

Rugged terrain and rigid hierarchy

Gen Tsudaka^{a,*}, Margaux N.A. Wienk^b, Jana B. Berkessel^c, Cynthia Boo^d

^a Department of Psychology, The New School for Social Research, USA

^b Department of Psychology, Columbia University, USA

^c Department of Psychology, University of Mannheim, Germany

^d Department of Psychology, New York University, USA

ARTICLE INFO

Dataset link: <https://osf.io/x9pj4/>

Keywords:

Socioecological psychology

Terrain ruggedness

Hierarchical orientations

Dominance-based leadership

Cultural evolution

ABSTRACT

Human societies differ markedly in their endorsement of hierarchical authority, ranging from strict obedience to powerful leaders and militaries to more decentralized and egalitarian governance. Although cultural values have traditionally been used to explain this diversity, socioecological perspectives suggest that physical environments also shape collective orientations toward authority. The current research examines whether terrain ruggedness—the degree of elevational variability—predicts hierarchical preferences across large-scale contexts. In Study 1 (78 countries; $N = 156,658$), we combined cross-national survey data from the European Values Study/World Values Survey with digital elevation models. Results demonstrated that national preferences for military rule and for a strong leader (who bypasses democratic processes) were higher in countries with more rugged terrain, even after controlling for economic factors, demographic indices, and spatial autocorrelation. Study 2 (50 U.S. states; $N = 336,491$), using Gallup Poll data, replicated and extended these findings within the United States, revealing that states with greater terrain ruggedness exhibited a higher proportion of vertical (“boss-like”) supervisory relations, rather than egalitarian, collaborative (“partner-like”) styles. These convergent findings bolster socioecological models of person–environment fit and extend prior research linking geography and social cognition. By identifying terrain ruggedness as a robust predictor of hierarchical orientation at both national and subnational scales, this research highlights how ecological constraints can legitimize dominance-oriented leadership, while also suggesting that socioeconomic and cultural developments may moderate terrain’s influence on social dynamics. Future longitudinal and historical research is needed to clarify how environments and governance structures co-evolve, further illuminating the interplay between ecology, hierarchy, and social organization.

1. Introduction

Human societies vary widely in their endorsement of hierarchical authority; some favor strong leaders with top-down control, whereas others maintain more egalitarian or decentralized structures. Understanding where these differences originate is a core question in cultural psychology. Classic explanations frequently highlight cultural logics and historical patterns (Berry, 1967, 1980; Hirschfeld, 1996; Hofstede, 1984; Inglehart, 1997; Markus and Kitayama, 1991; Minkov and Hofstede, 2012; Miller, 1984; Nisbett and Cohen, 1996; Schweder, 1991; Swidler, 1986; Triandis, 1995), emphasizing how beliefs and traditions evolve into stable power structures over time. This perspective illuminates how societal norms and practices become ingrained and transmitted across generations, ultimately shaping social dynamics.

In recent years, socioecological perspectives have gained prominence, emphasizing how physical environments influence social organization and governance (Anderson, 2001; Gelfand et al., 2011; Oishi, 2014; Oishi and Graham, 2010; Sng and Ackerman, 2020; Varum and Grossmann, 2017). Within this tradition, researchers propose that communities adapt to ecological pressures—such as climate fluctuations, limited resources, or pathogen threats—in ways that systematically shape norms and institutions (Berry, 1967; Fincher, 2008; Gelfand et al., 2011; Morris and Peng, 1994; Nisbett et al., 2001; van Vugt et al., 2008). For example, higher disease prevalence has been linked to tighter social norms and stronger hierarchical preferences (Fincher et al., 2008; Gelfand et al., 2011), whereas harsh ecological conditions or resource fluctuations may promote cooperative or centralized solutions (van Vugt et al., 2008).

* Corresponding author.

E-mail address: tsudaka@newschool.edu (G. Tsudaka).

<https://doi.org/10.1016/j.cresp.2025.100220>

Received 25 July 2024; Received in revised form 12 March 2025; Accepted 14 April 2025

Available online 22 April 2025

2666-6227/© 2025 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

An illustrative case involves water irrigation. Paddy-rice cultivation requires communal irrigation systems, continual maintenance of canals, and synchronized planting schedules (Talhelm et al., 2014). Over generations, these constraints foster interdependent or vertical social organization. Indeed, recent quasi-experimental evidence shows that individuals randomly assigned to rice-farming regions adopt more cooperative and relational thought patterns within a single generation (Talhelm and Dong, 2024). These findings illustrate how ecological constraints interact with economic and social incentives to reinforce particular leadership styles or governance structures.

1.1. Terrain ruggedness as a socioecological factor

Beyond irrigation systems, topographical features can also shape social coordination and governance (Kitayama et al., 2006; Oishi et al., 2015; Scott, 2009; Tilly, 1990; Qiu et al., 2023). Rugged terrain—characterized by high elevational variability—fragments populations, obstructs travel, and complicates resource distribution (Conway et al., 2017; Körner, 2007). Over time, localized adaptations to these conditions can crystallize into enduring norms regarding authority (Uskul et al., 2008). While certain mountainous enclaves maintain decentralized, autonomous governance (Scott, 2009), many rugged ecologies see dominant leaders emerge to manage defense, resources, or infrastructure (Tilly, 1990). For example, Tilly (1990) argues that steep or remote terrains historically hindered direct centralized governance, allowing local populations to evade taxation or conscription, thereby enabling regional strongmen to consolidate authority. Such dynamics parallel “culture of honor” phenomena (Nisbett and Cohen, 1996), illustrating how ecological factors can concentrate power locally when central authority is weak or impractical.

