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Property Rights and Violence: Evidence from the End of the American West

Luke Petach*

September 2025

Abstract

Prior to the widespread adoption of barbed wire in the late 19th century, the absence of cheap fencing materials in the western United States led to violent conflict in the presence of competing claims over land-use. Using data from the full count U.S. Censuses of Mortality for the years 1850 to 1880, I demonstrate that an increase in the cost of property rights enforcement—captured by an increase in fencing costs per-acre—results in an increase in violent mortality. The effect of fence prices on violent mortality is exacerbated in counties with a greater degree of agricultural land-use polarization. The main findings are supported by an instrumental variables specification using the county woodland area share—a measure of the local scarcity of natural fencing materials, and a placebo specification demonstrating that fence prices have no effect on infectious disease mortality.

JEL Codes: N41, D23, K42

Keywords: Property Rights, the West, Barbed Wire, Violent Conflict

*Associate Professor of Economics, Jack C. Massey College of Business. Belmont University. 1900 Belmont Boulevard, Nashville, TN, 37212. luke.petach@belmont.edu. GLO Fellow.

> Men's memories are uncertain and the past that was differs little from the past that was not.
>
> Cormac McCarthy, *Blood Meridian*

1 Introduction

In the epilogue to his violent epic *Blood Meridian*, Cormac McCarthy depicts a post hole digger traversing an arid plain as the many wandering characters of the American West are slowly enclosed behind a wall of barbed wire. Despite its portrayal by McCarthy and others as a place of unprecedented violence, historians and economists are at odds regarding the true extent of violence in the 19th century Western United States (Anderson and Hill, 1975, 2004; Dykstra, 1996, 2009; DiLorenzo, 2010; Roth et al., 2011). The lack of consensus among scholars as to the extent of violence in the American West at least partially reflects a lack of comprehensive data on crime rates and mortality for the time period. Roth et al. (2011) argues for the "high-violence" hypothesis using data on the homicide rate in nine California counties for the years 1850 to 1865. A seemingly inordinate amount of ink has been spilled on attempts to extrapolate about violence in the West from the prevalence of violence in Dodge City, KS alone (Dykstra, 1996). Dykstra (2009) argues that the relatively small populations of many Western counties combined with significant year-to-year variability in violent crime results in a "small-numbers fallacy," wherein single-year estimates greatly overstate the true prevalence of violence. Anderson and Hill (1975, 2004) argue that institutional entrepreneurs intervened in the West to structure property rights in such a fashion that cooperation, rather than conflict, was the behavioral norm.

This paper makes two contributions to the literature on violence in the American West. First, using recently released data from the full count U.S. Census of Mortality for the years 1850 to 1880—which provides individual-level details on 1,829,279 persons who died in the year prior to each decadal population census—covering nearly all United States counties over three decades (Hacker et al., 2024a), I investigate the extent to which the violent death rate was higher in the West. The Census of Mortality data suggest that violent deaths occurred at higher frequency in the West relative to the rest of the country. Between 1850 and 1880, the ten states with the highest average county-level violent death rate (measured as violent deaths per 1,000 persons) are all located on

the frontier. A similar rank-ordering holds among states even when counties with a population less than 1,000 are excluded, suggesting the results are not driven by the "small numbers fallacy." Among all counties, two-thirds of those in the top decile of violent mortality are located west of the 100th meridian.[1]

Second, I argue that the high rate of violence in the West during the 19th century can be explained by conflicting claims over land-use in the presence of incomplete property rights. In particular, I build on the work of Hornbeck (2010) highlighting the importance of barbed wire fencing as a technology for defining and enforcing property rights. The invention of barbed wire in DeKalb, Illinois in 1873[2] reduced the cost of fencing in counties with little access to natural fencing materials (i.e., wood). Prior to the widespread adoption of barbed wire between 1880 and 1900, the absence of cheap fencing in the West led to conflicting claims over land-use—particularly between farmers and cattlemen (McCallum and McCallum, 1965)—due to the inability of landowners to clearly delineate and enforce property rights. In the absence of clearly defined property rights, Coasean bargaining is untenable, and parties may resort to alternative dispute resolution mechanisms such as violence. I provide support for this hypothesis in two ways. First, using data from the full count decennial Census for the years 1850 to 1880 (Ruggles et al., 2025), I show that county-level violent mortality is positively related to an index of agricultural polarization capturing conflict over land-use between cattlemen and farmers. In a simple panel two-way fixed-effects model, increasing polarization leads to an increase in the county-level violent mortality rate. These results are supported by a placebo test that shows that agricultural polarization has no effect on infectious disease mortality. Second, using county-level data on the cost of building and repairing fencing prior to the widespread adoption of barbed wire from the 1880 Census (Haines, 2010), I show that fence prices are positively related to violent mortality across counties. To address concerns about endogeneity in the relationship between fence prices and violence, I support the ordinary least squares results with an instrumental variables specification wherein fence prices are instrumented with the county woodland area share, a measure of the relative local scarcity of natural fencing materials. The IV specifications suggest that higher fence prices result in higher

[1] Only 17% of counties included in the sample are located west of the 100th meridian. One might alternatively note that among western counties, nearly 40% are in the top decline for violent mortality.

[2] Some wire fencing prototypes likely existed prior to 1873, but they were not widespread. See McCallum and McCallum (1965) for a complete history of barbed wire technology. See also Figure 1.

violent mortality rates, and are supported by a placebo specification indicating that fence prices have no effect on infectious disease mortality. Taken together, the results suggest that Cormac McCarthy's post hole digger may indeed have played a part in bringing an end to the violence of the American West.

The rest of the paper is organized as follows. Section 2 discusses the existing literature on the relationship between property rights, violence, and the economics of the 19th Century Western United States, Section 3 discusses the data, Section 4 presents the results, Section 5 offers some concluding remarks.

2 Property Rights, Violence, and the 19th Century American West

The theoretical starting point for this paper is the insight of Umbeck (1981) that "[f]orce is the relevant constraint underlying any initial agreements (and subsequent agreements) which allocate wealth among competitors" (p.40). The existence of functional legal mechanisms for contracting and enforcing property rights serve a dual purpose: resource allocation and violence suppression. If property rights cannot be clearly defined or enforced then non-market mechanisms for resource allocation must be relied on. Although it is possible for non-violent mechanisms of non-price resource allocation to emerge, Donohue and Levitt (1998) argue that "[i]n the absence of law, it is likely that violence (or the threat thereof), rather than prices, is the means by which resources will be allocated" (p.463). The relevance of violence as an allocation mechanism has been documented in various settings where property rights are not legally enforceable, including markets for illegal drugs (Canada, 1995; Donohue and Levitt, 1998; Glaeser and Glendon, 1998), within organized criminal enterprises (Thompson, 2024), and in marital contracts in the absence of a legal right to divorce (Stevenson and Wolfers, 2006).

Although the absence of formal property rights may lead to reliance on violence as an allocation mechanism, the deadweight loss incurred by victims and perpetrators of violence creates a subsequent opportunity for institutional entrepreneurs to propose new legal arrangements that mitigate the costs of violence. Davis and North (1971) theorize that new institutions emerge to help transacting parties internalize currently overlooked profit opportunities (or in this case, to increase the surplus from bargaining by mitigating potentially unnecessary violent conflict): "[I]t

is the possibility of profits that cannot be captured within the existing arrangemental structure that leads to the formation of new (or the mutation of old) institutional arrangements" (p.59). Thus, much of the literature examining the influence of property rights on the economy of the 19th century American West focuses on either cases where the absence of formal governance results in violent conflict and deadweight loss, or examples of institutional entrepreneurship in which new property rights arrangements serve to abate violent conflict by facilitating resource allocation through markets (Anderson and Hill, 1975; Libecap, 1978; Umbeck, 1981; Anderson and McChesney, 1994; Anderson and Hill, 2004; Allen et al., 2025). Of particular interest to the present study are the work of Anderson and Hill (1975, 2004) and Allen et al. (2025).

