Fence Laws: Liability Rules and Agricultural Development

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Abstract

This paper uses the evolution of fence laws in the American West to show that liability assignment can influence resource allocation and productivity. Local fence laws assign animal trespassing liability to either farmers or livestock owners. I compiled a dataset documenting all county-level fence law changes from the earliest legislative session to 1930 for eight states on the Great Plains. I compare adjacent counties with different fence laws to identify the causal effect of liability assignment on agricultural development. Results show that liability assignments had persistent effects on land use, value of output, and settlement patterns. Shifting the liability from farmers to livestock owners increased acreage in farmland, investment in machinery, and grain production. These effects were driven by an increase in total land used for agricultural production, with no detectable impact on average productivity. On the other hand, increasing farmers' liability shifted the composition of new settlement by reducing the share of land acquired through cash purchase, while it had no effect on homestead.

JEL Classifications: K11, D23, N41, N51, Q15

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1 Introduction

In his seminal article, Coase (1960) uses an example between a farmer and a cattle-raiser adjacent to each other to illustrate that the assignment of property damage liability does not affect the allocation of resources. Cattle may stray and destroy the crops on the farmer's land. Regardless of whether the farmer or the cattle-raiser is legally liable for the trespassing damage, the land allocation between the two types of production should reach the same equilibrium, as long as the liability is well-defined and enforced, and the transaction is costless. Coase' argument has since inspired a series of theoretical (Cheung, 1970; Demsetz, 1964) and empirical research (Besley, 1995; Alston, Libecap, and Schneider, 1996; Libecap, 2007) on property rights regulations. However, despite the wide application, most research focuses on the effect of establishing and enforcing property rights. Few empirical works study how the assignment of property damage liability may influence resource allocation.

This paper uses the historical evolution of fence laws in the American West to analyze the long-term effect of liability rules on resource allocation and productivity. Under the "fence-out" rule, farmers (crop growers) can claim damage from owners of the trespassing animals *only if* they have enclosed the land with fences that satisfy specific regulatory requirements, such as materials used, height and width, etc. Meanwhile, under the "fence-in" rule, livestock owners are liable for trespassing damages *regardless* of whether the farms are enclosed with fences. In other words, the liability for livestock trespassing is assigned to farmers in some areas and livestock owners in others. Ranchers and farmers have long contested fence regulations. Prolonged public debates and occasional violent conflicts between farmers and ranchers suggest that this supposedly innocuous rule had profound economic implications.

I compiled data on all county-level fence law changes from the first state (or territorial) legislature until 1930, covering eight states on the "Great Plains".[1] To the best of my knowledge, this is the first dataset that fully captures the legal environment on property rights protection during this period. I combine the fence law data with the decennial censuses and land patents from the Bureau of Land Management to quantify the effects of fence laws on settlement, land use, and productivity over the past century.

The empirical strategy measures the effects of liability rules by comparing adjacent counties that had the same regulation but only one county changed the liability rule afterwards. Adjacent counties on the Plains have similar natural endowments but may be subject to different fence laws over time. The main identification challenge is that all the counties were subject to some type of fence law, and counties switched back and forth between different fence laws. Therefore, I define the treatment in terms of the direction of fence law *changes*: a county either shifted the liability from farmers to ranchers, or the other way around. By comparing adjacent counties that started off with the same regulation, but only one experienced a fence law change, I can plausibly identify the causal effects of the liability regulation on agricultural production.

[1]The "Great Plains" is referred to the areas located west of the Mississippi River and east of the Rocky Mountains. In this paper, the 8 Plain states include CO, IA, KS, MN, ND, NE, NM, SD.

The results indicate that increasing rancher's liability increased agriculture land use. On the extensive margin, shifting liability from farmers to ranchers increased the share of land area in farmland by 5.2 percent. Almost all the changes were driven by the increase in improved land. Meanwhile, the effects were not symmetric: for counties that shifted the liability from farmers to ranchers, the share of farmland did not change. Shifting liabilities also had no long-term effects on farm size or population density.

The changes in production decisions translated to changes in product values. The total value of farm products was 15% higher for counties that increased ranchers' liability. This increase is driven primarily by the expansion of production (farmland acreage). There was no changes in average productivity, and thus no changes in land value.

Finally, I use the land patent data from the Bureau of Land Management to estimate whether fence laws shifted the composition of settlement, in particular between homesteaders and cash purchases. Results show that increasing farmers' liability discouraged cash purchases: counties that shifted the liability from ranchers to farmers saw a smaller share of land acquired through cash purchase, and the plots that were acquired in cash also became smaller. Meanwhile, increasing ranchers liability did not affect the fraction of land acquired by homesteaders or size of the homestead plots.