Additionally, personality research has indicated that certain traits—such as introversion—correlate with preferences for mountainous areas (Götz et al., 2020; Oishi et al., 2015). Although these place preferences differ from formal governance structures, they underscore how environmental constraints align with deeper cognitive and behavioral orientations. Recent research on embodied hierarchies also indicates humans conceptualize rank through physical dimensions—such as elevation, size, or strength (Schubert et al., 2013; Schubert, 2020). Thus, rugged terrain could provide a symbolic and literal “higher ground” that resonates psychologically with hierarchical thinking (Eliade, 1959; Morgan, 1990). Collectively, these perspectives imply that terrain complexity not only influences local adaptations but also shapes broader social and political outcomes.

1.2. Linking terrain ruggedness to hierarchical orientations

A critical question remains whether rugged terrain consistently fosters centralized authority or instead supports decentralized governance. In some contexts, fragmented landscapes impede large-scale control, prompting local autonomy (Scott, 2009; Lamer et al., 2021). Conversely, communication barriers and defense challenges may legitimize stronger top-down leadership (Ronay et al., 2020; Tilly, 1990). Although recent studies suggest mountainous regions attract individuals with specific traits, such as introversion (Götz et al., 2020; Oishi et al., 2015), systematic large-scale evidence linking terrain ruggedness to hierarchical governance preferences remains sparse.

Dominance-prestige frameworks (Cheng et al., 2013; Henrich and Gil-White, 2001; Ronay et al., 2020) provide a useful lens for understanding these divergent outcomes. Dominance-based leadership relies on coercion and intimidation, potentially allowing leaders to unify fragmented communities or secure scarce resources (Nisbett and Cohen, 1996). Conversely, prestige-based leadership emerges through recognized expertise or technical proficiency. Thus, rugged terrain might encourage dominance-oriented structures when physical challenges necessitate centralized coordination (Tilly, 1990), whereas prestige-based leadership could thrive when specialized knowledge or

resource management is the primary path to social influence.

1.3. Potential moderators and confounds

Naturally, elevational variability does not operate in isolation. Previous literature highlights economic factors such as GDP per capita as predictors of lower authoritarian governance preferences (Inglehart and Baker, 2000). Population density also shapes hierarchical preferences by influencing social norms and structures (Milgram, 1970; Nisbett and Cohen, 1996; Sng and Ackerman, 2020); and spatial autocorrelation can introduce clustering effects across neighboring regions (Minkov and Hofstede, 2012; Muthukrishna et al., 2020). These considerations underscore the importance of controlling for economic, demographic, and spatial variables when investigating terrain’s socioecological influence.

1.4. Overview of the present research

Drawing from socioecological frameworks, we investigate whether terrain ruggedness predicts stronger hierarchy preferences across large-scale contexts. In Study 1 (78 countries), we link elevational variability to preference for a strong leader and military governance, controlling for wealth, population density, and spatial autocorrelation. In Study 2 (50 U.S. states), we test whether terrain complexity similarly predicts vertical supervisory practices at a subnational scale. By examining these effects across both international and domestic contexts, we clarify the scope and robustness of terrain ruggedness effects, illuminating the role ecological constraints play in shaping social organization and leadership norms.

2. Study 1: A 78-country test

2.1. Method

2.1.1. Data sources and sample

We utilized cross-national survey data from the European Values Study and World Values Survey, collected between 2017 and 2022 (EVS/WVS, 2022). Countries ($N = 78$) were included in our analyses if they provided complete responses on two items assessing support for authoritarian governance:

1. Preference for a strong leader (“Having a strong leader who does not have to bother with parliament and elections”).
2. Preference for a strong military rule (“Having the army rule the country”).

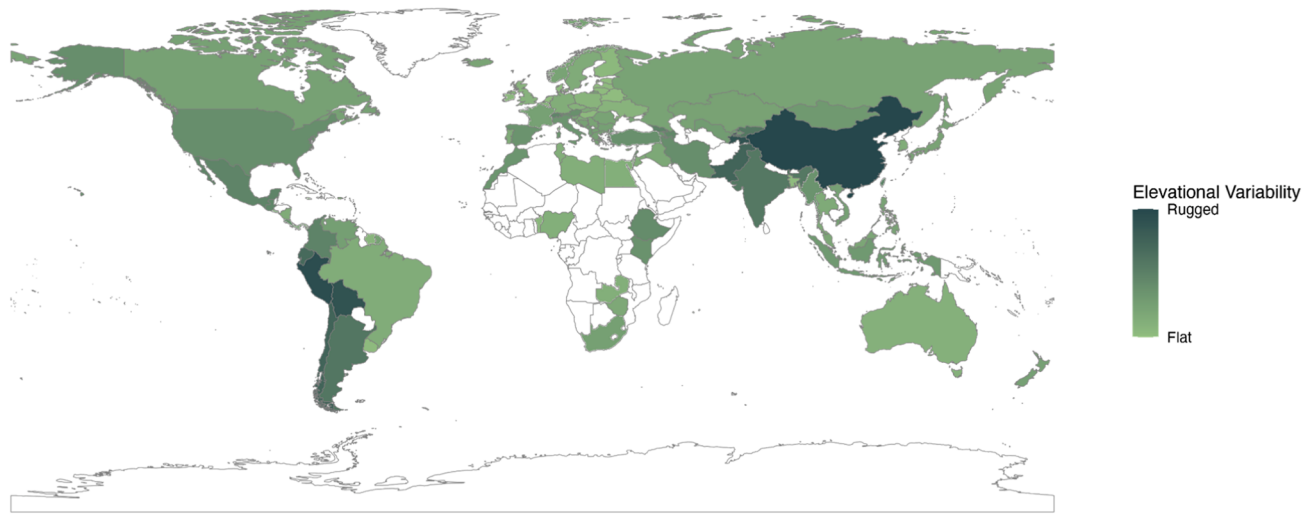
Both items were originally measured on 4-point scales (1 = *very good*, 4 = *very bad*). For interpretability, we reverse-coded responses so that higher scores indicated greater endorsement of centralized, authoritarian authority. Responses were aggregated at the national level into a composite measure of authoritarian preference ($\alpha = 0.85$). Countries lacking complete data on these items or the covariates were excluded from analysis, leaving a total sample of 78 nations.