Anderson and Hill (1975, 2004) focus on institutional entrepreneurship in the West, arguing institutional entrepreneurs ensured "violence (a negative-sum game) generally [was] supplanted by trade and cooperation (positive-sum games)...[t]o the extent that institutions encouraged cooperation and gains from trade the 'wild, wild West' was really the '*not* so wild, wild West" (Anderson and Hill, 2004, p.4-5). To the extent that this paper provides evidence that violent mortality was significantly higher in the Western United States relative to the rest of the country throughout the 19th century, the results presented below might be interpreted to suggest the claims of Anderson and Hill (1975, 2004) regarding the effectiveness of institutional entrepreneurship are overstated.[3] However, although I present evidence that the West was more violent than the picture painted by Anderson and Hill (2004)'s "*not* so wild, wild West" characterization, high levels of violence in the West do not necessarily contradict Anderson and Hill (2004)'s claims regarding the nature of institutional entrepreneurship on the frontier. In fact, rather than playing down the violence of the West, an alternative account that is otherwise consistent with Anderson and Hill (2004) might note the presence of violent conflicts as a *pre-condition* for the type of legal-institutional entrepreneurship cataloged by Anderson and Hill (2004): in the absence of such a market failure there is no

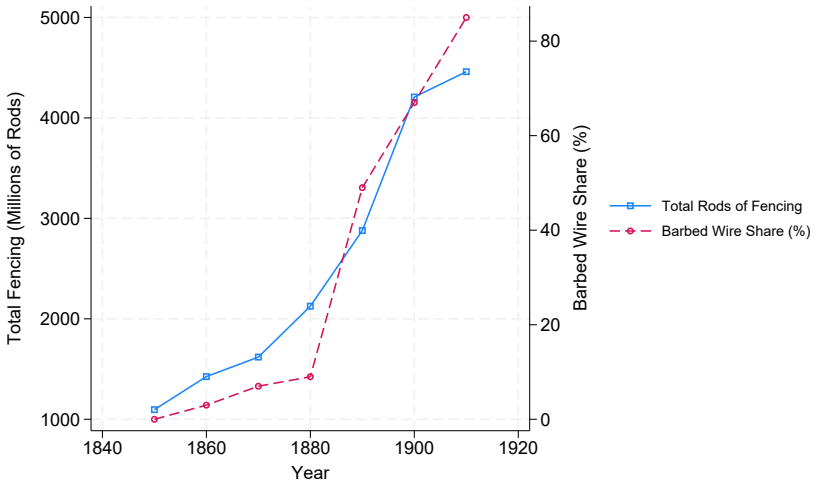
[3]Importantly, in claiming the West was less violent than commonly understood Anderson and Hill (1975, 2004) do not claim that violence was absent from the West. Anderson and Hill (2004) write:

> [T]his is not to deny the violence of the West. Violence certainly occurred, and when it did, it usually took one of two forms. First, violence, or more precisely coercive power, was used by private persons and institutions to defend property rights against intruders. For example, cattlemen's associations flexed their muscle to exclude newcomers from the open range, and vigilante groups acted to enforce laws. Second, violence manifested itself through the exercise of governmental power to take assets from others. The Indian wars of the late nineteenth century were a quintessential example (p.5).

need for institutional entrepreneurship. The high levels of institutional entrepreneurship in the American West reflect the efforts of frontier populations to capture the economic surplus that is otherwise dissipated through violence in the absence of clearly defined property rights and formal governance.

In recent work, Allen et al. (2025) document both the tendency for violence to emerge in the absence of clearly defined or enforced property rights, and the role of formal governance as a tool for subsequently ameliorating these violent conflicts. In particular, Allen et al. (2025) study violent conflict between Native Americans and white settlers between 1840 and 1870 using a novel dataset on deaths across more than 200 tribes in 21 states. The findings of Allen et al. (2025) complement those presented in this paper: Allen et al. (2025) show that mineral discoveries incentivized settlement ahead of formal state capacity, and that the encroachment of these settlements on Native land triggered conflict. Allen et al. (2025) show that subsequent the arrival of formal statehood "all but eliminated decentralized violence" (p.35). The empirical findings of Allen et al. (2025) highlight the key mechanisms emphasized in this study: the emergence of violence in the absence of clearly defined or enforced property rights, and the ability of formal governance arising out of new institutions or technology to resolve violent conflict linked to incomplete property rights.

Figure 1: Fencing in the United States, 1850-1910



Notes: Data from Primack (1969).

In this paper, I focus on a particular type of conflict—conflict between cattlemen and farmers over agricultural land-use in the presence of incomplete (or incompletely enforced) property

rights—and a particular institutional innovation (in this case, a new technology)—barbed wire. Figure 1 plots total fencing capital (measured in millions of rods) and the share of national fencing capital composed of barbed wire fencing between 1850 and 1910. Figure 1 illustrates the acceleration in the adoption of barbed wire fencing after 1880.

The importance of barbed wire as a technology facilitating economic development in the West has previously been emphasized by McCallum and McCallum (1965) and Hornbeck (2010). Hornbeck (2010) identifies the effect of barbed wire on *agricultural* development in the West, emphasizing "the role of barbed wire in protecting farmland from encroachment by others' cattle" (p.769).[4] McCallum and McCallum (1965) similarly emphasize the protective role of barbed wire fencing:

> In an almost treeless land, with a scarcity of loose stones, and removed from navigable waterways, effective protection was hard to come by. No one knew it better than the homesteader, yet no one knew better than he that he must have protection—not only from the elements but from man and beast as well (p.9).

In the era prior to the widespread adoption of barbed wire fencing, cattlemen operated "by a sort of feudalistic arrangement" wherein "they worked out customs which were, by their hierarchy, the equivalent of law" (McCallum and McCallum, 1965, p.11). Conflict between cattlemen and farmers arose as a result of the so-called "Law of the Open Range." Because few persons were able to finance the purchase the large swaths of land necessary to support both summer and winter grazing, "free use of unoccupied government lands was the foundation of the range cattle industry" (p.11). Farmers, on the other hand, "realized that if they were to homestead the unclaimed lands beyond the fringes of established settlement, they must arm themselves with fencing to withstand assault by unruly cattle" (p.12). As a result, "cowmen regarded settlers with hostility and with derision also" (p.11). The contradiction between the Law of the Open Range and the demands of settled agriculture, and the lack of adequate fencing material in the era prior to the invention of barbed wire, set the stage for potential violent conflict over land-use in the West.

[4] Hornbeck (2010) also notes the potential contribution of barbed wire to agricultural technology: "[A]side from any external protection effects, cheaper fencing benefits an isolated farm by providing greater control over a farmer's own cattle. This allows the production of cattle and crops in close proximity, and increases cattle productivity through improvements in feeding and breeding" (p.769). In either use-case—fencing cattle out or fencing cattle in—barbed wire is likely to reduce violence by reducing opportunities for conflicting claims over land-use.