This paper contributes to the growing literature on the role of property rights in economic development (Anderson and Hill, 2004; Besley and Ghatak, 2010; Edwards, Fiszbein, and Libecap, 2022), and more broadly, the long-term influence of legal frameworks on economic outcomes (La Porta, Lopez-de Silanes, and Shleifer, 2008; Acemoglu, Johnson, and Robinson, 2005). Default liability assignments imposed a high cost on one party while prohibiting private agents from negotiating and entering into alternative arrangements. It created high transaction costs, which are the usual sources of inefficiency and welfare loss (Demsetz, 1968). The historical case from the US frontier development suggests that the liability rules may distort resource allocation. More importantly, the results suggest that the effects are not symmetric, suggesting that better designed policies can increase total welfare.

By highlighting the effects of liability rules, this paper also contributes to contemporary policy discussions on property rights and liability assignments (Posner, 2005; Hazlett and Muñoz, 2009; Greenwood and Ingene, 1978). Many current policies still default property protection and damage liability to specific parties. The fence law example also suggests that regulations that determine liability rules are likely to cause sub-optimal outcomes.

I also contribute to a large literature on fence laws and agricultural development in the US. Fence laws have long been a contentious policy issue in the US (Sanchez and Nugent, 2000; Vogel, 1987). Many prairie farmers supported the fence law changes that held livestock owners responsible for trespassing damages (Bogue, 1963).[2] Empirical work using data from the Southern states suggests that fence laws that make stock owners liable for damages can significantly

[2]Ellickson (1991) found that in the 1990s, farmers and ranchers in California may appeal more to social norms rather than formal legal rules to resolve conflicts over property rights.

increase farm values and crop production (King, 1982; Kantor, 1998). Similarly, by drastically reducing the cost of protecting the land, the barbed wire also increased settlement, land value, and productivity (Hornbeck, 2010). This paper is the first to document the evolution of local fence law changes over the long run. The empirical strategy provides clear identification of the causal relationship between the fence laws and long-term development.

Finally, my findings also contribute to the literature on the development and evolution of wealth in the American West. Past research highlight the persistent impact of the initial land allocation of land, in particular the Homestead Act (Mattheis and Raz, 2019), the effects of railroad grants (Smith, 2020) and other regional policy variations (Bleakley and Ferrie, 2014). By highlighting the effects of fence laws on long-term development, I show that in addition to the initial land allocation, other policies that affect property owners' liabilities can also have persistent welfare implications.

The rest of the paper is organized as follows. 2 reviews the evolution of fence laws in the western states and documents historical accounts of how the laws affected farmers and livestock owners. 3 provides a stylized model to motivate the empirical analysis. 4 describes the county-level fence law data and provides descriptive evidence on the impact of fence laws. 5 develops the empirical strategy and 6 presents the main results. 7 concludes.

2 Historical Background: Fence Laws on the Great Plains

Legislatures and courts used fence laws to establish liability rules and resolve conflicts between farmers and livestock owners. Some required farmers to enclose their land and allow livestock to run at large; others made livestock owners liable for all trespassing damages while farmers could leave their land unfenced. On the Great Plains, conflicts over fence laws arose as the settlement expanded west and the agricultural land moved closer to the open range for livestock (Webb, 1959; Hayter, 1963; Bennett and Abbott, 2017). Local fence laws changed over time. As a result, adjacent counties can have different fence laws, assigning the damage liability to farmers or livestock owners, which may also vary by type of animal, season, or even time of the day.

2.1 Three Types of Fence Laws

I classify the fence laws into three main groups, depending on the assignment of trespassing liability. To attract settlers to the frontier, early regulations on the Plains usually required farmers to enclose their land against trespassing livestock.[3] As the frontier expanded westward and the agricultural land pushed closer to grazing ground, conflicts between farmers and livestock owners increased. The growing agricultural interest started to push for fence laws that would impose the liability on livestock owners and thus relieve them from the high cost of fencing the land (Kawashima, 1994). Therefore, counties either (1) required livestock owners to restrain their

[3]This is not unique to the western frontier. For example, colonial law in Virginia and Georgia required land owners to fence their crops, while cattle and hogs were allowed to roam freely. See Kantor (1994) and Kawashima (1994).

animals, (2) or required farmers to enclose their land, or (3) assigned the liability to either party under different scenarios.