2.1.2. Operationalizing ruggedness

Terrain ruggedness was operationalized using elevational variability data from the Copernicus GLO-90 digital elevation model (European Space Agency, 2024). Specifically, for each country in our dataset, we clipped the digital elevation raster to national boundaries, extracted elevation values, and calculated the standard deviation of elevation as our measure of ruggedness (see Fig. 1). This metric captures the overall mountainousness and complexity of a country’s landscape. The five flattest countries, in descending order, were Singapore, The Netherlands, Denmark, Belarus, and Estonia. Conversely, the five most rugged countries were China, Peru, Bolivia, Tajikistan, and Pakistan (see Table 1 in Appendix for exact ruggedness values).

Terrain Ruggedness Across Countries

Elevational Variability Derived from Topographic Data



Data source: Copernicus Digital Elevation Model (GLO-90)

Fig. 1. Terrain ruggedness across countries.

Terrain ruggedness (elevational variability) across countries, measured as the standard deviation of elevation using the Copernicus Digital Elevation Model (GLO-90). Darker shades indicate greater ruggedness, while lighter shades represent flatter terrain.

2.1.3. Covariates

To control for alternative explanations linking terrain ruggedness and hierarchical governance preferences, we included three key covariates. First, GDP per capita (Purchasing Power Parity, 2017–2022) from the International Monetary Fund (IMF, 2024) captures economic development, which typically predicts reduced authoritarian endorsement (Inglehart and Baker, 2000). Second, population density (2017–2022; United Nations Statistics Division, 2024) was log-transformed to address skewness, accounting for how densely versus sparsely populated regions differentially shape social norms and hierarchical structures (Freedman, 1975; Milgram, 1970; Nisbett and Cohen, 1996; Sng and Ackerman, 2020). Third, spatial proximity—measured as the log-transformed geodesic distance from Amsterdam (the EVS headquarters)—helps rule out geographic clustering and regional cultural diffusion as alternative drivers of our observed effects (Beugelsdijk and Mudambi, 2013; Minkov and Hofstede, 2012; Muthukrishna et al., 2020).

2.2. Analytical approach and results

We conducted three linear regressions predicting preferences for (1) a strong leader, (2) military rule, and (3) a composite authoritarianism index. Elevational variability served as the primary predictor. GDP per capita, population density, and spatial proximity were included as covariates in multiple regression analyses. Diagnostic checks (normality, homoscedasticity, variance inflation factor < 1.25) indicated no serious violations.

2.2.1. Preference for a strong leader

In the bivariate model, greater terrain ruggedness positively predicted preference for a strong leader ($b = 0.163$, $SE = 0.056$, $t(76) = 2.89$, $p = .005$), and the overall regression was significant, $F(1, 76) = 8.35$, $p = .005$. In the multiple regression model—including GDP per capita, population density, and spatial proximity—terrain ruggedness remained a significant predictor ($b = 0.152$, $SE = 0.060$, $t = 2.53$, $p = .014$), and the overall model was significant, $F(4, 73) = 4.59$, $p = .002$. GDP per capita was inversely related to strong-leader support ($b =$

-0.078 , $SE = 0.030$, $t(73) = -2.60$, $p = .011$), whereas population density ($b = 0.04$, $SE = 0.04$, $t(73) = 0.92$, $p = .359$) and spatial proximity ($b = 0.05$, $SE = 0.03$, $t(73) = 1.39$, $p = .168$) were not significant.

2.2.2. Preference for a military rule

Similarly, terrain ruggedness significantly predicted greater preference for military rule ($b = 0.162$, $SE = 0.052$, $t(76) = 3.11$, $p = .003$, overall model: $F(1, 76) = 9.66$, $p = .003$). In the multivariate model, terrain ruggedness again remained significant ($b = 0.152$, $SE = 0.056$, $t(73) = 2.73$, $p = .008$), even after controlling for GDP per capita, population density, and spatial proximity ($F(4, 73) = 5.02$, $p = .001$).

2.2.3. Composite index

Combining both authoritarianism measures into a composite index yielded consistent results. In the bivariate model, ruggedness significantly correlated with higher authoritarian preference ($b = 0.16$, $SE = 0.05$, $t(76) = 3.25$, $p = .002$, overall model: $F(1, 76) = 10.53$, $p = .002$). In the multiple regression model controlling for GDP per capita, population density, and spatial proximity, terrain ruggedness remained robust ($b = 0.152$, $SE = 0.053$, $t(73) = 2.86$, $p = .005$, overall model: $F(4, 73) = 5.60$, $p = .001$). Again, GDP per capita was negatively associated with authoritarian endorsement ($b = -0.067$, $SE = 0.027$, $t(73) = -2.51$, $p = .014$), while population density ($p = .142$) and spatial proximity ($p = .087$) did not reach statistical significance. Fig. 2 illustrates this positive link between elevational variability and authoritarian orientation across 78 nations.

2.3. Discussion

Study 1 provides cross-national evidence linking terrain ruggedness to greater endorsement of authoritarian governance. Nations characterized by more rugged topography displayed consistently higher tolerance for leaders bypassing democratic norms and greater approval of military governance, even after controlling for economic, demographic, and spatial factors. Consistent with modernization theory (Inglehart and Baker, 2000), GDP per capita negatively predicted authoritarian preferences, indicating that wealth partially mitigates the