3 Data and Estimation Strategy

3.1 Data

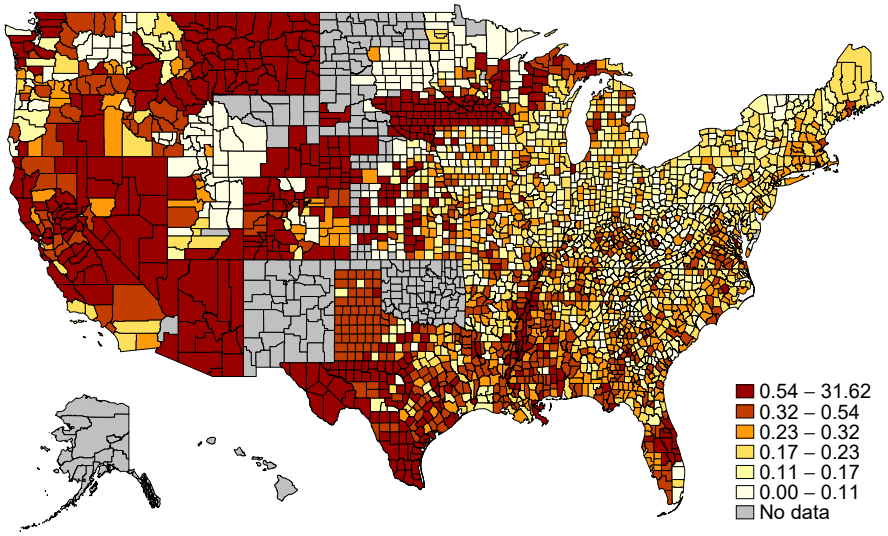
Mortality Data. Data on mortality are obtained from the Integrated Public Use Microdata Series (IPUMS) full count datasets of the U.S. Censuses of Mortality for 1850 to 1880 (Hacker et al., 2024a). The data include details on 1,829,279 persons who died in the year prior to the decennial population census for each decade. For each observation, a person's cause of death is listed along with other individual characteristics (including state, county, age, sex, race, marital status, and occupation). Importantly, the Censuses of Mortality are the only nationally representative individual-level mortality data produced in the United States prior to the twentieth century (Hacker et al., 2024b). As such, these data are arguably the most comprehensive source available for economic historians interested in exploring trends in 19th century mortality statistics (despite various shortcomings, discussed below). To compare mortality across geographies, I aggregate mortality counts by various causes of death to the county-level for each year from 1850 to 1880. I focus on two main sources of mortality: violence-related mortality and infectious disease mortality. Table 9 in Appendix A lists the individual causes of death included under each classification. To calculate mortality rates, I divide aggregate mortality counts by county-level population counts obtained from Ruggles et al. (2025). To facilitate comparison across years, I harmonize county boundaries to 1990 following Eckert et al. (2020)[5]. The resulting dataset is an unbalanced panel of 2,895 counties spanning the period from 1850 to 1880. Figure 2 maps the average violent mortality rate from 1850 to 1880 across counties, Figure 3 maps the average infectious disease mortality rate from 1850 to 1880 across counties.

Hacker et al. (2024b) note several potential limitations in using the Censuses of Mortality to compare mortality trends across counties. First, deaths of persons living in single-person households and/or deaths of household heads that resulted in the dissolution of a household are likely to be under-reported.[6] To the extent that violent conflict in the West was driven by unmarried

[5] Eckert et al. (2020) describe a general method for harmonizing county boundaries over time. In particular, Eckert et al. (2020) compute the share of the area of each reporting unit (county) nested in a given reference unit. Using these shares, data can be re-aggregated from the reporting to the reference units (i.e., aggregated from 1850 county boundaries to 1990 county boundaries). Eckert et al. (2020) use this method to construct a crosswalk for mapping county-level data from 1790 to 2010 to present-day boundaries.

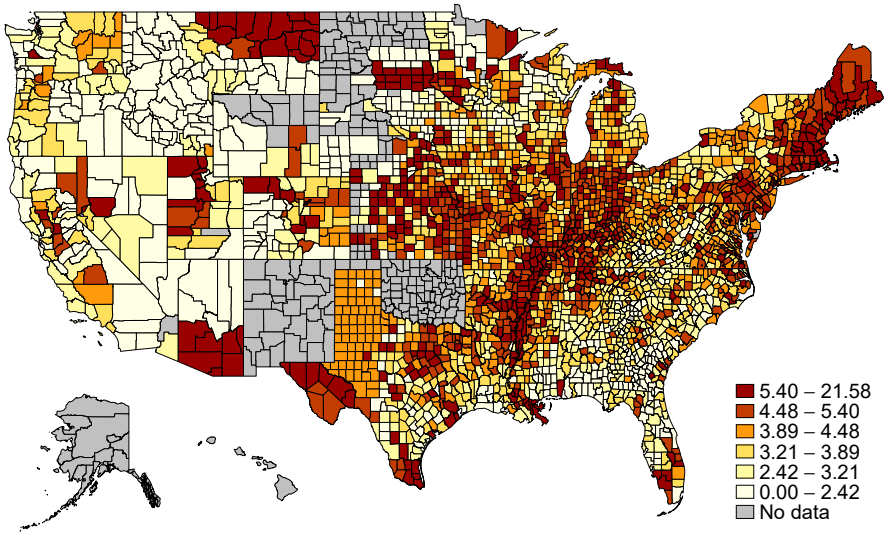
[6] Hacker et al. (2024b) note that deaths of infants and the elderly are also under-reported in the Censuses of Mortality. In contrast, mortality among children aged 5 to 19 appears to have been recorded with remarkable accuracy.

Figure 2: Average Violent Mortality Rate, 1850-1880



Notes: Figure presents the average violence-related mortality rate—measured as violence related deaths per 1,000 persons—-across counties from 1850 to 1880. Violence-related deaths classified according to Table 9.

Figure 3: Average Infectious Disease Mortality Rate, 1850-1880



Notes: Figure presents the average infectious disease mortality rate—measured as infectious disease deaths per 1,000 persons—across counties from 1850 to 1880. Infectious disease deaths classified according to Table 9.

men or resulted in the dissolution of a household (e.g., as a result of the death of the household head), these deaths are likely to be under-reported relative to violent deaths in Eastern population centers. Second, Hacker et al. (2024b) note explicitly that deaths in the South and the West are under-counted relative to deaths in other regions. Both of the aforementioned limitations imply that any estimate of violent mortality in the West obtained from the Censuses of Mortality is likely to be a lower-bound estimate. To the extent that measured violent mortality in the West exceeds measured violent mortality in the rest of the country, the estimated difference will *understate* the true extent to which violent mortality in the West exceeded violent mortality in the rest of the country.

Table 1: Violent Mortality West of the 100th Meridian, 1850-1880

	Pr(Top Mortality Decile | West of 100th Meridian)	**Pr**(West of 100th Meridian | Top Mortality Decile)
All Counties	0.4	0.67
Excl. Population < 1,000	0.47	0.46
Share of Counties West of 100th Meridian		0.17
Share of Counties > 1,000 Persons West of 100th Meridian		0.10
Median Violent Mortality Rate (Full Sample)		0.23
Median Violent Mortality Rate (Pop > 1,000)		0.22
Top Decile Violent Mortality Rate (Full Sample)		0.66
Top Decile Violent Mortality Rate (Pop > 1,000)		0.51

Notes: Table presents conditional violent mortality probabilities based on U.S. Censuses of Mortality (Hacker et al., 2024a). The first column presents the share of counties west of the 100th meridian that are in the top decile for violent mortality. The second column presents the share of counties in the top decile for violent mortality that are located west of the 100th meridian. The mortality rate is calculated as total deaths between 1850 and 1880 divided by total population (measured in thousands of persons) for the same period. All counties, $N = 2,895$. Counties greater than 1,000 persons, $N = 2,541$. Mortality rate measured as deaths per 1,000 persons.

