor climatic stress, $r = .15$, ns, was significantly correlated with gender inequality. Next we entered our predictors simultaneously into a regression model with gender inequality as the dependent variable. Results indicated a good model fit, $R^2 = .70$. Pathogen prevalence remained a significant predictor of gender inequality, $\beta = .75$, $t = 8.26$, $p < .001$, $r_{part} = .69$, as did unemployment, $\beta = -.22$, $|t| = 2.56$, $p < .02$, , $r_{part} = -.21$. Climatic stress was also a significant predictor in this model, $\beta = .20$, $|t| = 2.27$, $p < .03$, $r_{part} = .19$, however war was not, $\beta = -.08$, $|t| = 0.87$, *ns*, $r_{part} = .07$

We next used cross-correlation function analysis to assess directionality. We focused our analysis on pathogen prevalence as it was by far the strongest predictor of temporal variation in gender inequality (see Figures S3-S5 for plots for unemployment, climatic stress, and war). This analysis produces a plot that allows one to assess the directionality of a relationship by comparing the magnitude of correlations between the two variables in a time-lagged fashion. For this analysis, greater values on the left of the graph indicate that changes in pathogen prevalence precede shifts in gender inequality, whereas a skew to the right would indicate the opposite to be the case. The results indicate that pathogen prevalence in the US was positively associated with gender inequality, with the largest correlation observed between pathogen prevalence and subsequent gender inequality 15 years later. The latter observation suggests that changes in pathogen prevalence preceded changes in gender inequality (Figure 2).

Finally, we assessed potential mechanisms for the link between pathogens and gender inequality. Separate regression analyses showed that pathogens remained a significant predictor of levels of gender inequality when controlling for collectivism, $R^2 = .49$, $\beta = .69$, , $t = 6.27$, $p < .001$, $r_{part} = .60$, and when controlling for conservatism, $R^2 = .64$, $\beta = .72$, $t = 5.29$, $p < .001$, $r_{part} = .71$. Pathogens remained a significant predictor of gender inequality when controlling for teen births, but the effect decreased, $R^2 = .62$, $\beta = .52$, $t = 4.15$, $p < .001$, $r_{part} = .33$. We tested for mediation by each of these variables using separate nonparametric bootstrapping analyses with 5000 resamples. Collectivism was not a significant mediator of the effect of pathogens on gender inequality as the bias corrected and accelerated 95% confidence interval for the indirect effect included zero [95% bias corrected and accelerated CI: -.0003, .0007], nor was conservatism a significant mediator of the effect of pathogens on gender inequality [95% bias corrected and accelerated CI: -.0011, .0044]. However we did observe significant mediation of the effect pathogens on gender inequality by fast life history strategies (teen birth rate) [95% bias corrected and accelerated CI: .0005, .0022].

In Study 2, we sought to replicate central Study 1 findings in the UK. Specifically, we examined whether the lagged relationship between pathogen prevalence and gender inequality, and whether life history strategies mediate the relationship between pathogens and gender inequality.

Gender inequality in the UK has declined over time, $r = -.87$, $p < .001$. Furthermore, UK gender inequality was positively associated with pathogen prevalence, $r = .33$, $p = .005$, and cross-correlation function analysis showed that changes in pathogen prevalence *precede* changes in gender inequality; we observed the strongest correlation at a lag of 25 years (Figure 3). Moreover, the effect of pathogens on gender inequality was reduced when controlling for teen births, $R^2 = .61$, $\beta = .26$, $t = 2.34$, $p = .02$, $r_{part} = .20$. Nonparametric bootstrapping analyses with 5000 resamples revealed that this mediation was significant [95% bias corrected and accelerated CI: 1.246, 3.4648].

Our results show that cultural changes in the US in gender inequality are associated with pathogen prevalence. Levels of gender inequality over time were most strongly correlated with levels of pathogen prevalence. This relationship was robust, holding when simultaneously controlling for other ecological dimensions. Further, the results of cross-correlation function analysis suggest that changes in pathogen prevalence *precede* changes in gender inequality, suggesting a causal direction from shifts in pathogens to shifts in gender inequality exists. Moreover, similar patterns of results emerged in the UK, suggesting this effect is not confined to the US. Taken together, these findings suggest a novel explanation for why time periods vary in how men and women are treated -- levels of infectious disease.

Our results also suggest that rather than reflecting more general effects of pathogen levels on broadly conservative or traditional attitudes and norms, pathogen levels have specific effects on gender inequality. Further, the results of mediation analyses in both countries suggest that links between pathogen prevalence and gender inequality may be due in part to women adopting faster life history strategies in response to higher levels of infectious disease prevalence. Collectivism did not significantly mediate this effect, nor did conservatism, providing further evidence that this effect is not due to more general links between levels of infectious disease and more traditional attitudes and norms. Rather, these findings are consistent with the notion that life history strategies may provide a mechanism for the link between pathogens and gender inequality.

Before concluding, we should note that the longitudinal data analyzed in the present studies do not enable definite inferences concerning causality. Although there are indications of the direction of the relationship between pathogens and gender inequality, further approaches involving experiments and agent-based modeling of societal change via computer simulations could help further corroborate causal inferences. This limitation none withstanding, the present research systematically explored the role of ecologically-derived explanations for what forces may cause societies to change in terms of levels of gender inequality. The results suggest a crucial role for pathogen prevalence. Beyond their theoretical implications, these findings also have practical implications of interest to policymakers. Our results suggest that efforts to reduce infectious diseases, such as vaccinations, free health care, public sanitation, and water treatment might also increase equality among the sexes.

Methods

Study 1. We gathered cross-temporal data covering a 6-decade period in the US (1951-2013). We created an index of gender inequality using data on indicators of political representation (the number of women in Congress, 22), wage inequality (male:female wage ratio based on data from the US Women's Bureau and the National Committee on Equal Pay), linguistic representation in cultural products (use of male vs. female pronouns in published books, 23), and sexist work attitudes (percentage of respondents in Gallup polls preferring a male boss, 24). These variables were standardized and averaged to create an overall gender inequality index. The items were highly intercorrelated and the index had high internal reliability, $.80 < r$s $\leq .95$, $\alpha = .95$. This index is conceptually similar to indices such as the United Nations Gender

Empowerment Measure and the Global Gender Gap Index which are used to assess levels of gender inequality across countries and include measures of political and financial gender parity.