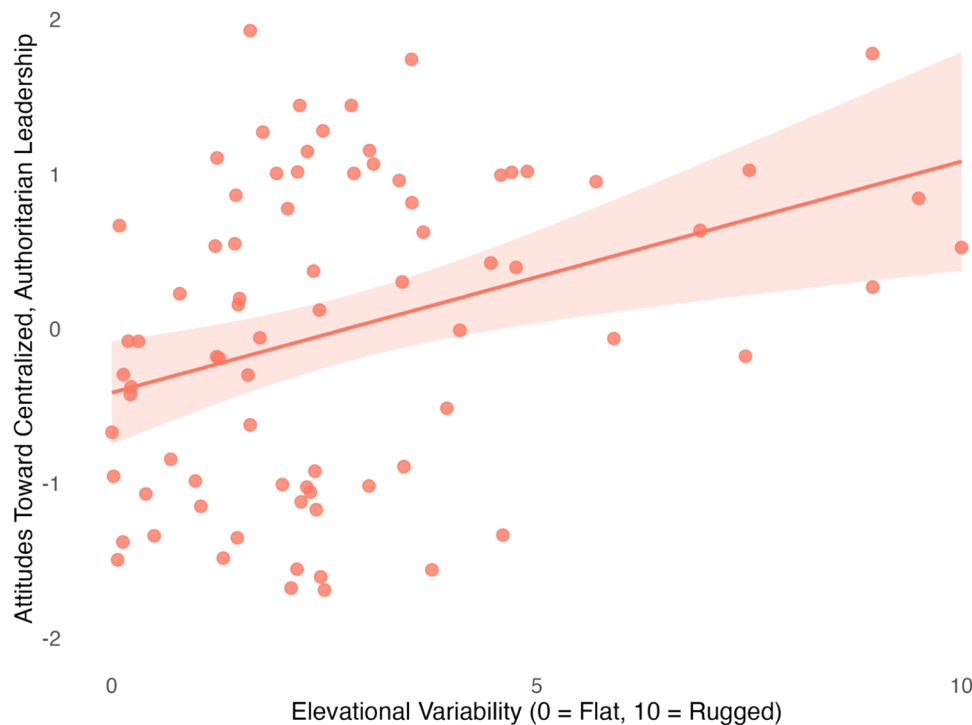


Fig. 2. Attitudes Toward Centralized, Authoritarian Leadership. Aggregated endorsement of centralized authority across 78 nations from the EVS/WVS dataset ($N = 156,658$, 2017–2022), overlaid with elevational variability from the Copernicus GLO-90 dataset. The measure is a composite ($\alpha = 0.85$) of two related items: (1) approval of a leader who bypasses parliament and elections, and (2) approval of an army-led government. Scores have been z-standardized, such that lower values represent stronger disagreement and higher values represent stronger agreement with centralized authority. Elevational variability is scaled from 0 (flat) to 10 (rugged).

hierarchical pull exerted by challenging terrains. Nonetheless, ruggedness remained a robust predictor, suggesting ecological constraints independently influence social governance preferences, beyond economic development and demographic patterns.

While cross-national analyses can control for major covariates, they cannot fully account for unmeasured national-level factors such as political history or cultural legacies. Therefore, Study 2 provides a narrower test within the United States to further isolate and examine terrain effects on hierarchical supervision preferences in a more controlled institutional and historical context.

3. Study 2: Replication within the United States

Study 2 examined whether elevational variability—shown in Study 1 to predict stronger endorsement of authoritarian leadership across national-level contexts—also shapes hierarchical tendencies within a single national context. By using state-level Gallup Poll data, we investigated whether challenging geographic conditions are associated with preferences for vertical supervisory relationships under relatively uniform political and cultural institutions. Replicating the terrain-hierarchy association within the United States would provide stronger evidence for the socioecological hypothesis, as it reduces cross-national confounds.

3.1. Method

3.1.1. Data and supervisory orientation outcome

We drew on aggregated state-level data from Gallup Daily Poll collected from 2012 to 2018 (Gallup, 2018). Employed respondents were asked:

“Does your supervisor at work treat you more like he or she is your boss or your partner?”

A higher proportion of “boss” responses indicates formal, vertical

supervision, whereas “partner” indicates a horizontal, collaborative supervisory style, similar to power distance measures used by Cho et al. (2024). This measure captures how supervisors position themselves—either hierarchically (“boss-like”) or collaboratively (“partner-like”)—rather than assessing employees’ personal preferences, thus minimizing self-presentation concerns. States with a larger proportion of “boss” answers were coded as exhibiting strong hierarchical orientations.

3.1.2. Elevational variability

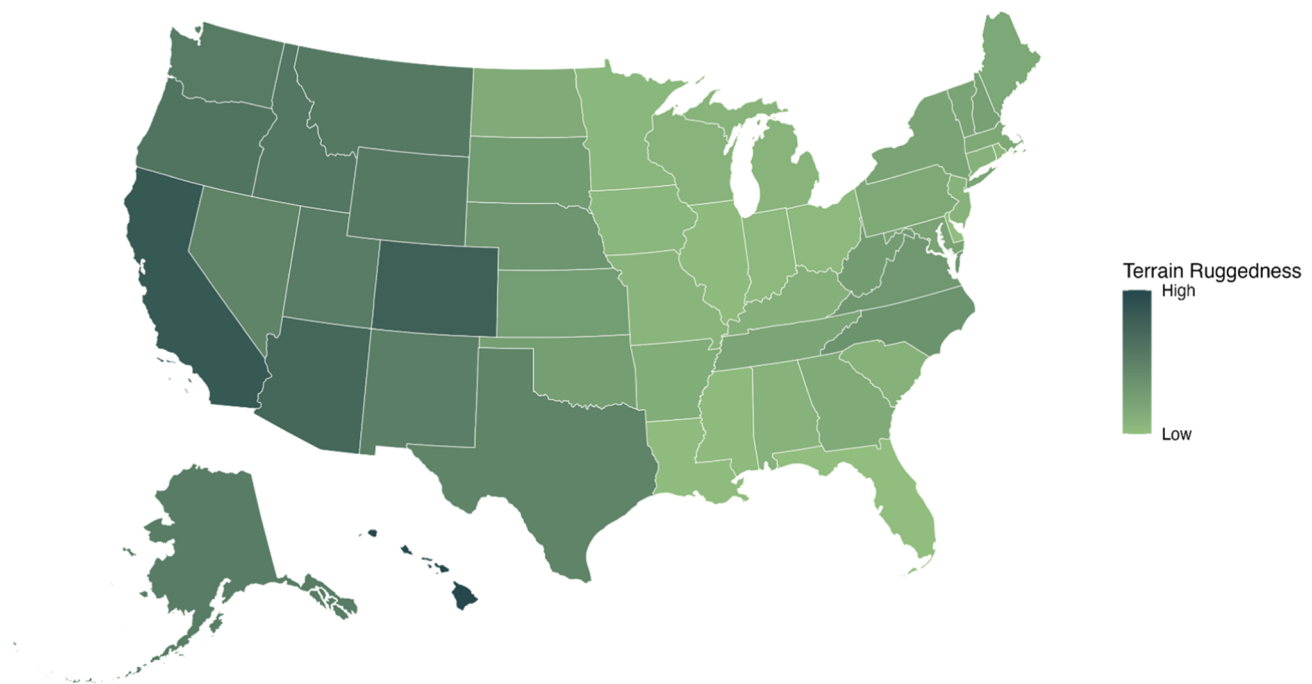
Following Study 1, terrain ruggedness was operationalized using the Copernicus GLO-90 digital elevation model (European Space Agency, 2024). For each state, we calculated the standard deviation of elevation, then log-transformed to reduce skewness. Fig. 3 visually illustrates terrain ruggedness across U.S. states, where darker shading represents greater ruggedness. The five states with the flattest terrain (least rugged) were Illinois, the District of Columbia, Louisiana, Delaware, and Florida, whereas the five most rugged states were Hawaii, California, Colorado, Arizona, and Oregon (see Appendix Table 2 for detailed ruggedness scores).