Table 1 presents estimates of (A) the share of counties in the top decile of violent mortality that are located west of the 100th meridian, and (B) the share of counties located west of the 100th meridian that are in the top decile of violent mortality. Both measures suggest counties in the West are over-represented at the top end of the mortality distribution relative to their overall sample prevalence. Approximately 67% of all counties in the top decile of violent mortality for the period between 1850 and 1880 are located west of the 100th meridian. In contrast, 40% of counties located in the West are in the top decile of *all* counties for violent mortality. To address concerns raised by Dykstra (2009) and others that disproportionate representation of Western counties in the top decile of violent mortality is driven by the "small-numbers fallacy" stemming from

small populations in Western counties, I also present estimates wherein I exclude counties with a population less than 1,000. For counties with a population greater than 1,000, 46% of counties in the top decile are located west of the 100th meridian, and 47% of all counties in the West are ranked in the top decile for mortality. By nearly any interpretation, the estimates presented in Table 1 suggest that the West was the most violent region in the United States from 1850 to 1880. Table 2 provides additional evidence this effect, ranking the top ten states in terms of average county-level violent mortality and infectious disease mortality from 1850 to 1880[7]. The ten states with the highest average violent mortality rates are all located in the West or on the Great Plains. In contrast, the ten states with the highest infectious disease mortality are largely located in the East or the Midwest (with the exceptions of Kansas and Nebraska).

Table 2: State Mortality Rankings, Top Ten States, 1850-1880

State	Violent Mortality	State	Infectious Disease Mortality
1. Montana	5.03	1. District of Columbia	6.72
2. Arizona	1.89	2. Massachusetts	6.35
3. South Dakota	1.67	3. Rhode Island	5.81
4. Nebraska	1.08	4. Maine	5.69
5. Nevada	1.03	5. Kansas	5.61
6. Colorado	0.77	6. New Hampshire	5.51
7. Texas	0.71	7. Missouri	5.18
8. California	0.62	8. Nebraska	5.14
9. Kansas	0.58	9. Connecticut	5.09
10. Wyoming	0.58	10. Indiana	5.07

Notes: Table 2 presents state mortality rankings for the period 1850-1880. Table 2 includes the top ten states for violent mortality and the top ten states for infectious disease mortality. Mortality rates calculated as the average mortality rate across counties within a state for the 1850 to 1880 period. County-level mortality rates calculated as total deaths between 1850 and 1880 divided by total population (measured in thousands of persons) for the same period.

Agriculture Data. Data on county-level agriculture are obtained from the full count Integrated Public-Use Microdata Series (IPUMS) for the U.S. Census for the years 1850 to 1880 (Ruggles et al., 2025). To measure potential conflict over land-use, I construct a polarization index for county-level agriculture following Esteban and Ray (2008, 2011). The polarization index is intended to capture the sum of "interpersonal antagonisms" resulting from the interaction of group identification and group alienation. For groups with population shares n_i, n_j, and inter-group distance equal to b_{ij}, Esteban and Ray (2008)'s generalized polarization measure is given by:

[7]Table 10 in Appendix B presents the same rankings excluding counties with a population less than 1,000 and weighting observations by county population.

$$P(\sigma, \mathbf{b}) = \sum_i \sum_{j \neq i} n_i^{1+\sigma} n_j b_{ij} \tag{1}$$

Where σ is a positive parameter capturing the extent of inter-group identification. Esteban and Ray (2008) show that—in order to facilitate computation—it is convenient to work with a special class of polarization indices, namely:

$$P(1,1) = \sum_i n_i^2 (1 - n_i) \tag{2}$$

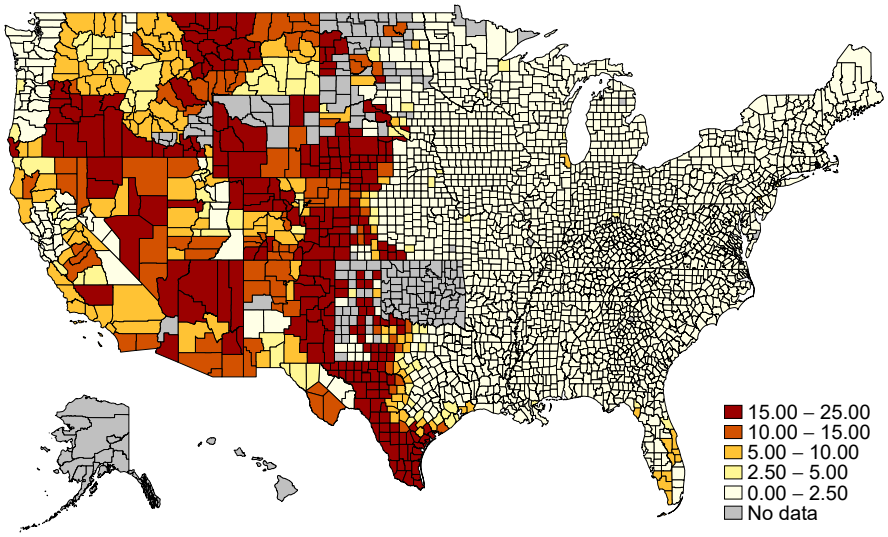
$P(1,1)$ is maximized when the population is concentrated in two equal sized groups. In the present case, I am interested in conflict between two groups only: cattlemen and farmers. Thus, the agricultural polarization index takes a theoretical maximum of 0.25 in a county where agricultural land-use is equally divided between cattle raising and farming and falls to a minimum of 0 in a county where agriculture is either entirely dominated by cattle raising or entirely dominated by farming.[8] To estimate the agricultural land-use shares, I construct the share of working-aged (18 to 54) men in agricultural occupations who list either farming-related occupations or cattle raising-related occupations using data from the full count Census.[9] Figure 4 maps the agricultural polarization index across counties for the year 1880. For ease of interpretation, the index is scaled by 100. For most Eastern counties, the index is near-zero, reflecting the relative absence of cattlemen and stock herders in the region. In contrast, various Western counties approach the theoretical maximum value for the polarization index, indicating the potential for conflicting claims over land-use. Comparison of the spatial distribution of agricultural polarization in Figure 4 with that of violent mortality in 2 offers *prima facie* evidence of a positive relationship.

Fencing Costs. Data on county-level fencing costs are obtained from Haines (2010). In particular, the 1880 Census contains data on the total cost of building and repairing fences in each U.S. county.

[8] Because I calculate the population shares as a share of persons in agricultural occupations (rather than as a share of the total county population) for cattle raising and farming-related occupations, the polarization index is undefined for counties with no persons in agricultural occupations.

[9] Cattle raising-related occupations include "Stock-drovers," "Stock-herders," "Stock-raisers," and "Traders and dealers in livestock." Farming-related occupations include "Agricultural laborers," "Apiarists," "Dairymen and dairywomen," "Farm and plantation overseers," "Farmers and planters," "Florists," "Gardeners, nurserymen, and vine-growers," Turpentine farmers and laborers," "Others in agriculture," and, "Traders and dealers in agricultural implements."

Figure 4: County-level Agricultural Polarization Index, 1880



Notes: Figure maps the Esteban and Ray (2008, 2011) polarization index for agricultural occupations across counties for the year 1880. Occupational shares measured as the share of persons in agricultural occupations in either farming-related occupations or cattle raising-related occupations.

To construct a measure of unit fence prices, I divide the total cost of building and repairing fences in each county by by the number of acres of land in farms to arrive at an estimate of fencing costs per acre[10]. Because data on the total cost of building and repairing fences is not collected in other Census years, the estimate of fencing costs per acre is limited to the 1880 sample.