We took pathogen prevalence and climatic stress data for this period from Grossmann & Varnum (7). Grossmann & Varnum's (7) pathogen index was based on prevalence of 9 of the most common infectious diseases based on data from the US Census Bureau and the Centers for Disease Control. Grossmann & Varnum's (7) climatic stress index was derived by calculating absolute deviations from 72 degrees F of average temperatures in January and July in year using data from the National Climatic Data Center. We operationalized resource scarcity as percentage of the population who were unemployed in a given year according to the US Department of Labor. We operationalized war as a binary variable indicating whether the US was engaged in a major armed conflict.

We also tested two potential mechanisms by which pathogens might be linked to levels of gender inequality, more broadly traditional views and norms and fast life history strategies. We operationalized traditionalism in two ways, first by using Grossmann & Varnum's (7) index of collectivist themes in Google Books. We also operationalized traditionalism using Gallup survey data on the percentage of Americans self-identifying as conservatives using data from the earliest year available (1992) until 2013. To assess fast life history strategies, we gathered data on annual rates of teen births per 1,000 women aged 15-19 (25).

Study 2. We gathered data from the UK over 7 decades (1945-2014) on markers of gender inequality: wage inequality (gender wage gap as a percentage of median male wage according to data from the Organization for Economic Cooperation and Development), male vs. female pronoun use in British books in the Google Ngrams database, and number of women in parliament retrieved from www.ukpolitical.info, which were standardized and averaged to form a single index, $.71 < rs \leq .90$, $\alpha = .92$. An index of pathogen prevalence during this period was computed using data on mortality rates per 100,000 due to tuberculosis and measles based on data from the UK Office for National Statistics. Data on annual teen birth rates per 1000 women under 20 were also gathered from the UK Office for National Statistics and Wellings & Kane (25). A complete list of data sources as well as notes on the data can be found in Tables S1 and S2 of the Supplementary Information.

Data Availability Statement

All data presented in this paper are available through the Open Science Framework at osf.io/s3pft.

Code Availability Statement

Code used to generate the data is available at osf.io/s3pft. All regression analyses were performed in IBM SPSS (version 22). All graphs and CFF analyses were performed using R language for statistical programming.

References

1. Inglehart, R., & Norris, P. *Rising tide: Gender Equality and Cultural Change Around the World*. (Cambridge University Press, 2003).

2. Kenrick, D.T., & Gomez-Jacinto, L. Economics, sex, and the emergence of society: A dynamic life history model of cultural variation. Pp. 78-123 in M. J. Gelfand, C.Y. Chiu, and Y.Y. Hong (Eds.) *Advances in Culture and Psychology, Volume 3*, (Oxford University Press, 2014).

3. Oishi, S. Socioecological psychology. *Annu. Rev. Psychol.* **65**, 581-609 (2014).

4. Thornhill, R., & Fincher, C. L. *The parasite-stress theory of values and sociality: Infectious disease, history and human values worldwide*. (Springer, 2014).

5. Van de Vliert, E. Climato-economic habitats support patterns of human needs, stresses, and freedoms. *Behav. Brain Sci.* **36**, 465-480 (2013).

6. Thornhill, R., & Fincher, C. L. Parasite stress promotes homicide and child maltreatment. *Phil. Trans. R. Soc. B* **366***,* 3466–3477 (2011).

7. Grossmann, I., & Varnum, M. E. W. Social structure, infectious diseases, disasters, secularism, and cultural change in America. *Psychol. Sci.* **26***,* 311-324 (2015).

8. Varnum, M. E. W., & Grossmann, I. Socio-ecological changes are linked to changes in the prevalence of contempt over time. *Behav. Brain Sci.* (in press).

9. Schaller, M., & Park, J. H. The behavioral immune system (and why it matters). *Curr. Dir. Psychol. Sci.* **20**, 99-103 (2011).

10. Murray, D. R., & Trudeau, R., & Schaller, M. On the origins of cross-cultural differences in conformity: Four tests of the pathogen prevalence hypothesis. *Pers. Soc. Psychol. Bull.* **37**, 318-329 (2011).

11. Murray, D. R., & Schaller, M. (2012). Threat(s) and conformity deconstructed: Perceived threat of infectious disease and its implications for conformist attitudes and behavior. *Eur. J. Soc. Psychol.* **42***,* 180-188 (2012).

12. Varnum, M. E. W. Frontiers, germs, and non-conformist voting. *J. Cross-Cult. Psychol.* **44***,* 832-837 (2013).

13. Murray, D. R., Schaller, M., & Suedfeld, P. Pathogens and politics: Further evidence that parasite prevalence predicts authoritarianism. *PLoS ONE* **8***,* e62275 (2013).

14. Schaller, M., & Murray, D. R. Pathogens, personality, and culture: Disease prevalence predicts worldwide variability in sociosexuality, extraversion, and openness to experience. *J.Pers. Soc. Psychol.* **95***,* 212-221 (2008).

15. Gelfand, M. J., et al. Differences between tight and loose cultures: A 33-nation study. *Science* **332**, 1100-1104 (2011).

16. Gangestad, S. W., Haselton, M. G., & Buss, D. M. Evolutionary foundations of cultural variation: Evoked culture and mate preferences. *Psychol. Inq.* **17***,* 75-95 (2006).

17. Thornhill, R., Fincher, C. L., & Aran, D. (2009). Parasites, democratization, and the liberalization of values across contemporary countries. *Biol. Rev.* **84***,* 113-131 (2009).

18. Hill, S. E., Boehm, G. W., & Prokosch, M. L. Vulnerability to disease as a predictor of faster life history strategies. *Adapt. Hum. Behav. Physiol.* (in press).

19. Del Giudice, M., Gangestad, S. W., & Kaplan, H. S. Life history theory and evolutionary psychology. *The Handbook of Evolutionary Psychology* (Wiley, 2015).

20. Varnum, M. E. W. (2014). Sources of regional variation in social capital in the United States: Frontiers and pathogens. *Evol. Behav. Sci.* **8**, 77-85.

21. Griskevicius, V., et al., (2013). When the economy falters do people spend or save?

Responses to resource scarcity depend on childhood environments. *Psychol. Sci.* **24**, 197-205 (2013).