3.1.3. Additional covariates

The use of state-level data enabled us to incorporate theoretically relevant covariates beyond those examined in cross-national analyses. We controlled for urbanization using the Urban Settlement Index (FiveThirtyEight, 2024), as urban and rural environments may differentially shape social structures and hierarchical norms (Oishi and Graham, 2010; Sng and Ackerman, 2020). We also included a 5-year average (2013–2018) of GDP per capita (U.S. Bureau of Economic Analysis, 2024), recognizing that wealth is often inversely associated with endorsement of hierarchy (Inglehart and Baker, 2000; Oishi, 2014). To account for demographic variability, we included a 5-year average (2013–2018) of population density, calculated as total state population

Terrain Ruggedness Across U.S. States

Elevational Variability



Data Source: Copernicus Digital Elevation Model (GLO-90)

Fig. 3. Terrain ruggedness across U.S. states. Terrain ruggedness (elevational variability) across U.S. states, measured as the standard deviation of elevation using the Copernicus Digital Elevation Model (GLO-90). Darker shades indicate greater ruggedness, while lighter shades represent flatter terrain.

divided by total state land area (U.S. Census Bureau, 2024), acknowledging that demographic density can independently influence hierarchical orientations (Sng and Ackerman, 2020). Finally, we controlled for gender composition (proportion of women, 2013–2018; U.S. Census Bureau, 2024) and average age (2013–2018; U.S. Census Bureau, 2024), given their established roles in shaping leadership dynamics and social structures (Kitayama et al., 2006; Van Vugt and Ahuja, 2011). All covariates were log-transformed, where appropriate, to address skewness and facilitate comparability across variables. Notably, total landmass was not included as a separate covariate because its influence is already captured in our population density measure, thereby avoiding redundancy and potential multicollinearity.

3.2. Analytical approach and results

3.2.1. Model specification

We employed a two-step analytic approach. First, we used Lasso regression (Least Absolute Shrinkage and Selection Operator; Tibshirani, 1996) with tenfold cross-validation to identify predictors best explaining variability in “boss” responses. Lasso regression employs an L1 penalty to shrink coefficients of less influential predictors toward zero, helping to address multicollinearity. The penalty parameter (λ) was optimized via cross-validation to minimize prediction error. Following the Lasso step, we conducted an ordinary least squares (OLS) regression using only the predictors identified by Lasso. This approach helps clarify robust associations and reduce the risk of overfitting.

3.2.2. Lasso regression findings

From the set of predictors—terrain ruggedness, GDP per capita, urbanization, population density, gender composition, and average age—terrain ruggedness emerged as the sole predictor retained by the

Lasso regression. The optimal penalty parameter (λ) was approximately 0.0034, indicating minimal but necessary regularization. All other variables had coefficients reduced to zero, suggesting limited unique explanatory power beyond terrain ruggedness.

3.2.3. Final regression model

Using terrain ruggedness as the sole predictor, the OLS regression significantly predicted variance in hierarchical workplace supervision, $F(1, 49) = 6.95, p = .011$, explaining approximately 12.4 % of the variance ($R^2 = 0.124$, adjusted $R^2 = 0.106$). Consistent with Study 1, higher terrain ruggedness predicted greater preference for vertical supervisory relationships ($b = 0.005, SE = 0.002, t(49) = 2.64, p = .011$). [Fig. 4](#) visually illustrates this positive relationship between terrain ruggedness and hierarchical supervision orientation.

3.3. Discussion

Study 2 replicated Study 1's finding of a significant relationship between terrain ruggedness and hierarchical orientation within the United States. Even when controlling for urbanization, GDP per capita, population density, gender composition, and age, rugged terrain uniquely predicted higher proportions of hierarchical ("boss-like") supervisory relationships. The modest yet reliable effect underscores terrain ruggedness as a distinct ecological factor shaping social organization, even within a relatively homogeneous national context. Further investigation at finer geographic scales may elucidate localized variations and the underlying mechanism of this relationship.