In his study of the effect of barbed wire on agricultural development, Hornbeck (2010) eschews direct measurement of fencing costs for a proxy measure of local access to fencing materials. In particular, Hornbeck (2010) uses the number of acres of woodland in farms in 1880 as a share of total county acreage as an indirect measure of fencing costs. Intuitively, if fencing construction materials were limited to what was locally available in the era prior to the widespread adoption of barbed wire, then the relative scarcity of the wood necessary for fence construction should be positively related to local fencing costs. Thus, I also obtain data on woodland in farms in 1880 as a

[10]Because the 1880 Census measures the cost of *building* and repairing fences, this variable is a measure of the price of *new* fencing (and fence repairs) divided by *total* aces of farmland in 1880. A more precise estimate of fence prices would include only newly fenced acreage in the denominator (rather than all acreage). This discrepancy explains the difference in the estimate of average fence prices in 1880 presented here (approximately \$0.28/acre) and the estimate presented by Primack (1969) (approximately \$3/acre). The latter accounts for the value of all installed fencing (divided by total fenced acreage). That is, Primack (1969)'s estimate is an estimate is a *stock* measure of the value of existing fencing stock, whereas the estimate presented here is a *flow* measure of the cost of new construction. Using Primack (1969)'s estimates of the change in the total cost of fencing between 1870 and 1880 and the change in total rods of fencing over the same period, the implied price of new fencing per acre of newly cultivated farmland is approximately \$1.37.

share of total county acreage from Haines (2010).

Additional County Characteristics. I obtain additional county-level characteristics from either Haines (2010) or the IPUMS full count decennial Census (Ruggles et al., 2025). I restrict the IPUMS sample to working-aged men (18 to 54). As data on wages were not collected by the Census until 1940, I follow the convention in the economic history literature and use occupational income scores as a measure of average county-level income (Abramitzky et al., 2014; Tabellini, 2020; Ferrara and Testa, 2023). Occupational income scores assign an individual the median income of their occupation in 1950 and are often interpreted as a measure of permanent income. Other county-level variables obtained from the Census data include literacy rates, racial composition, and labor force participation. From Haines (2010), I obtain data on the number of county-level manufacturing establishments and population density (persons per sq. mile), both for the year 1880. Summary statistics for all variables are presented in Table 3.

Table 3: Summary Statistics

	Mean	Std. Dev.	*N*	Source
Violent Mortality Rate	.45	2.24	9,412	Hacker et al. (2024a)
Infectious Disease Mortality Rate	4.06	2.97	9,412	Hacker et al. (2024a)
Agriculture Polarization Index	.02	.049	10,636	Ruggles et al. (2025)
Farming Occupation Share	.55	.25	10,656	Ruggles et al. (2025)
Cattle Raising Occupation Share	.01	.06	10,656	Ruggles et al. (2025)
Population	3,090	7,788	10,667	Ruggles et al. (2025)
Occupational Income Score	18.33	3.19	10,656	Ruggles et al. (2025)
Literacy Rate	.81	.19	10,667	Ruggles et al. (2025)
Not in Labor Force	.12	.12	10,667	Ruggles et al. (2025)
White Share	.89	.20	10,667	Ruggles et al. (2025)
Black Share	.08	.16	10,667	Ruggles et al. (2025)
Hispanic Share	.03	.12	10,667	Ruggles et al. (2025)
Total Fencing Cost, 1880	$26,679	$28,922	2,921	Haines (2010)
Fencing Cost per Acre, 1880	$0.28	$1.92	2,850	Haines (2010)
Woodland Area Share, 1880	.20	.19	2,921	Haines (2010)
Mfg. Establishments (per 1,000), 1880	3.15	2.65	2,921	Haines (2010)
Population Density (per sq. mi.), 1880	72	1,212	2,921	Haines (2010)

Notes: Table presents summary statistics for all key variables. Mortality rate data obtained from full count US Censuses of Mortality (Hacker et al., 2024a). County-level economic characteristics obtained from the IPUMS full count decennial Census (Ruggles et al., 2025). Data on fencing costs and woodland acreage in 1880 obtained from Haines (2010). County-level characteristics (including population, racial composition, literacy rate, labor force participation, and occupational income scores) calculated from the working-aged (18-54) male population in each county.

3.2 Estimation Strategy

To explore the potential influence of conflicting claims over land-use on violent mortality, I estimate the following regression:

$$Ln(Mortality_{it}) = \beta_0 + \beta_1 Polarization_{it} + \mathbf{X}_{it}^T \alpha + \gamma_i + \delta_t + \epsilon_{it} \tag{3}$$

Where $Ln(Mortality_{it})$ is the natural log of the violent mortality rate in county i in year t[11], $Polarization_{it}$ is the county-level agricultural polarization index, constructed following Esteban and Ray (2008, 2011), $\mathbf{X}_{it}$ is a vector of county-level characteristics, γ_i is a county-fixed effect, δ_t is a year-fixed effect, and ϵ_{it} is an idiosyncratic error term. Inclusion of county-fixed effects captures any unobserved time-invariant county-specific heterogeneity influencing the relationship between polarization and mortality, year-fixed effects capture any time-specific shocks common to all counties. I also estimate additional specifications including state-by-year fixed-effects and county population weights. Finally, I validate the estimated effect of conflicting claims over land use on violent mortality using a placebo specification in which the infectious disease mortality rate is used as the dependent variable. Intuitively, if the effect of agricultural polarization on mortality is driven primarily by increases in violent conflict between persons engaged in settled agriculture and persons engaged in cattle raising, then an increase in agricultural polarization should have no impact on other, non-violent sources of mortality.

To interrogate the role of incomplete property rights in driving violent conflict, I estimate the following specification relating fence prices to violent mortality in 1880:

$$Ln(Mortality_i) = \beta_0 + \beta_1 FencePrices_i + \mathbf{X}_i^T \alpha + \eta_s + \delta_t + \epsilon_i \tag{4}$$

Where $FencePrices_i$ is the cost of building and repairing fences per acre of farmland in county i in 1880, η_s is a state-fixed effect, and all other variables are defined as before. In addition to estimating equation 4 using the infectious disease placebo, I address concerns about potential endogeneity in the fence price-mortality relationship using an instrumental variables specification. In particular, I use the county woodland area share to instrument for fence prices. Following the

[11] To admit counties with zero values for the mortality rate, in practice I apply the inverse hyperbolic sine transformation, rather than than the natural log transformation.

logic of Hornbeck (2010), prior to the widespread adoption of barbed wire the cost of installing new fencing was inversely related to the prevalence of local fencing materials. Thus, counties with significant forest coverage should have reduced fence prices, more installed fencing, and less conflict over land use. In contrast, fence prices should be higher in counties with less woodland area. The identifying assumption of the IV estimator is that county woodland area has no impact on violent mortality *except* via its influence on fence prices.

4 Results

4.1 Agricultural Polarization and Mortality

Table 4: Estimation Results - Agricultural Polarization and Mortality

	(1) Ln(Mortality)	(2) Ln(Mortality)	(3) Ln(Mortality)	(4) Ln(Mortality)	(5) Ln(Mortality)
A: Violent Mortality					
Ag. Polarization	2.159***	2.116***	2.132***	2.153**	1.038**
	(0.680)	(0.787)	(0.782)	(0.872)	(0.515)
N	9,403	9,403	9,403	9,403	9,403
Controls	Y	Y	Y	Y	Y
County FE	N	Y	Y	Y	Y
Year FE	N	N	Y	Y	Y
State × Year FE	N	N	N	Y	Y
Population Weights	N	N	N	N	Y
B: Infectious Disease Mortality					
Ag. Polarization	-0.798	-0.0375	-0.203	0.0459	-1.817
	(0.488)	(1.453)	(1.552)	(1.680)	(1.762)
N	9,403	9,403	9,403	9,403	9,403
Controls	Y	Y	Y	Y	Y
County FE	N	Y	Y	Y	Y
Year FE	N	N	Y	Y	Y
State × Year FE	N	N	N	Y	Y
Population Weights	N	N	N	N	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Agricultural polarization is measured using the Esteban and Ray (2008, 2011) index. The dependent variable is the inverse hyperbolic sine transformation of either the county violent mortality rate or the county infectious disease mortality rate. Control variables include the (log-) county population, (log-) county average occupational income score, the county literacy rate, the Hispanic population share, and the share of the county not in the labor force.