***Fence-in* by livestock owners:** Under the fence-in rule, livestock owners were liable for animal trespassing. Farmers could claim damages regardless of whether the land was enclosed by fences. It prohibited animals from roaming freely, so owners needed to restrain their animals, either with fences or by herding the animals. Because the fence-in rule assigned the liability to livestock owners, it was also known as "herd law" or "stock law". For example, the 1873 law for Nobles County, Minnesota[4] stated that:

> Section 1. It shall be unlawful for any person or persons to allow any cattle, sheep, swine, or other domestic animals [...] to run at large upon any public highway or upon the lands of any other person or persons in the county of Nobles and state of Minnesota, during any season of the year, unless they be carefully herded.
>
> Section 2. Any person or persons who shall violate or neglect the provisions of the first section of this act shall be liable for all damages that may ensue in consequence of the trespass of such animal or animals.

***Fence-out* by farmers:** Under the fence-out rule, farmers could claim trespass damage only if a lawful fence enclosed the land to keep animals out of the farm. The provision usually had specific criteria regarding what constitutes a "lawful fence". For farmers to claim damage, they must build a fence up to the standard specified in the law. Though this does not require or force farmers to build a fence, farmers could not recover any damage without a fence. Meanwhile, the fence-out law allows livestock can run at large and roam freely in the open range. In 1859, the Territory of Kansas adopted the following fence-out requirement:[5]

> Section 1. All fields and inclosures shall be inclosed with a fence, composed of posts and rails, posts and palings, posts and planks or palisades, rails alone, laid up in the manner commonly called a worm fence, or of turf, with ditches on each side, or a hedge, composed either of thorn or Osage orange.
>
> Section. 2. All such fences [...] shall be at least four feet and a half high; the lower rail shall not be more than two feet from the ground; those composed of turf shall be at least four feet high, and trenches on either side, at least three feet wide at the top and three feet deep; and what is commonly called a worm fence shall be at least five feet high to the top of the rider [...] and a fence composed of hedge shall be of such hight and thickness as will be sufficient to

[4] "An Act to Prevent the Running at Large of Cattle or Other Domestic Animals within the County of Nobles", in Special Laws of the State of Minnesota, 15th Session of the State Legislature, Chapter LXV

[5] "An Act Regulating Inclosures", in General Laws of the Territory of Kansas, 5th Session of the Legislative Assembly, Chapter LXXVIII

protect such field or inclosure.

Section 4. If any horse, cattle or other stock shall break into any inclosure, the fence being of the height and sufficiency aforesaid, the owner of such animal shall make reparation to the party injured for the true value of the damages he shall sustain[...]

***Partial* fence requirement:** While the above examples imposed unconditional fence rules that applied to all animals at all times, some regulations limit the regulation to certain time periods or specific species. For example, Iowa passed legislation in 1868[6] making livestock owners liable for trespassing damages done during the nighttime:

> Section 1. That any stock taken in the act of doing damage, between the hours of sunset and sunrise, may be distrained by the person or persons whose property is damaged [...] whether the fences surrounding such property are lawful or otherwise.

Similarly, in 1865, Colorado prohibited stallions, sheep, and hogs from running at large and owners of such animals were liable for damages.[7] Cattle, however, was not subject to the law:

> Section 1. That any person or persons owning or having in charge any stallion or stallions more than one year old, and shall permit the same to run at large, he or they shall be fined in a sum not less than twenty dollars nor more than one hundred dollars for each and every such offense, and any person or persons owning or having in charge sheep, hog or hogs, and shall permit the same to run at large without a herder or pasturer, he or they shall be fined in a sum not less than five nor more than ten dollars for each and every offense, and be responsible for any and all damage which they may commit [...]

Such regulations varied on the specifics, including time of the day, time of the year, or species. I classify such fence laws as "partial". In particular, when the fence law enumerate a list of animals prohibited from running at large, I consider the fence law to be "partial" when the list does not include cattle.