22. Manning, J. E., & Brudnik, J. A. *Women in the United States Congress, 1917-2004: Biographical and Committee Assignment Information and Listings by State and Congress. Congressional Research Service Report RL30261.* (Congressional Research Service, 2014).
23. Twenge, J. M., Campbell, W. K., & Gentile, B. Male and female pronoun use in US books reflects women's status, 1900–2008. *Sex Roles* **67**, 488-493 (2012).
24. Jones, J., & Saad, L. *Gallup Poll Social Series: Work and Education*. (Gallup, 2014).
25. Ventura, S. J., Hamilton, B. E., & Matthews, T. J. *National and state patterns of teen births in the United States, 1940-2013. National Vital Statistics and Reports, 63, No. 4* (US Census Bureau, 2014).
26. Wellings, K., & Kane, R. Trends in teenage pregnancy in England and Wales: how can we explain them? *J. R. Soc. Med.*, **92** 277-282 (1999).
27. Mills, T. C. (1991). Nonlinear time series models in economics. *J. Econ. Surv.*, **5** 215-242 (1991).
28. Tommaso, P., & Helmut, L. *Does the Box-Cox Transformation Help in Forecasting Macroeconomic Time Series?* (University Library of Munich, 1991).

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Author Contributions

MEWV developed the original study concept. MEWV and IG gathered the data. MEWV and IG analyzed the data. MEWV and IG drafted and revised the manuscript.

Competing Interests

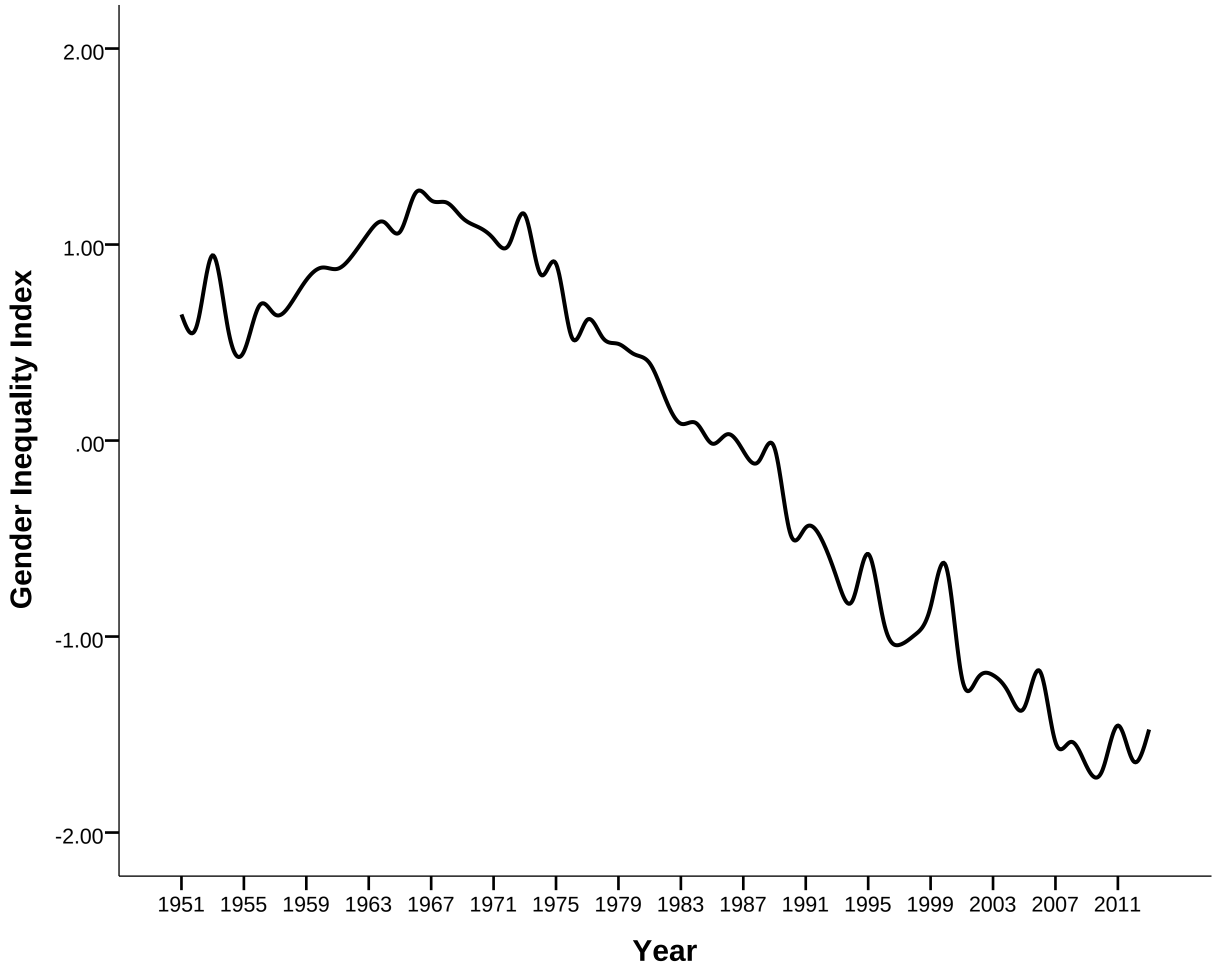
The authors declare no financial or non-financial competing interests.

Figure Legends

Figure 1. Gender inequality over time in the US.

Figure 2. Cross-correlation function analysis of the relationship between pathogen prevalence and gender inequality over time in the US. Due to non-linear time series trends, to improve time series estimates, gender inequality index is Box-Cox transformed (27, 28). Analyses with raw data yield a similar picture, with pathogen prevalence slightly preceding gender inequality (see supplementary online materials Figure S2).