Table 4 presents results from estimating equation 3. Panel A presents results using the county violent mortality rate as the dependent variable. Panel B presents results using the county infectious disease mortality rate as the dependent variable. Column (1) includes control variables but no fixed-effects. Column (2) adds county-fixed effects. Column (3) adds county- and year-fixed effects. Column (4) adds county, year-, and state-by-year fixed-effects. Column (5) adds county-,

year-, and state-by-year fixed-effects and weights observations by the average sample county population. Across all specifications, conflict over agricultural land-use—captured by the Esteban and Ray (2008, 2011) agricultural polarization index—is significantly positively related to violent mortality. In particular, the results in Columns (1)-(4) suggest that a county going from complete specialization (agricultural employment entirely devoted to either farming or cattle raising) to complete polarization (agricultural employment equally divided between cattle raising and farming) experiences an approximately 50% increase in violent mortality. The result in Column (5), which weights observations by the average sample population for each county, is reduced but nonetheless remains statistically and economically significant. Column (5) suggests that moving from complete specialization to complete polarization increases violent mortality by approximately 25%.

In contrast to the results for violent mortality, the results from the placebo test presented in Panel B suggests there is no effect of agricultural polarization on infectious disease mortality. In every specification, the regression coefficient on agricultural polarization is statistically insignificant, suggesting that conflict over land-use has no impact on infectious disease mortality. Intuitively, the estimated effect on infectious disease mortality *should* be statistically insignificant if the primary effect of incomplete property rights is to increase violence in the presence of conflicting claims over land-use. Incomplete property to rights to agricultural land should exert no impact on infectious disease mortality if conflict over land-use is the primary mechanism linking incomplete property rights to mortality. The results presented in Panel B of 4 are consistent with this logic.

4.2 Fence Prices and Mortality

Table 5 presents results from estimating equation 4 via ordinary least squares. Column (1) and Column (2) present results for violent mortality, Column (3) and Column (4) present results for infectious disease mortality. Column (1) and Column (3) present results in levels for both the mortality rate and fence prices, Column (2) and Column (4) present results in logs. Observations are weighted by the 1880 county population. Each column includes a vector of county controls and state-fixed effects. Table 5 suggests that higher fence prices are associated with higher rates of violent mortality. In particular, Column (1) suggests a $1 increase in per-acre fencing costs increases the violent mortality rate by 0.12 persons per 1,000 (a nearly 25% increase relative to the sample mean). The regression coefficient in Column (2)—which takes the form of an elasticity—suggests

Table 5: Estimation Results - 1880 Fence Prices and Mortality, OLS

	(1) Violent Mortality	(2) Ln(Violent)	(3) Disease Mortality	(4) Ln(Disease)
$\frac{FenceCosts}{Acre}$	0.120***		0.12	
	(0.0315)		(0.148)	
$Ln(\frac{FenceCosts}{Acre})$		0.151***		0.0167
		(0.037)		(0.0687)
N	2,649	2,649	2,649	2,649
Controls	Y	Y	Y	Y
Pop. Weights	Y	Y	Y	Y
State FE	Y	Y	Y	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is either the county violent mortality rate or the county infectious disease mortality rate for 1880. Fencing costs measured as the total cost of building and repairing fences from the 1880 Census. Each specification includes controls for the (log-) county population, the (log-) average occupational income score, (log-) population density, the county literacy rate, the county Hispanic population share, the share of the county population not in the labor force, and the number of manufacturing establishments in the county.

that a 10% increase in county fence prices increases violent mortality by approximately 1.5%. In contrast, the results from the placebo test presented in Column (3) and Column (4) suggest that fence prices exert no impact on infectious disease mortality. Consistent with the logic of this paper, if fence prices impact mortality via their influence on property rights enforcement, there should be no relationship between fence prices and infectious disease mortality.

To address concerns about possible endogeneity in the fence price-mortality relationship, Table 6 presents results from an instrumental variables specification wherein fence prices are instrumented with the county woodland area share. For an instrumental variable to be valid it must be both highly correlated with the endogenous variable of interest and orthogonal to the regression error term. As a test for weak instruments, Staiger and Stock (1997) suggest a conventional rule of thumb that the first-stage F-statistic must exceed 10. In each specification presented in Table 6 the first-stage F-statistic exceeds this threshold. As an additional check on instrument strength, I report Anderson-Rubin weak-instrument robust confidence intervals for the second-stage regression coefficient. The Anderson-Rubin weak instrument robust confidence interval is constructed based on the AR statistic defined by Anderson and Rubin (1949). Anderson-Rubin weak instrument robust confidence intervals are constructed via test inversion. Specifically, for a test of size α of the hypothesis $\beta = \beta_0$ one can construct a $1 - \alpha$ confidence interval for the

Table 6: Estimation Results - 1880 Fence Prices and Mortality, IV

	(1) Violent Mortality	(2) Ln(Violent)	(3) Disease Mortality	(4) Ln(Disease)
$\frac{FenceCosts}{Acre}$	0.219**		0.228	
	(0.0847)		(0.386)	
$Ln(\frac{FenceCosts}{Acre})$		0.253***		-0.0121
		(0.0869)		(0.123)
First-Stage Results				
Ln(Woodland)	-0.18***	-0.11***	-0.18***	-0.11***
	(0.05)	(0.03)	(0.05)	(0.03)
First-Stage F-Statistic	11.31	12.43	11.31	12.43
AR Weak-IV Robust CI	[0.05, 0.82]	[0.07, 0.76]	[-0.67, 2.33]	[-0.44, 0.33]
N	2,649	2,649	2,649	2,649
Controls	Y	Y	Y	Y
Pop. Weights	Y	Y	Y	Y
State FE	Y	Y	Y	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is either the county violent mortality rate or the county infectious disease mortality rate for 1880. In each specification, the county woodland area share is used as an instrumental variable for per-acre county fencing costs. Fencing costs measured as the total cost of building and repairing fences from the 1880 Census. Each specification includes controls for the (log-) county population, the (log-) average occupational income score, (log-) population density, the county literacy rate, the county Hispanic population share, the share of the county population not in the labor force, and the number of manufacturing establishments in the county.

value of β as the set of all non-rejected values of $\beta = \beta_0$.[12] In each case the AR weak-instrument robust confidence interval presented in Table 6 for the effect of fence prices on violent mortality is strictly positive, suggesting that the estimated positive effect of fence prices on mortality is not driven by weakness in the instrument.

Although a direct test of the exclusion restriction is not possible in the current context, in Appendix C I present additional results from the "plausibly exogenous" estimator of Conley et al. (2012). Specifically, Conley et al. (2012) provide a method for constructing confidence intervals in an instrumental variables setting that are robust to violations of the exclusion restriction. The results in Appendix C suggest that the confidence interval for the second-stage coefficient remains strictly positive even under large violations of the exclusion restriction (as large as the estimated reduced-form effect of the woodland area share on mortality), indicating that the estimated effect is robust to a substantial degree of instrument endogeneity.