2.2 Enforcement

Fence laws also include enforcement mechanisms to ensure that owners of trespassed land can recover their losses. In most cases, the landowner has a lien on the trespassing livestock until the damages and the costs associated with keeping the animals during the dispute are paid in full. If the owners of the trespassing livestock are unknown or refuse to pay, the owner of the damaged land can sell the livestock at a public auction. When the two parties disagree on specific aspects

[6] "An Act to Protect Crops against the Invasions of Stock", in Acts and Resolutions Passed at the Regular Session of the 12th General Assembly of the State of Iowa, Chapter 144

[7] "An Act to Restrain Sheep, Hogs, and Stallions from Running at Large", in General Laws Passed at the 4th Session of the Legislative Assembly of the Territory of Colorado

of the case, such as whether the enclosure qualifies as a legal fence or the value of the damage, they can request the involvement of fence viewers—usually disinterested third parties or town clerks—to assess the situation. These provisions ensure that most damages can be quickly and easily recovered by allowing landowners to retain and sell the trespassing livestock. While one can always bring the case to a local justice of the peace, most damages and disputes can be resolved without undergoing the lengthy and costly legal process.

For example, in 1859, when Colorado first adopted the fence-out rule, the regulation also included the following provisions:[8]

> "Section 4. When any domestic animal shall break into the enclosure of any person, such person [...] may take up such animal as an estray [...].
>
> Section 5. Such taker-up, before posting or advertising, shall procure from two disinterested persons an examination and assessment of damages, with a certificate of the same incluing reasonable charges for such assessment.
>
> Section 6. The owner shall not be entitled to demand the trespassing animal from such taker-up, unless he proceed [...] to pay costs allowed in the case of estrays, and also damages and the cost of assessment.
>
> Section 7. When a trespassig animal is sold, the taker-up, in addition to the usual costs and allowances in the case of estrays, may retain [...] the damages sustained by such trespass, and the costs of their assessment."

2.3 Supporters for Each Type of Fence Laws

Farmers claim that the fence-out rule discouraged settlement and investment in farmland, as fences were costly to construct and maintain. Public outcry and grievances over fence laws increased as the frontier expanded westward. Policymakers became concerned that the fence-out rule may likely deter future settlement in the west (Department of Agriculture, 1872). Correspondingly, when states tried to change the fence law and shift the liabilities from farmers to livestock owners, they usually cited attracting new settlers and improving farmland as the policy target. In the presidential address at the 1872 Kansas State Agricultural Society, supporters of the fence-in rule claim that:

> "if you were to enact a law which shall enable him to make the improvements desirable [...] without compelling him to inclose his crops with fences, (now so expensive) against his neighbor's stock [...] it would bring to Kansas double, if not quadruple, the immigration that would otherwise come."

Unlike farmers, livestock owners were divided on whether they support the fence-in or fence-out rule. Large ranchers could benefit more from fences, while small livestock owners were more likely to be against the fence-in requirement. While costly, fences can be beneficial to animal

[8] "An Act Concerning Enclosures and Trespassing Animals", in Provisional Laws and Joint Resolutions Passed at the First and Called Sessions of the General Assembly of Jefferson Territory, 1859, Chapter XXIII.

husbandry. Enclosed livestock was less susceptible to contagious diseases. To improve their stock through breeding, ranchers also needed to fence in their herds against inferior bulls. Finally, like farmers, ranchers sometimes cultivated fodder crops to feed their stock and would prefer to have other animals restrained from trespassing their land (White, 1975). Such benefit accrued more to large ranchers, partly because it is more cost-effective to fence a large area. On the other hand, small livestock owners relied more on the open range to support their herds, so the fencing requirement would essentially limit their access to the free prairie land for feed and water.

2.4 Adoption and Evolution

Fence laws varied across counties. The regulations could be adopted either through statewide legislation or at the county level via special provisions. The regulation also evolved over time, exposing adjacent counties to different laws at different points in time. [9]

Statewide vs. County-level Adoption Statewide regulations in principle apply to all the counties, thus switching the whole state from one type of fence law to another overnight. For example, in 1850, Minnesota first adopted a fence-out rule, so livestock owners were not liable for damages unless the land was enclosed with a legal fence. However, by 1865, the state changed to a partial-in rule, making livestock owners liable for trespass damages during the night time, "from eight o'clock in the evening until sunrise", and shall pay for the damages "without regard to the sufficiency of the fences on such lands."

Fence laws can also vary at the county level through two channels. First, the state legislature can adopt a special act or exemptions for specific counties. For example, Colorado was under the fence-out rule since 1859. However, in 1864, the state legislature passed a special act for Douglas and Weld counties, stating that "no person farming or cultivating land within the limits of Douglas and Weld counties shall be required to fence or enclose the same against any stock running at large". In other words, the two counties became fence-in, while the rest of the state remained under fence-out rules. Second, states can allow counties to choose whether to adopt specific fence law provisions, usually through a petition or general elections. Consider the aforementioned partial rule passed in Iowa in 1868. The law also stated that "a majority of the board of supervisors in each organized county in this State shall determine whether the adoption of the provisions of this act shall be submitted to the legal voters of the county at the ensuing the people general election."[10]

Frequent Fence Law Changes in the 19th Century Most fence law changes occurred during the 19th century. Figure 1(a) plots the share of counties with fence law changes each year.[11] For

[9] See Appendix B for detailed texts cited in this section.