Figure 3. Cross-correlation function analysis of the relationship between pathogen prevalence and gender inequality over time in the UK.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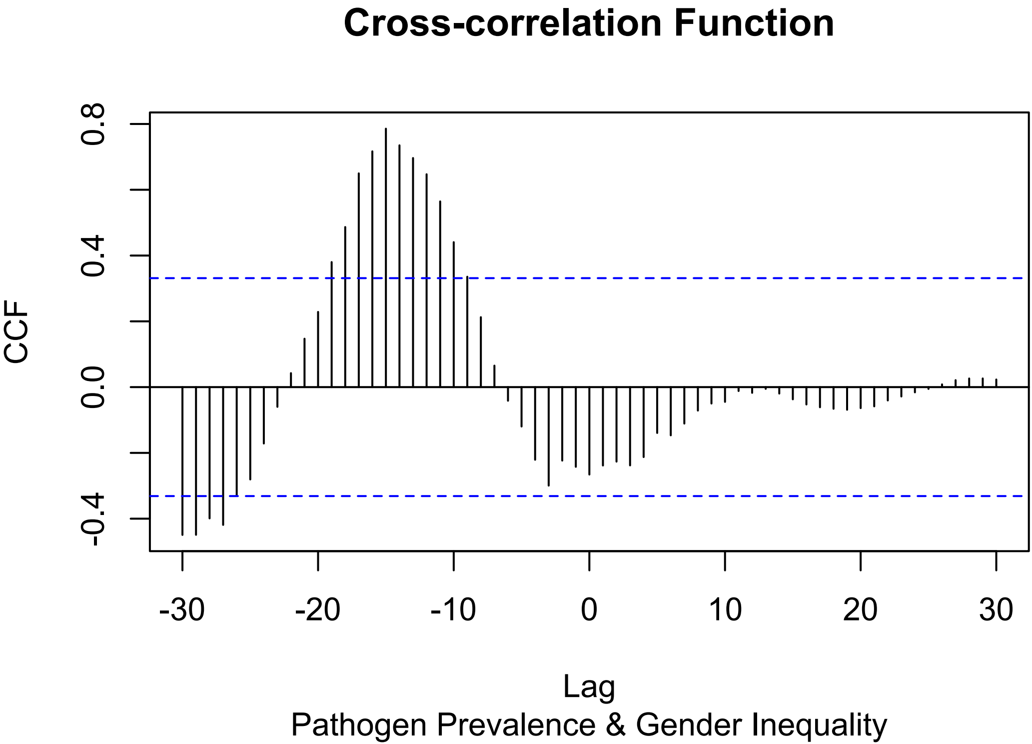
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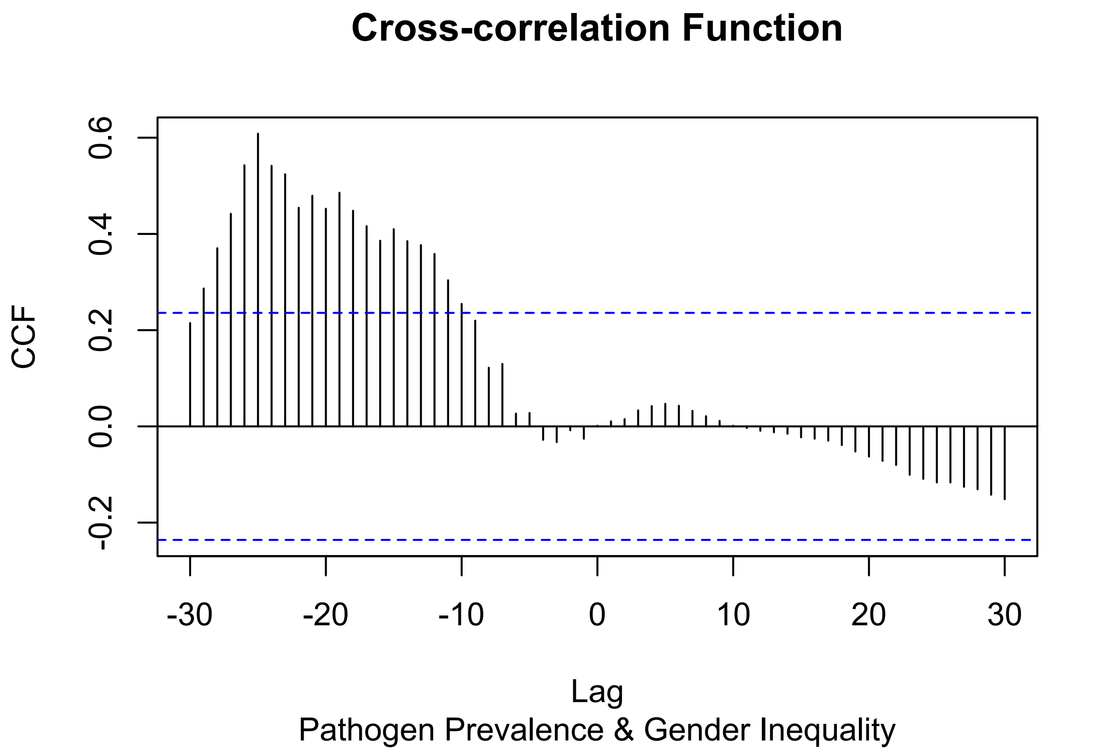
Pathogen Prevalence & Gender Inequality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Pathogen Prevalence & Gender Inequality

Supplementary Information for Varnum & Grossmann

Cross-cultural differences in pathogen prevalence and gender inequality

In the first step, we aimed to replicate and extend cross-cultural findings by Thornhill, Fincher, and Aran (1), using a wide range of markers of gender inequality and comparing empirical reality of various theoretical accounts of gender inequality (see main text). Furthermore, we tested whether the relationship between pathogens and gender inequality -- the key research question in the main manuscript -- holds above and beyond the cross-cultural relationship between markers of traditionalism/collectivism.

Methods

Gender inequality across societies was assessed using the 2014 Global Gender Gap index (an index created by the World Economic Forum). This index a composite of 14 indicators of gender inequality including economic participation, political empowerment, and access to education. The data were reverse-scored so that higher scores correspond to greater gender inequality. Pathogen prevalence was assessed using Fincher et al's (2) indices of historical and contemporary pathogen prevalence. Levels of economic resources were assessed using IMF's 2015 GDP per capita estimates. A binary code was used to indicate whether a country was the site of an armed conflict (including civil war, insurrection, invasion, border war) in 2014 according to Wikipedia.com. Climatic stress was assessed using Van de Vliert's (3) total climatic stress index. Data was not available for all indicators for all countries. Hence, $N_{\text{countries}}$ here varies from 83 to 142. We first assessed zero-order correlations between our predictors and gender inequality, next we assessed the relative contribution of four predictors using multiple regression.

We used two distinct ways to operationalize traditionalism. First, we utilized the established estimates of the traditionalism (vs. rational secularism) dimension from the World

Values Survey (4), creating country-level estimates from the last two decades (to ensure reliability of the estimates, given that not all questions were asked in each country in each of the survey waves). Data were available for 77 countries.