Given one believes the instruments are both sufficiently strong and satisfy the exclusion restriction, the results in Table 6 suggest that more expensive property rights enforcement—captured by higher per-acre fencing costs—is associated with higher rates of violent mortality. The first-stage regression coefficient is negative and statistically significant, suggesting that—as expected—a larger woodland area share reduces fence prices in the pre-barbed wire era. The estimated IV coefficients are nearly double the OLS coefficients. Column (1) of Table 6 suggests a \$1 increase in per-acre fencing costs increases the violent mortality rate by approximately 0.22 persons per 1,000 (an approximately 50% increase, relative to the sample average). Column (2) suggests that a 10% increase in fence prices increases violent mortality by approximately 2.5%. In contrast, the estimated effect of fence prices on infectious disease mortality remains statistically insignificant. The regression coefficients in Column (3) and Column (4) are statistically insignificant (and the estimated coefficient in Column (4) is close in magnitude to zero). In contrast to those estimated for Column (1) and Column (2) (which are strictly positive), the Anderson-Rubin weak-IV robust confidence intervals for Column (3) and Column (4) are wide and encompass zero. Taken together, the results presented in Table 6 strongly support the hypothesis that incomplete property rights enforcement—captured by higher per-acre fencing costs—was a significant driver of violence on

[12] Importantly, Andrews et al. (2019) note that test inversion is particularly useful in a weak instruments context, because the IV parameter β implies restrictions on the distribution of the data that hold whether or not the instruments are weak. See Andrews et al. (2019) for a more complete discussion of weak instruments.

the frontier in the 19th century.

4.3 Robustness Check: Small Population Counties

Although the application of population weights to observations in the regressions that produce the coefficients presented in Table 6 should—to a large extent—address concerns about bias stemming from outlier counties with small populations, there may nonetheless still be concern that the results are driven by the so-called "small-numbers fallacy." Thus, Table 7 presents estimates from additional specifications excluding counties with less than 1,000 persons. The results in Table 7 remain positive and statistically significant, suggesting the positive relationship between the cost of property rights enforcement and mortality found in Table 6 is not driven primarily by counties with an exceptionally small population.

Table 7: Estimation Results - Excluding Small Population Counties (≤ 1,000 persons)

	(1)	(2)	(3)	(4)
	OLS		IV	
	Violent Mortality	Ln(Violent)	Violent Mortality	Ln(Violent)
$\frac{FenceCosts}{Acre}$	0.0932***		0.162**	
	(0.0314)		(0.0661)	
$Ln(\frac{FenceCosts}{Acre})$		0.133***		0.202***
		(0.0318)		(0.0729)
N	2,419	2,419	2,419	2,419
Controls	Y	Y	Y	Y
Pop. Weights	Y	Y	Y	Y
State FE	Y	Y	Y	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the county violent mortality rate for 1880. In Column (3) and Column (4), the county woodland area share is used as an instrumental variable for per-acre county fencing costs. Fencing costs measured as the total cost of building and repairing fences from the 1880 Census. Each specification includes controls for the (log-) county population, the (log-) average occupational income score, (log-) population density, the county literacy rate, the county Hispanic population share, the share of the county population not in the labor force, and the number of manufacturing establishments in the county.

4.4 Robustness Check: Violence-Polarization Interaction

If violent mortality is driven by conflicting claims over land-use in the presence of incomplete property rights enforcement, then the effect of fence prices on violent mortality should be larger in counties with a greater degree of agricultural polarization (i.e., a greater degree of conflict over

land-use). Table 8 presents results from three alternative specifications that test whether fence prices have a larger impact on violent mortality in counties with a high degree of agricultural polarization. Column (1) presents results from an OLS specification including an interaction term between the agricultural polarization index and fence prices. Column (2) presents results from an OLS specification that restricts the sample to counties in the top decline of agricultural polarization. Column (3) presents results from an IV specification that restricts the sample to counties in the top decline of agricultural polarization.

Table 8: Estimation Results - Violence-Polarization Interaction

	(1) Polarization Interaction	(2) Polarization Top Decile (OLS)	(3) Polarization Top Decile (IV)
	Ln(Violent)	Ln(Violent)	Ln(Violent)
$Ln(\frac{FenceCosts}{Acre})$	0.118***	0.387**	0.656*
	(0.0334)	(0.161)	(0.326)
Ag. Polarization	0.370		
	(0.371)		
$Ln(\frac{FenceCosts}{Acre}) \times$ Ag. Polarization	1.284**		
	(0.564)		
N	2,648	317	317
Controls	Y	Y	Y
Pop. Weights	Y	Y	Y
State FE	Y	Y	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the county violent mortality rate for 1880. In Column (2) and Column (3) the sample is restricted to counties in the top decile of agricultural polarization. In Column (3), the county woodland area share is used as an instrumental variable for per-acre county fencing costs. Fencing costs measured as the total cost of building and repairing fences from the 1880 Census. Each specification includes controls for the (log-) county population, the (log-) average occupational income score, (log-) population density, the county literacy rate, the county Hispanic population share, the share of the county population not in the labor force, and the number of manufacturing establishments in the county.

In each specification presented in Table 8, the effect of fence prices on violent mortality is intensified in counties with a greater degree of conflict over agricultural land-use. In Column (1), the interaction term between per-acre fencing costs and agricultural polarization is statistically and economically significant. The results in Column (1) suggest that a 10% increase in per-acre fencing costs increases the violent mortality rate by approximately 1.2% in a county with complete specialization, whereas a 10% increase in per-acre fencing costs increases the violent mortality rate by approximately 4.4% in a county with complete polarization. That is, the elasticity of violent

mortality to fence prices is nearly three times as large in a county with complete agricultural polarization compared to a county with complete agricultural specialization. Alternatively, one could interpret the results in Column (1) as indicating that when fencing costs per-acre are zero (such that there is perfect property rights enforcement), agricultural polarization has no impact on violent mortality.

In Column (2), the OLS estimate of the effect of per-acre fencing costs on violent mortality when the sample is limited to counties in the top decile of agricultural polarization is more than double the OLS estimate for the full sample (Table 5, Column (2)). Similarly, the IV estimate presented in Column (3) is more than double the IV estimate for the full sample (Table 6, Column (2)).[13] For counties in the top decile of agricultural polarization, the IV estimate in Column (3) suggests that a 10% increase in fence prices increases the violent mortality rate by approximately 6.6%. Altogether, the results in Table 8 support the hypothesized mechanism linking competing claims over land-use in the presence of incomplete property rights enforcement to violent conflict.

5 Conclusion

This paper argues that the absence of a low-cost technology for property rights enforcement in the era prior to the widespread adoption of barbed wire fencing contributed to increased rates of violence in the 19th century American West. Using data from the 1850 to 1880 U.S. Censuses of Mortality, I show that (A) violent deaths occurred at a higher frequency in the West relative to the rest of the country, and (B) the increased violent mortality rate can be explained by the elevated cost of property rights enforcement in the face of competing claims over land-use. The link between property rights, land-use conflict, and violence is demonstrated in two ways. First, I show that county-level violent mortality is positively related to an index of agricultural polarization capturing conflict over land-use between cattlemen and farmers. Second, using data on fencing costs per-acre from the 1880 Census, I show than an increase in per-acre fencing costs results in an increase the county violent mortality rate. To address concerns about endogeneity in the fence price-mortality relationship, I instrument for fence prices using the county woodland area share—a measure of the relative local scarcity of natural fencing materials. The findings are supported by a

[13] The standard error is slightly inflated—although the estimate remains statistically significant at the 10% level—likely due to the reduced sample size.

placebo specification showing that fence prices have no impact on infectious disease mortality.