[10] "An act to protect crops against the invasions of stock", Acts and Resolutions Passed at the Regular Session of the 12th General Assembly of the State of Iowa, Chapter 114

[11] This accounts for the expansion of the frontier with new counties being incorporated and adopted specific fence laws. See Appendix Figure 6 for the total count over time.

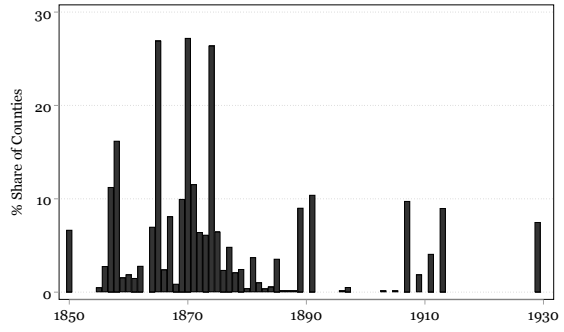
each state (or territory), the first fence law was usually adopted at the first or second legislative session (see Appendix Figure 5). This is consistent with the historical accounts that, as more people settled at the western frontier, a clear legal definition of property damage liability became an essential institutional tool to settle conflicts over property rights (Hayter, 1963).

Shifting Liability from Farmers to Ranchers Most Plain states first established fence-out rules when the frontier was sparsely populated with livestock owners taking advantage of the free grazing land.[12] However, as the frontier expanded west, the high cost of fencing became the main source of discontent of farmers. The farming community pushed for regulatory changes to shift the burden of constructing and maintaining fences to livestock owners. For example, Kansas initially established a fence-out rule in 1855. It shifted to a partial rule, first in 1858 that required hogs to be restrained and then in 1864, making livestock owners liable for all damages done at night. In 1874, when the state legislature allowed each county to adopt local fence laws, 39 percent of the counties immediately switched to the fence-in rule that assigned all trespassing liabilities to livestock owners. The number gradually increased over time, and by 1885, 58 percent of the counties were under the fence-in rule.

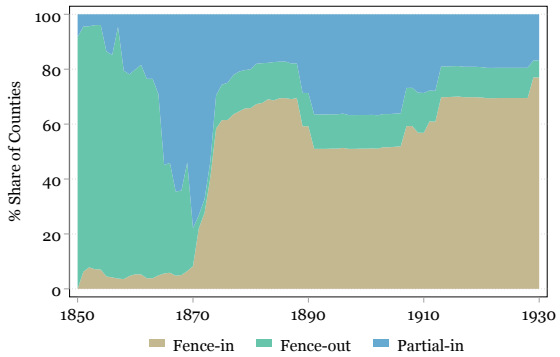
Figure 1(b) plots the share of counties under each type of fence law from 1850 to 1930.[13] Before 1860, most counties were under the fence-out rule that required farmers to enclose their land against trespassing. The fence laws started to shift in farmers' favor as the number of partial rules started to pick up by the early 1860s. The 1870s saw a more drastic change when more counties switched to full fence-in requirements, making ranchers liable for all damages. Fence laws stabilized by the turn of the century, with more than half of the counties settling for the fence-in rule.

Figure 1: Evolution of Fence Laws

(a) Share of Counties with Fence Law Changes



(b) Share of Counties by Types of Fence Law



[12]The only exception is New Mexico, which started with a fence-in rule. See Appendix B for more discussion.
[13]See Appendix Figure 7 for the number of counties under each type of regulation.

2.5 Fence Cost and Barbed Wire

In the 19th century, fencing cost was one of the largest capital investment in agriculture. According to the report to the House of Representatives in 1872, the cost of fences was nearly equal to the total amount of the national debt, or the value of all farm animals in the United States (U.S. House, 1872).

The high fencing cost was one cause for the growing discontent of frontier farmers. The high cost was exacerbated as the frontier moved further into the timber-less prairie where fencing materials were scarce. Historians point out that "the scarcity of timber for fencing and other farm construction prevented whole areas of the prairie from being settled" (Rice, 1937). Crumbling fences could not protect the farm against livestock trespassing. It is not unusual for such devastation to lead to permanent hostility and brutal conflicts between neighbors (Hayter, 1963).