Second, we examined country-level estimates of collectivism. To this end, we used the country-level estimates from two of the most extensive multi-country studies of individualist-collectivist attitudes: (a) the most recent estimates of individualism-collectivism by Hofstede, based on a series of surveys of employees (5); (b) scores of in-group collectivist practices in the GLOBE study of managers by House, Hanges, Javidan, Dorfman, and Gupta (6). These studies use somewhat different methodologies, focus on different population strata (Hofstede's study covered 97 countries, whereas GLOBE covers 57 countries in the present dataset) and have different strengths and weaknesses (7). Notably, when one of us previously (7) examined associations across 45 countries in which Hofstede's and House et al.'s surveys overlap, he observed a highly significant degree of convergence across indicators, $r = -.73$, $p < .001$. Therefore, we first reverse-coded Hofstede's scores, so that higher scores on both indices reflect greater collectivism. Next, we standardized each set of scores across all countries available in the respective databases. Given that many countries had missing values on one of the two indicators that could greatly bias the average estimate, we first estimated missing values on a respective index. Specifically, we used data from all countries to estimate a linear regression weight for Hofstede's index, based on available GLOBE index and vice versa. The resulting missing value estimation formula were:

$$\textit{Hofstede score} = -0.177876 + (0.778173 \times \textit{GLOBE score})$$

$$\textit{GLOBE score} = 0.087549 + (0.656158 * \textit{Hofstede score})$$

Subsequently, we averaged the resulting scores, resulting in estimates for 103 countries, with higher scores on this index indicating greater traditionalism/collectivism.

Results

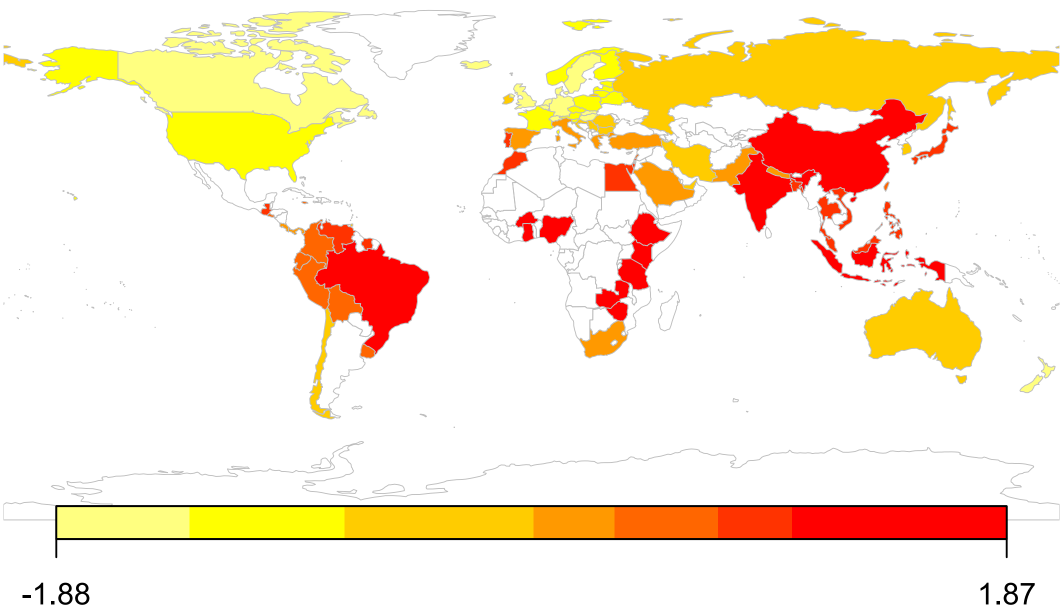
Higher levels of both contemporary, $r = .40$, $p < .001$, and historical, $r = .55$, $p < .001$, pathogens were correlated with greater gender inequality (see Figure S1). GDP was negatively correlated with gender inequality, $r = -.44$, $p < .001$, as was climatic stress, $r = -.28$, $p = .001$. War was positively correlated with gender inequality, $r = .30$, $p < .001$. The relative effects of these predictors was tested using multiple regression analyses. In the first analysis, historical pathogen prevalence, GDP, war, climatic stress, and climatic stress X GDP were simultaneously entered as predictors of gender equality, $R^2 = .36$. Historical pathogen prevalence remained a significant predictor of gender inequality, $\beta = .39$, $t = 2.40$, $p = .01$, $r_{\text{part}} = .21$, and climatic stress X GDP remained a marginal predictor, $\beta = -.23$, $|t| = 1.83$, $p = .07$, $r_{\text{part}} = .16$. However war, $\beta = .07$, $t < 1$, *ns*, GDP, $\beta = -.15$, $t < 1$, *ns*, and climatic stress, $\beta = .07$, $t < 1$, *ns*., were no longer significant predictors. In the model in which contemporary pathogen prevalence replaced historical pathogen prevalence, $R^2 = .31$, only climatic stress X GDP remained a significant predictor of gender inequality, $\beta = -.35$, $|t| = 2.92$, $p = .002$, $r_{\text{part}} = -.26$. Albeit not significant, the trend for contemporary pathogen prevalence was in the predicted direction, $\beta = .20$, $|t| = 1.48$, $p = .142$, $r_{\text{part}} = .13$. Other predictors either showed an opposite association from the one predicted or were negligible, $-.10 < \beta\text{s} < .11$, *ns*.

To zero-in on Van de Vliert's model of climatic-economic interaction, we conducted a regression analysis with mean-centered climatic stress and GDP , and their product as predictors and gender inequality as the dependent variable, $R^2 = .25$. Both climatic stress, $B = -.0005$, $SE = .0002$, $|t| = 2.63$, $p = .010$, and GDP, $B = -.0000008$, $SE = .0000003$, $|t| = 2.71$, $p = .008$, were significant predictors, as was the interaction of climatic stress x GDP, B = -.00000003, SE = .00000001, $|t|$ = 2.44, p = .02. However, the pattern of the interaction was not entirely consistent with Van de Vliert's model. Among countries above the median GDP for the sample climatic stress was indeed negatively correlated with gender inequality, at 90th quantile: B = -.0014, SE = .0004, $|t|$ = 3.16, p = .002; at 75% quantile: B = -.0007, SE = .0002, $|t|$ = 3.00, p = .003. However climatic stress was not significantly correlated with gender inequality among countries below median GDP for the sample, with the trend in the same direction as among high GDP countries, at 25% quantile: B = -.0002, SE = .0002, $|t|$ = .70, *ns;* at 10% quantile: B = -.0001, SE = .0002, $|t|$= .53, *ns*.