In addition to clarifying the extent of violence in the 19th century American West and highlighting the role of property rights enforcement in mitigating that violence, this paper raises various unanswered questions pertaining to the larger literature in political economy and development economics on the importance of the rule of law. The adoption of barbed wire fencing after 1880 was successful in mitigating violent conflict only insofar as transacting parties accepted the prevailing property rights regime. That is—for property rights to facilitate the allocation of resources through markets, not only must property rights be clearly defined and enforced, but transacting parties must share a mutual commitment to the rule of law. In the absence of mutual commitment to rule of law, it is theoretically possible that technology enabling increased property rights enforcement *increases* violent conflict rather than reducing it (insofar as one or more transacting parties rejects the asserted property rights regime). Thus, important questions for future research concern the institutional basis of the social commitment to the rule of law presumed in any property rights regime and the effect of property rights on violence in a setting where mutual commitment to the rule of law is absent (or declining). This paper suggests that property rights served a dual role on the American frontier: resource allocation and violence suppression. It remains an open question whether they will continue to serve the latter function in a setting where mutual commitment to the rule of law can no longer be taken for granted.

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A Cause of Death Classifications

Table 9 presents the individual causes of death used to construct county-level estimates of violent mortality and infectious disease mortality. To construct the estimate of violent mortality, I include all sources of interpersonal violence as well as various sources of mortality stemming from self-harm (alcoholism, suicide). Although self-harm need not originate *directly* from conflicting claims over property rights, if these conflicting claims contribute to a culture of violence they may result in an increased propensity for self-harm. This broad conception of violent mortality takes inspiration from Case and Deaton (2020)'s concept of "Deaths of Despair," to the extent that self-harm in the West can be understood as a negative response to the pressures created by a cultural context characterized by violence and limited opportunity.

Table 9: Cause of Death Classifications, Violent Mortality and Infectious Disease Mortality, 1850-1880

Violent Causes	Infectious Disease Causes
Death by poison	Typhoid Fever
Firearms	Typhus Fever
Cutting	Smallpox
Homicide by firearms	Measles
Homicide by cutting	Scarlet Fever
Homicide, other	Pertussis
Other acts of violence	Croup, Diphtheria
Alcoholism or related	Influenza
Suicide	Cholera
	Dysentery
	Yellow Fever
	Leprosy
	Erysipelas
	Chicken Pox, Mumps, German Measles (rubella)
	Tuberculosis
	Malaria

Notes: Table lists causes of death for each mortality category from 1850 to 1880. Causes of death are listed as recorded in the U.S. Censuses of Mortality (Hacker et al., 2024a).

B Alternative State Mortality Rankings

To address concerns that the average state mortality rankings presented in Table 2 are driven by counties with small populations, Table 10 presents an alternative set of average state mortality rankings which (A) exclude counties with less than 1,000 persons, and (B) weight the remaining observations by the county population. The rankings presented in Table 10 tell a similar story to those presented in Table 2. Nine of the then states with the highest average county-level violent mortality rate for the period between 1850 and 1880 are states located in the West or the Great Plains, even after dropping the smallest counties and weighting the remaining observations by population. Similarly, infectious disease mortality remains highest in Eastern states (although weighting by population increases the average county-level infectious disease mortality rate for Louisiana, a change likely driven by the city of New Orleans).

Table 10: Population Weighted Average State Mortality Rankings, Top Ten States, 1850-1880, Excluding Counties ≤ 1,000 Persons

State	Violent Mortality	State	Infectious Disease Mortality
1. Arizona	1.62	1. Massachusetts	6.88
2. Nevada	1.00	2. District of Columbia	6.72
3. Wyoming	0.93	3. Rhode Island	6.62
4. Montana	0.92	4. Louisiana	6.25
5. California	0.70	5. Missouri	5.82
6. Idaho	0.66	6. Maine	5.78
7. Louisiana	0.49	7. Kansas	5.77
8. Colorado	0.47	8. Nebraska	5.67
9. Washington	0.43	9. New Hampshire	5.61
10. South Dakota	0.42	10. New York	5.48

Notes: Table 10 presents state mortality rankings for the period 1850-1880, excluding counties with a population less than 1,000. Table 10 includes the top ten states for violent mortality and the top ten states for infectious disease mortality. Mortality rates calculated as the average mortality rate across counties within a state for the 1850 to 1880 period. County-level mortality rates calculated as total deaths between 1850 and 1880 divided by total population (measured in thousands of persons) for the same period.

C Conley et al. (2012) Plausibly Exogenous Estimator

Conley et al. (2012) present a method for bounding instrumental variables estimates in the presence of violations of the exclusion restriction. Conley et al. (2012) assume the instrumental variable, Z, may have a direct effect, γ, on the variable of interest, Y. In this context, Conley et al. (2012) show that one can derive bounds on the instrumental variables parameter of interest, β, if one knows the support of γ by taking taking a union of γ-specific confidence intervals.[14] To implement the Conley et al. (2012) estimator, I first estimate a reduced-form regression of violent mortality on the instrumental variable and controls. I then follow Azar et al. (2022) and Petach (2024) in assuming the value of γ is bounded between zero and the reduced-form effect of the instrument.

Table 11 presents the results obtained from the Conley et al. (2012) estimator. $\gamma_{woodland}$ is the reduced-form effect of the woodland area share instrument. $\overline{\gamma}$ is the approximate largest (negative) value of γ such that the entire confidence interval for β remains above zero.[15] In both Column (1) and Column (2), the estimated confidence interval for β is strictly positive, suggesting that the IV estimate is robust to violations of the exclusion restriction up to the reduced-form value of γ.

[14] Specifically, Conley et al. (2012) show that one can obtain bounds on β by estimating the model $(Y - Z\gamma_0) = X\beta + \epsilon$ via two-stage least-squares using the transformed dependent variable $(Y - Z\gamma_0)$. The bounds on β are given by the union of all confidence intervals obtained for $\gamma \in [\gamma_{min}, \gamma_{max}]$.

[15] I find this value via grid search, incrementing the value of γ by 0.25 until the lower-bound for β crosses zero.

Table 11: Estimation Results — Conley et al. (2012) Plausibly Exogenous Estimator

	(1) Violent Mortality	(2) Ln(Violent)
Reduced-Form Effect		
$\gamma_{woodland}$	-0.04***	-0.0276***
	(0.0102)	(0.00692)
Conley et al. (2012) Bounds		
β (lower bound)	0.09	0.03
β (upper bound)	0.54	0.52
$\overline{\gamma}$	-0.06	-0.03
N	2,649	2,649
Controls	Y	Y
State FE	Y	Y
Pop. Weights	Y	Y

Notes: Standard errors in parenthesis, clustered at the state-level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The reported $\gamma_{woodland}$ coefficients represent the reduced-form effect of the woodland area share instrument on violent mortality. I use the reported values of $\gamma_{woodland}$ as the lower-bound estimate for γ and zero as the upper-bound estimate. The reported bounds for β are obtained by applying the plausibly exogenous method of Conley et al. (2012) via the `plausexog` command in Stata.

For both the *level* of the mortality rate and the log mortality rate, the largest value of γ for which the confidence interval for β remains positive *exceeds* the estimated reduced-form value of γ.[16] In other words, the effect of the woodland area share on violent mortality through some channel *other* than fence prices would have to exceed the reduced-form estimate of the effect of the woodland area share in order to push the instrumental variables coefficient below zero: a seemingly unlikely result.

[16] i.e., is of a greater negative magnitude than.