The introduction and wide adoption of barbed wire in 1875 did not resolve all the conflicts over fencing rules, despite that it largely reduced fencing cost, especially in the Great Plains with less timber supply (Hornbeck, 2010). Historical accounts show after the introduction of barbed wire, "there ensued a conflict, violent and sanguinary, between fence men and non-fence men" (Webb, 1959). The increasing conflicts may be driven by the westward expansion of farming: people could now settle in places that were too expensive to fence before barbed wire, thus putting farmers closer to stock raisers in the western states. The conflicts spread throughout the Great Plains, ranging from skirmishes between neighbors to large-scale "fence cutter wars". Local sentiment can be so strong that many did not oppose cutting others' fences and the "lawless element of the fence-cutters were held up in glowing colors"(Hayter, 1939). In addition to the conflicts between farmers and ranchers, other groups were also influenced by the adoption of barbed wire. Cowboys may lose their jobs when a ranch became effectively fenced with barbed wire; small stock owners were unhappy about illegal fences on public land that kept them away from water sources.

It is also worth noting that most fence law changes predated the introduction of barbed wire around 1875. More importantly, the 1870s saw the shift of trespassing liabilities from farmers to livestock owners, as the fence-in requirement that made livestock owners liable for damages became the dominant form of fence laws.

3 Theoretical Framework: Producer's Problem

A producer is endowed with one unit of farmland, which can be used to produce either grains or livestock, indexed by $c \in \{g, l\}$. Farmlands are perfect substitutes in the production of either output, but vary in exogenous productivity A_c for each output. The producer chooses to allocate the fraction of land S_c and variable inputs V_c to each product c and produce Q_c units of output, or

$$Q_c = Q_c(A_c, S_c, V_c) \tag{1}$$

Fence liabilities determines how much of the total output can the farmer receive from the land. For example, if farmers are liable to build fences, they would lose some output to the damage and only receive a fraction of the output. Conversely, if ranchers a liable to restrain their livestock, they would need to pay for the damages and thus also only receives a fraction of the output. Let R denote the fence law, and $\tau_c(R)$ be fraction of the total output the producer can receive for product c. Thus, under the fence law regime R, the producer can receive $\tau_c(R)Q_c$ units of output for product c.

The producer is a price-taker in both the input and the product market. Given input prices r_c and output prices p_c in the grain or livestock market, the producer chooses the fraction of land S_c allocated to grain versus livestock, and the corresponding variable inputs V_c, to maximize the total profit. The land allocation is subject to the constraint that the total area of land does not exceeds the total endowment.

The producers' problem can be written as:

$$\begin{aligned} \max_{S_c, V_c} \Pi = & \sum_{c \in (g,l)} p_c \tau_c(R) \underbrace{Q_c(A_c, S_c, V_c)}_{\text{output}} - \sum_{c \in (g,l)} \underbrace{C_c(S_c, V_c, r_s, r_v)}_{\text{cost}} \\ & \text{s.t.} \sum_{c \in (g,l)} S_c \leq \bar{S} \end{aligned} \tag{2}$$

Consider two counties with the same natural conditions, face the same inputs and output market, but opted to have different fence laws. Let $\bar{A}_c$, $\bar{r}_c$ and $\bar{p}_c$ denote the common productivity and prices. The optimal land allocation, variable inputs, and the corresponding maximum output can thus be expressed as

$$\begin{aligned} S_c^* &= S(\bar{A}_c, \bar{p}_c, \bar{r}_s, \bar{r}_v, \tau_c(R)) \\ V_c^* &= V(\bar{A}_c, \bar{p}_c, \bar{r}_s, \bar{r}_v, \tau_c(R)) \\ Q_c^* &= Q_c(\bar{A}_c, S^*, V^*) \end{aligned} \tag{3}$$

Given the same prices and productivity, the land allocation, variable inputs, and total output would differ across the two counties only if the liability regime R is different.

This simple model abstracts from potential productivity gains through agglomeration or specialization. For example, if a county produces mostly corn, one might expect to have more suppliers for crop-specific inputs (i.e. fertilizers, irrigation), or more technology diffusion (i.e. agricultural experiment station). However, for the late 19th century western frontiers, I assume the agglomeration effects to be negligible for counties in close proximity.