Finally, we examined whether the effect of pathogens on gender inequality holds when controlling for traditionalism and collectivism. To this end, we ran a series of linear regressions, comparing effects of pathogen prevalence vs. traditionalism/collectivism on gender inequality. Results of a linear regression with pathogens and traditionalism as predictors of gender inequality revealed significant effects of historical pathogen prevalence, R^2 = .31, β = .42, t = 3.06, p = .003, r_{part} = .34, and trend level effects of traditionalism, β = .23, t = 1.69, p = .097, r_{part} = .19. Similarly, linear regressions with pathogens and collectivism as predictors of gender inequality revealed effects of pathogen, R^2 = .33, β = .34, t = 2.59, p = .01, r_{part} = .23, and collectivism, β = .30, t = 2.27, p = .026, r_{part} = .21. Notably, in both cases pathogens were a stronger predictor of gender inequality than traditionalism/collectivism. Additionally, consistent with the longitudinal data presented in the main manuscript, historical pathogen prevalence was a more potent predictor of gender inequality, R^2 = .29, β = .52, t = 4.00, $p < .001$, r_{part} = .37, than contemporary pathogen prevalence, β = .04, t = .28, *ns.*, r_{part} = .03.

Figure S1. Study 1: Levels of pathogen prevalence and gender inequality across the globe. Values represent z-scores.

Historical Pathogen Prevalence



Gender Inequality

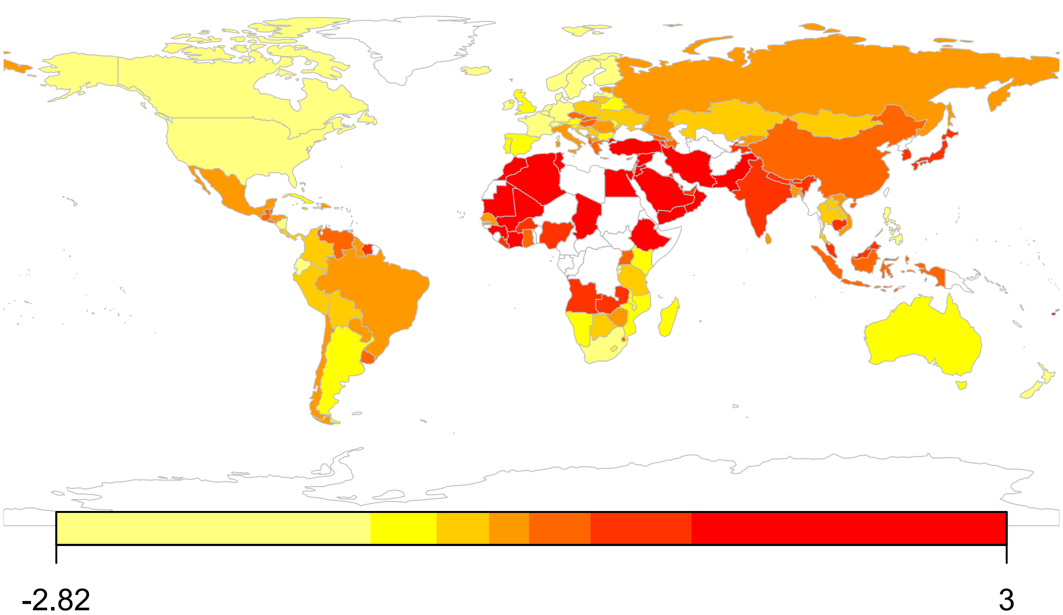


Table S1. List of sources for and notes on US data

Variable	Operationalization	Years covered	Source
Female Political Representation	N women in Congress	1951-2013 (*N* = 63)	Manning et al., 2014
Wage Inequality	Male:Female wage ratio	1951-2013 (*N* = 63)	US Women's Bureau; National Committee on Equal Pay http://www.infoplease.com/ipa/A0193820.html http://www.pay-equity.org/info-time.html
Gender Pronoun use	Male: Female pronoun frequency in text corpus, as per Twenge et al., 2008	1951-2008 (*N* =58)	American English Google Ngrams database
Sexist Work Attitudes	Percent reporting preference for male boss in Gallup Polls, also see http://www.gallup.com/185477/gallup-poll-social-series-work.aspx	1953-2013 (*N* = 13)	Jones, J., & Saad, L. (2014). Gallup Poll Social Series: Work and Education. Gallup: Washington: DC Retrieved from http://www.gallup.com/file/poll/178490/Preference_Male_vs_Female_Boss_141014%20.pdf
Pathogen Prevalence	Mortality rate due to 9 infectious diseases	1951-2012 (*N* = 62)	Grossmann & Varnum, 2015 based on data from CDC
Resource Scarcity	Unemployment rate	1952-2013 (*N* = 45)	US Department of Labor and Bureau of Statistics, retrieved from http://www.infoplease.com/ipa/A0104719.html
Climatic Stress	Annual deviation in average temperatures from 72%	1951-2012 (*N* = 62)	Grossmann & Varnum, 2015 based on data from National Climatic Data Center
War	Binary variable indicating US involvement in major armed conflict (Korean War, Vietnam War, Gulf War, Afghanistan War, Iraq War)	1951-2013 (*N* = 63)	Wikipedia.com
Fast Life History Strategy	Teen births (age 15-19) per 1000 women (age 15-19)	1951-2013 (*N* = 63)	Ventura, et al., 2014
Collectivism	Use of collectivist words in American English Google Ngrams database	1951-2006 (*N* = 56)	Grossmann & Varnum, 2015
Conservatism	Percent of Americans self-identifying as "conservative"	1992-2013 (*N* = 22)	Gallup http://www.gallup.com/poll/166787/liberal-self-identification-edges-new-high-2013.aspx

Table S2. List of sources for and notes on UK data.