4. General discussion

Across two studies—a cross-national analysis (Study 1) and a within-

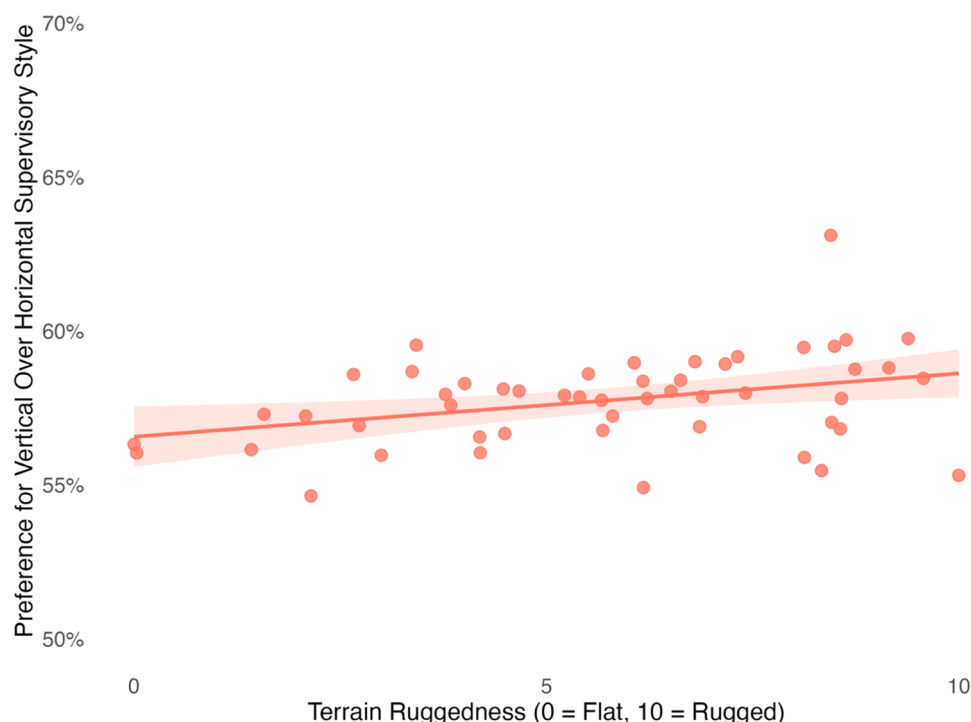


Fig. 4. Elevational Variability and Preference for Formal Over Informal Supervisors. State-level distribution of “boss” versus “partner” supervisory behaviors derived from the U.S. Gallup Daily Poll ($N = 336,491$, 2013–2018). Elevated proportions of “boss” responses indicate stronger vertical leadership preferences, shown alongside elevational variability from Copernicus GLO-90 data.

country replication in the United States (Study 2)—we found consistent evidence linking terrain ruggedness to hierarchical preference. Study 1 demonstrated that countries characterized by more uneven terrain exhibited stronger preferences for centralized authority, including greater endorsement of a strong leader and military governance, even after controlling for economic, demographic, and spatial factors. Study 2 replicated these findings at the subnational level within the United States, revealing that states with greater terrain ruggedness showed higher proportions of vertical (“boss-like”) supervisory practices. Together, these findings identify terrain as a robust ecological predictor of hierarchical structures across diverse geographic scales.

Our results align with socioecological perspectives (Oishi, 2014; Sng and Ackerman, 2020) and dominance-based leadership frameworks (Cheng et al., 2013), suggesting that challenging physical environments legitimize centralized governance structures, potentially due to increased demands for coordinated resource allocation, infrastructure maintenance, or collective defense. While previous socioecological research has emphasized climatic or pathogenic factors (Fincher et al., 2008; Gelfand et al., 2011), this research highlights terrain ruggedness as an additional, influential environmental constraint shaping social organization and governance norms.

Interestingly, GDP per capita, a significant predictor of reduced hierarchical endorsement in Study 1, did not significantly predict supervisory orientation within the U.S. context (Study 2). This discrepancy may reflect narrower economic disparities at the state level or shared historical and cultural legacies within the United States that moderate how ecology influences hierarchy (Kitayama et al., 2006). Future longitudinal or historical research could clarify causal pathways, exploring whether rugged terrain actively shapes hierarchical structures or whether historically entrenched power structures merely cluster in geographically challenging regions.

Further research employing more granular geographic analyses—such as at the county or ZIP-code level—would also enhance understanding of localized variability and could reveal specific mechanisms underpinning terrain’s influence on hierarchy. For

instance, exploring infrastructure quality, transportation accessibility, or broadband connectivity could clarify conditions under which ecological constraints either amplify or diminish hierarchical preferences. Such analyses could also illuminate the dynamic interplay between ecological features and modernization processes.

Taken together, these two studies provide robust support for the socioecological hypothesis that terrain ruggedness is systematically associated with hierarchical endorsement across diverse political and cultural contexts. By underscoring the role of geographic constraints, our findings emphasize the importance of ecological factors in shaping social organization and governance preferences. Future research incorporating historical trajectories, moderating influences, and detailed ecological conditions will further clarify how physical environments and social hierarchies co-evolved over time.

Availability of data and material

All datasets used in this study are publicly accessible from the sources cited. Analysis codes and scripts for data preprocessing and statistical modeling are openly available on the Open Science Framework (OSF) at <https://osf.io/x9pj4>.

Ethics approval

The research presented did not involve human subjects and therefore did not require ethics committee approval.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

CRediT authorship contribution statement

Gen Tsudaka: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Visualization, Project administration. **Margaux N.A. Wienk:** Conceptualization, Validation, Methodology, Writing – review & editing. **Jana B. Berkessel:** Conceptualization, Validation, Methodology, Writing – review & editing. **Cynthia Boo:** Validation, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

We gratefully acknowledge Shigehiro Oishi, Lawrence A. Hirschfeld, Minoru Karasawa, Joan G. Miller, Keiko Ishii, Matthew Wice, and Ruthe Foushee for their insightful feedback and comments.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.cresp.2025.100220](https://doi.org/10.1016/j.cresp.2025.100220).