4 Data

In this section, I discuss the data for fence law and outcome measures. I then provide some descriptive evidence on the evolution of fence laws over time. The inter-temporal variation of the fence laws motivated the comparison of adjacent counties with different fence laws. In the last part, I discuss the sample construction to utilize the discontinuity across county boundaries.

4.1 Fence Law Data

I first collect data on all fence laws from state (or territorial) session laws for eight states on the Great Plains. The fence law data is the first comprehensive collection of the historical evolution of state and county-level fence laws and codified both the assignment of liability and specific requirements that can influence the transaction cost when recovering damages. The data consists of 688 regulatory changes, including both statewide and county level changes.

The session laws document all the legislative actions during each state legislative session, which occurs once every one or two years. This covers both the statewide adoption and special provisions for individual counties. Thus, the session laws track all the adoption, amendments, and repeals of fence laws for each county. The data expands from the first legislative session to 1930. When states allowed individual counties to adopt fence laws through petition or general election, as discussed in section 2.4, the final adoption decisions were not recorded in the session laws. For such cases, I use the reports from state agricultural associations or similar organizations to collect county-level fence law adoptions.

Fence laws exhibited substantial variation across counties and over time. Figure 2 shows the fence law changes from 1873 to 1879 as an example. Adjacent counties can have different fence laws at any given point in time. For each individual county, it may also change the fence laws and thus shifting the liability from farmers to ranchers or vice versa.[14]

I used two sources to verify the data. First, I checked the session law data against state statutes, which collected all regulatory changes adopted at the past legislative sessions. This assures that the session law data did not miss any changes or adoptions. Second, because court rulings may also influence the adoption, I search through state case laws regarding fences.[15] This ensures that relevant regulations were not overthrown by the court. In a few cases, the courts provided clarification on certain clauses. Appendix A provides more details on the data collection and verification process.

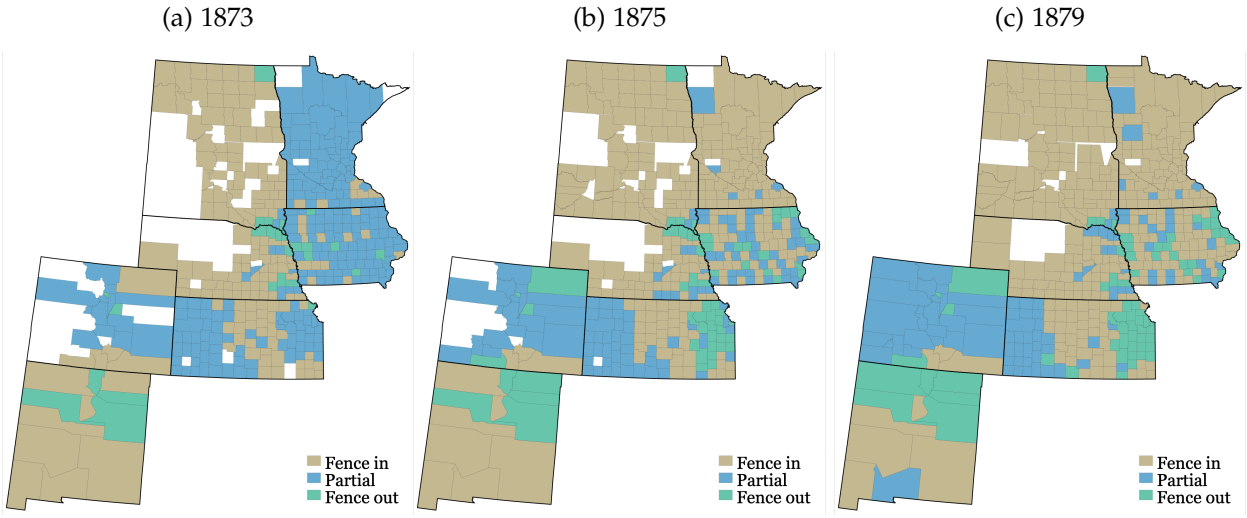
4.2 Outcome and Suitability Measures

I collect the main outcome variables, including population, land use pattern, land value, and farm output, from the Census of Population and Census of Agriculture from 1860 to 1930 (Haines

[14] Appendix Figure 4 displays the county-level fence laws for every decade from 1870 to 1920.

[15] Digitized state case laws are available at The CaseLaw Access Project, https://case.law/. This database is hosted by Harvard Law School and includes all official, book-published state and federal United States case law.