Variable	Operationalization	Years covered	Source
Female Political Representation	N women elected to parliament; for intervening years it is assumed that the N women in parliament remains constant	1945-2014 (*N* = 70)	http://www.ukpolitical.info/FemaleMPs.htm
Wage Inequality	Gender wage gap as a percentage of median male wage	1970-2014 (*N* = 45)	OECD https://data.oecd.org/earnwage/gender-wage-gap.htm
Gender Pronoun use	Male: Female pronoun frequency in text corpus, as per Twenge et al., 2008	1945-2008 (*N* = 64)	British English Google Ngrams database
Pathogen Prevalence	Average of deaths per 100,000 due to Tuberculosis and Measles	1945-2013 (*N* = 69)	UK Office for National Statistics; Public Health England https://www.gov.uk/government/publications/measles-deaths-by-age-group-from-1980-to-2013-ons-data/measles-notifications-and-deaths-in-england-and-wales-1940-to-2013 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/363056/Tuberculosis_mortality_and_mortality_rate.pdf&bvm=bv.124088155,d.d24
Fast Life History Strategies	Teen births (age < 20) per 1000 women (age < 20)	1960-2014 (*N* = 55)	UK Office for National Statistics; Wellings & Kane, 1999 http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/dcp171778_410897.pdf

Figure S2. US CCF for Pathogens and Gender Inequality without Box-Cox transformation.

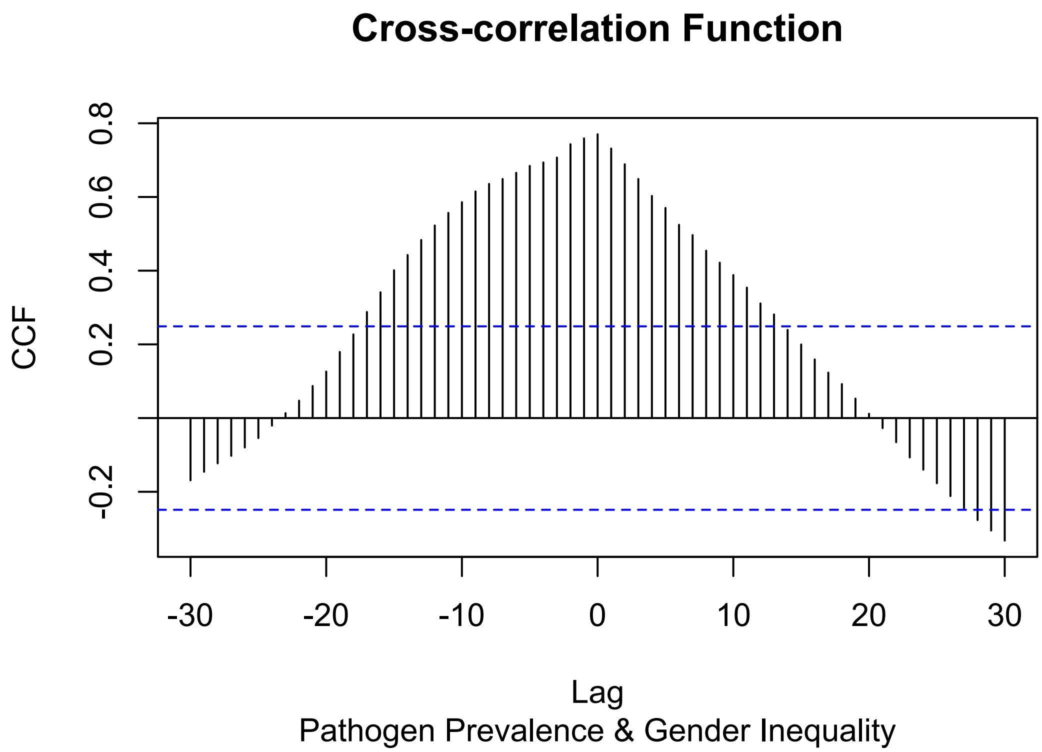


Figure S3. US CCF for Unemployment and Gender Inequality.

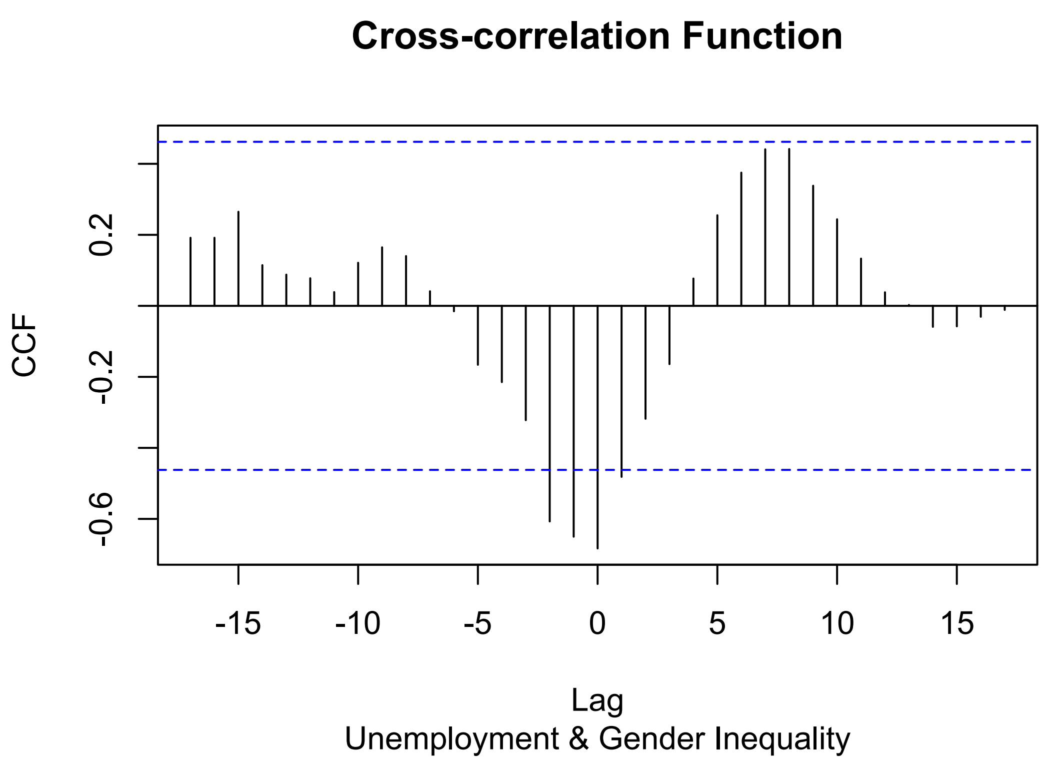


Figure S4. US CCF for Climatic Stress and Gender Inequality.