Data availability

<https://osf.io/x9pj4/> ()

References

- Anderson, C.A., 2001. Heat and violence. *Curr. Dir. Psychol. Sci.* 10 (1), 33–38.
- Berry, J.W., 1967. Independence and conformity in subsistence-level societies. *J. Pers. Soc. Psychol.* 7 (4), 415–418. <https://doi.org/10.1037/h0025231>. Pt.1.
- Berry, J.W., 1980. Acculturation as varieties of adaptation. In: Padilla, A.M. (Ed.), *Acculturation: Theory, Models and Some New Findings*. Westview, pp. 9–25.
- Beugelsdijk, S., Mudambi, R., 2013. MNEs as border-crossing multi-location enterprises: the role of discontinuities in geographic space. *J. Int. Bus. Stud.* 44 (5), 413–426. <https://doi.org/10.1057/jibs.2013.23>.
- Cheng, J.T., Tracy, J.L., Foulsham, T., Kingstone, A., Henrich, J., 2013. Two ways to the top: evidence that dominance and prestige are distinct yet viable avenues to social rank and influence. *J. Pers. Soc. Psychol.* 104 (1), 103–125. <https://doi.org/10.1037/a0030398>.
- Cho, J., Wasti, S.A., Savani, K., Tan, H.H., Morris, M.W., 2024. Formal versus informal supervisor socio-emotional support behaviors and employee trust: the role of cultural power distance. *Asian J. Soc. Psychol.* 27 (2), 203–218. <https://doi.org/10.1111/ajsp.12590>.
- Conway, L.G., Bongard, K., Plaut, V., Gornick, L.J., Dodds, D.P., Giresi, T., Tweed, R.G., Repke, M.A., Houck, S.C., 2017. Ecological origins of freedom: pathogens, heat stress, and frontier topography predict more vertical but less horizontal governmental restriction. *Personal. Soc. Psychol. Bull.* 43 (10), 1378–1398. <https://doi.org/10.1177/0146167217713192>.
- Eliade, M., 1959. *The Sacred and the Profane: The Nature of Religion*. Brace & World, Harcourt.
- European Space Agency. (2024). *Copernicus Global Digital Elevation Model* [Data set]. Distributed by OpenTopography. <https://doi.org/10.5069/G9028PQB>.
- EVS/WVS. (2022). *European Values Study and World Values Survey: joint EVS/WVS 2017–2022 dataset (Joint EVS/WVS) (Version 5.0.0)* [Data set]. GESIS Data Archive. <https://doi.org/10.4232/1.14320>.
- 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 Biol. Sci.* 275 (1640), 1279–1285. <https://doi.org/10.1098/rspb.2008.0094>.
- FiveThirtyEight. (2024). *Urbanization index by state* [Data set]. <https://fivethirtyeight.com/fivethirtyeight/urbanization-index-2/Furbanization-state>.
- Freedman, J.L., 1975. *Crowding and Behavior*. Viking Press.
- Gallup. (2013–2018). *WP58* [Data set]. Gallup World Poll.
- Gelfand, M.J., Raver, J.L., Nishii, L., Leslie, L.M., Lun, J., Lim, B.C., Duan, L., Almaliah, A., Ang, S., Arndt, J., Aycan, Z., Boehnke, K., Boski, P., Cabecinhas, R., Chan, D., Chhokar, J., D'Amato, A., Subirats Ferrer, M., Fischlmayr, I.C., Yamaguchi, S., 2011. Differences between tight and loose cultures: a 33-nation study. *Science* 332 (6033), 1100–1104. <https://doi.org/10.1126/science.1197754>.
- Götz, F.M., Stieger, S., Gosling, S.D., Potter, J., Rentfrow, P.J., 2020. Physical topography is associated with human personality. *Nature Human Behav.* 4 (11), 1135–1144. <https://doi.org/10.1038/s41562-020-0930-x>.
- Henrich, J., Gil-White, F.J., 2001. The evolution of prestige: freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evol. Hum. Behav.* 22 (3), 165–196. [https://doi.org/10.1016/S1090-5138\(00\)00071-4](https://doi.org/10.1016/S1090-5138(00)00071-4).
- Hirschfeld, L.A., 1996. *Race in the Making: Cognition, Culture, and the Child's Construction of Human Kinds*. MIT Press.
- Hofstede, G., 1984. *Culture's Consequences: International Differences in Work-Related Values*, 5. SAGE.
- Inglehart, R., 1997. *Modernization and Postmodernization: Cultural, Economic, and Political Change in 43 Societies*. Princeton University Press.
- Inglehart, R., Baker, W.E., 2000. Modernization, cultural change, and the persistence of traditional values. *Am. Sociol. Rev.* 65 (1), 19–51. <https://doi.org/10.2307/2657288>.
- International Monetary Fund. (2024, October). *World Economic Outlook (October 2024): GDP per capita, current prices (PPP)* [Data set]. IMF DataMapper. <https://www.imf.org/external/datamapper/PPP@WEO/OEMDC/ADVEC/WEOWorld?year=2025>.
- Kitayama, S., Ishii, K., Imada, T., Takemura, K., Ramaswamy, J., 2006. Voluntary settlement and the spirit of independence: evidence from Japan's "northern frontier." *J. Pers. Soc. Psychol.* 91 (3), 369–384. <https://doi.org/10.1037/0022-3514.91.3.369>.
- Körner, C., 2007. The use of 'altitude' in ecological research. *Trends Ecol. Evol. (Amst.)* 22 (11), 569–574. <https://doi.org/10.1016/j.tree.2007.09.006>.
- Lamer, S.A., Suiter, C., Maass, A., Caccioppoli, R., Pradell, H., 2021. The function of vertical and horizontal space to social group identity. *Self and Identity* 20 (6), 774–810. <https://doi.org/10.1080/15298868.2020.1785929>.
- Markus, H.R., Kitayama, S., 1991. Culture and the self: implications for cognition, emotion, and motivation. *Psychol. Rev.* 98 (2), 224–253. <https://doi.org/10.1037/0033-295X.98.2.224>.
- Milgram, S., 1970. The experience of living in cities. *Science* 167 (3924), 1461–1468. <https://doi.org/10.1126/science.167.3924.1461>.
- Miller, J.G., 1984. Culture and the development of everyday social explanation. *Journal of Personality and Social Psychology* 46 (5), 961–978. <https://doi.org/10.1037/0022-3514.46.5.961>.
- Minkov, M., Hofstede, G., 2012. Hofstede's fifth dimension: new evidence from the World Values Survey. *J. Cross. Cult. Psychol.* 43 (1), 3–14.
- Morgan, C., 1990. *Athletes and Oracles: The Transformation of Olympia and Delphi in the 8th Century BC*. Cambridge University Press.
- Morris, M.W., Peng, K., 1994. Culture and cause: american and Chinese attributions for social and physical events. *J. Pers. Soc. Psychol.* 67 (6), 949–971. <https://doi.org/10.1037/0022-3514.67.6.949>.
- Muthukrishna, M., Bell, A.V., Henrich, J., Curtin, C.M., Gedranovich, A., McInerney, J., Thue, B., 2020. Beyond western, educated, industrial, rich, and democratic (WEIRD) psychology: measuring and mapping scales of cultural and psychological distance. *Psychol. Sci.* 31 (6), 678–701. <https://doi.org/10.1177/0956797620916782>.
- Nisbett, R.E., Cohen, D., 1996. *Culture of Honor: The psychology of Violence in the South*. Westview Press.
- Nisbett, R.E., Peng, K., Choi, I., Norenzayan, A., 2001. Culture and systems of thought: holistic versus analytic cognition. *Psychol. Rev.* 108 (2), 291–310. <https://doi.org/10.1037/0033-295X.108.2.291>.
- Oishi, S., Graham, J., 2010. Social ecology: lost and found in psychological science. *Perspect. Psychol. Sci.* 5 (4), 356–377. <https://doi.org/10.1177/1745691610374588>.
- Oishi, S., 2014. Socioecological psychology. *Annu. Rev. Psychol.* 65, 581–609.
- Oishi, S., Talhelm, T., Lee, M., 2015. Personality and geography: introverts prefer mountains. *J. Res. Pers.* 58, 55–68. <https://doi.org/10.1016/j.jrp.2015.07.001>.
- Qiu, M., Pei, Q., Lin, Z., 2023. The geography of religions: comparing Buddhist and Taoist sacred mountains in China. *Geographical Res.* 61 (1), 58–70. <https://doi.org/10.1111/1745-5871.12562>.
- Ronay, R., Maddux, W.W., Von Hippel, W., 2020. Inequality rules: resource distribution and the evolution of dominance- and prestige-based leadership. *Leadersh Q* 31 (2), 101246. <https://doi.org/10.1016/j.leafqua.2018.04.004>.
- Schubert, L., Schubert, T.W., Topolinski, S., 2013. The effect of spatial elevation on respect depends on merit and medium. *Soc. Psychol.* 44 (2), 147–159. <https://doi.org/10.1027/1864-9335/a000134>.
- Schubert, T.W., 2020. Grounding of rank: embodiment, space, and magnitude. *Curr. Opin. Psychol.* 33, 222–226. <https://doi.org/10.1016/j.copsyc.2019.09.012>.
- Scott, J.C., 2009. *The Art of Not Being Governed: An Anarchist History of Upland Southeast Asia*. Yale University Press.
- Shweder, R.A., 1991. *Thinking Through Cultures: Expeditions in Cultural Psychology*. Harvard University Press.
- Sng, O., Ackerman, J.M., 2020. Too many people, women, men? The psychological effects of population density and sex ratio. *Curr. Opin. Psychol.* 32, 38–42. <https://doi.org/10.1016/j.copsyc.2019.06.015>.
- Swidler, A., 1986. Culture in action: symbols and strategies. *Am. Sociol. Rev.* 51 (2), 273–286.
- Talhelm, T., Dong, X., 2024. People quasi-randomly assigned to farm rice are more collectivistic than people assigned to farm wheat. *Nat. Commun.* 15. Article 1782.

- Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., Kitayama, S., 2014. Large-scale psychological differences within China explained by rice vs. wheat agriculture. *Science* 344 (6184), 603–608. <https://doi.org/10.1126/science.1246850>.
- Tibshirani, R., 1996. Regression shrinkage and selection via the lasso. *J. Royal Statist. Society: Series B* 58 (1), 267–288. <https://doi.org/10.1111/j.2517-6161.1996.tb02080.x>.
- Tilly, C., 1990. *Coercion, Capital, and European States: AD 990–1990*. Basil Blackwell.
- Triandis, H.C., 1995. *Individualism and Collectivism*. Westview Press.
- United Nations Statistics Division. (2024). Population density and urbanization [Data set]. Retrieved April 23, 2025, from <https://unstats.un.org/unsd/demographic/scenariocens/densurb/>.
- U.S. Census Bureau. (2024, November 25). *State population by characteristics: 2020–2024*. [Data set]. <https://www.census.gov/data/tables/time-series/demo/popest/2020s-state-detail.html>.
- U.S. Bureau of Economic Analysis. (2024, December 20). *Gross domestic product by state and personal income by state*. [Data set]. <https://www.bea.gov/data/gdp/gdp-state>.
- Uskul, A.K., Kitayama, S., Nisbett, R.E., 2008. Ecocultural basis of cognition: farmers and fishermen are more holistic than herders. *Proc. Natl Acad. Sci.* 105 (25), 8552–8556. <https://doi.org/10.1073/pnas.0803874105>.
- van Vugt, M., Ahuja, A., 2011. *Naturally Selected: The evolutionary Science of Leadership*. Harper Business.
- van Vugt, M., Hogan, R., Kaiser, R.B., 2008. Leadership, followership, and evolution: some lessons from the past. *Am. Psychol.* 63 (3), 182–196. <https://doi.org/10.1037/0003-066X.63.3.182>.
- Varnum, M.E.W., Grossmann, I., 2017. Cultural change: the how and the why. *Perspect. Psychol. Sci.* 12 (6), 956–972. <https://doi.org/10.1177/1745691617699971>.