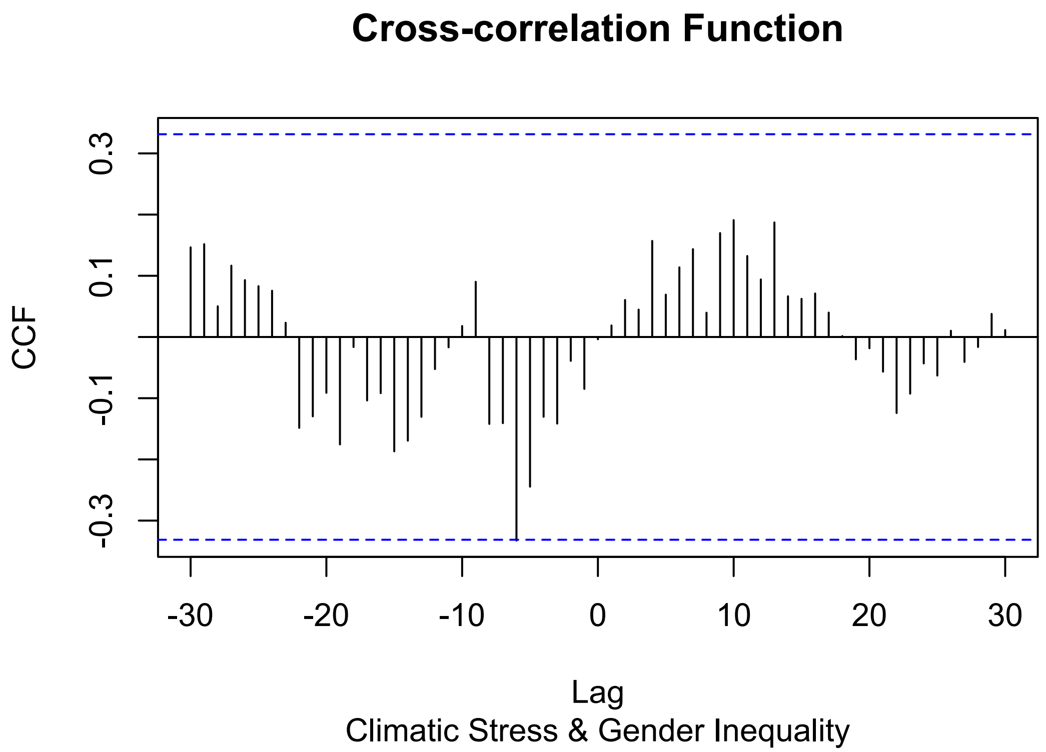
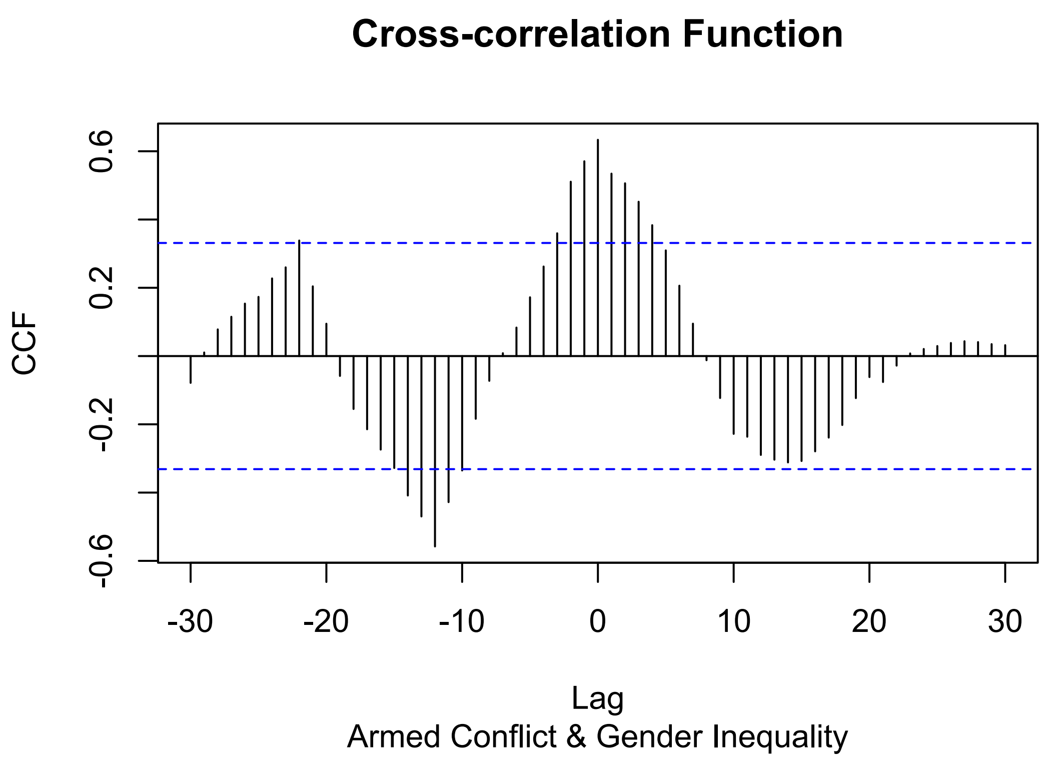


Figure S5. US CCF for War and Gender Inequality.



References

1. Thornhill, R., Fincher, C. L., & Aran, D. Parasites, democratization, and the liberalization of values across contemporary countries. *Biol. Rev.* **84**, 113-131 (2009).
2. Fincher, C. L., Thornhill, R., Murray, D. R., & Schaller, M. (2008). Pathogen prevalence predicts human cross-cultural variability in individualism/collectivism. *Proc. R. Soc. B.* **275**, 1279-1285 (2008).
3. Van de Vliert, E. Climato-economic habitats support patterns of human needs, stresses, and freedoms. *Behav. Brain Sci.* **36**, 465-480 (2013).
4. *World Values Survey* (2016). http://www.worldvaluessurvey.org/wvs.jsp.
5. Hofstede, G., Hofstede, G. J., & Minkov, M. *Cultures and Organizations: Software of the Mind: Intercultural Cooperation and its Importance for Survival* (3rd edition). (McGraw-Hill, 2010).
6. House, R. J., Hanges, P. J., Javidan, M., Dorfman, P. W., & Gupta, V. *Culture, Leadership, and Organizations: The GLOBE Study of 62 societies*. (Sage, 2004).
7. Grossmann, I., Huynh, A. C., & Ellsworth, P. C. Emotional complexity: Clarifying definitions and cultural correlates. *J. Pers. Soc. Psychol*. http://doi.org/dx.doi.org/10.1037/pspp0000084 (2015).