Figure 2: Fence Law Changes



et al., 2018). These data provide a consistent measure of agricultural production at the county level over the long run. Because the western states experienced frequent county border changes, yet all fence laws are defined at the county level, I kept the census measure at the original county level and did not homogenize the borders to a baseline year.

The natural conditions also influences agricultural production decisions. In producers' problem, this is captured by the crop-specific productivity term A_c. I use the "agro-climatically attainable yield" from the Global Agro-Ecological Zones (GAEZ) project created by the Food and Agriculture Organization (FAO) to measure each county's natural endowment for different types of agricultural products.[16] I aggregated the data at the county level and calculated the average yield level for each county. Throughout, I use the yield measure under irrigation and intermediate input intensity.

4.3 Bureau of Land Management Land Patent Data

Fence laws may also influence the selection and sorting in settlement. The primary distinction is between homestead and cash purchases. Homesteaders with small plots may have different preferences than large ranches acquired through cash purchase. However, the county-level Census of Agriculture does not contain information on the type of settlement, i.e. cash purchase versus homestead; it also does not have detailed measures on the concentration of land, which influences the severity of externality.[17]

I use the patent files from the Bureau of Land Management to measure land acquisition types.

[16] The FAO first collects a set of input measures, including the soil types and conditions, the elevation, and climatic variables (i.e. rainfall, temperature, sun exposure). The input measures are then fed through an agronomic model to predict the attainable yield for each type of crop (Fischer et al., 2021; Costinot and Donaldson, 2016; Nunn and Qian, 2011).

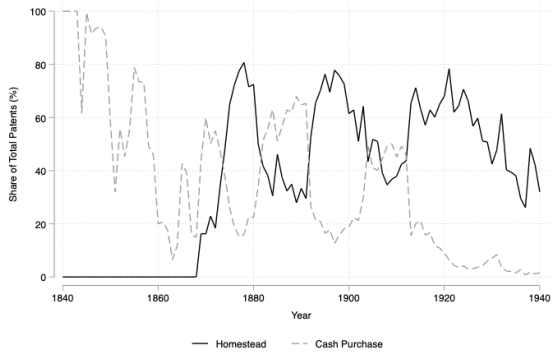
[17] For example, a county with large ranches and few shared boundaries would face fewer trespassing problems than a county with a lot of small adjacent homesteading plots.

The land patents were issued to all the land transferred from the federal government to individuals, states, and corporations. Each patent records the time of issuance, acreage covered under the patent, location of the land, and the type of transaction (i.e. homestead vs cash purchase). This allows me to measure the composition of land ownership for each county.

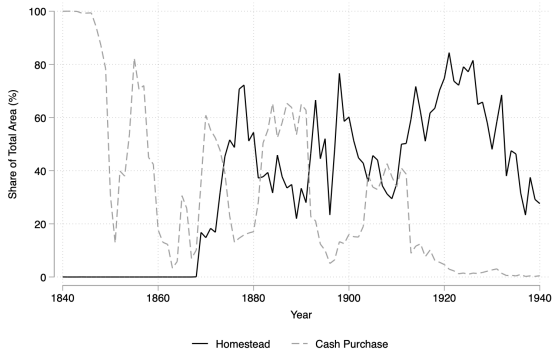
Figure 3 shows the number of patents issued and the acreage covered under each type. For the analysis, I focus on land patent issued before 1940. The data contains 2.8 million patents in the 8 states covered in this paper.[18] Land claimed under the Homestead Acts accounts for 36.8 percent of the total number of patents issued before 1940, or 37.8 percent of all the land transfers.[19] Meanwhile, 41.4 percent of patents were obtained through cash purchase, or 29.8 percent of the land areas.[20]

Figure 3: Evolution of Land Patent

(a) % Number of Patent Per Year



(b) % Patented Area Per Year



5 Identification Strategy

The empirical analysis leverages the county-level policy variation to identify fence laws' causal effects on agricultural production. The solutions for the producer's problem described in section 3 suggests that, for counties with similar natural conditions and faces the same market prices, the differences in land allocation and the corresponding gaps in output can be attributed to the differences in fence laws. The empirical strategy thus relies on the comparison of adjacent counties.

While the county-level regulation changes provide rich variation, they also introduce a unique problem. The treatment is not an absorbing state because counties switched back and forth between the three types of fence laws (fence-in, partial, and fence-out). Figure 4(a) plots the

[18] The BLM data covers 11 out of the 12 states in the sample. Notably, land patent data does not cover Texas, which does not have federal land to dispose of.

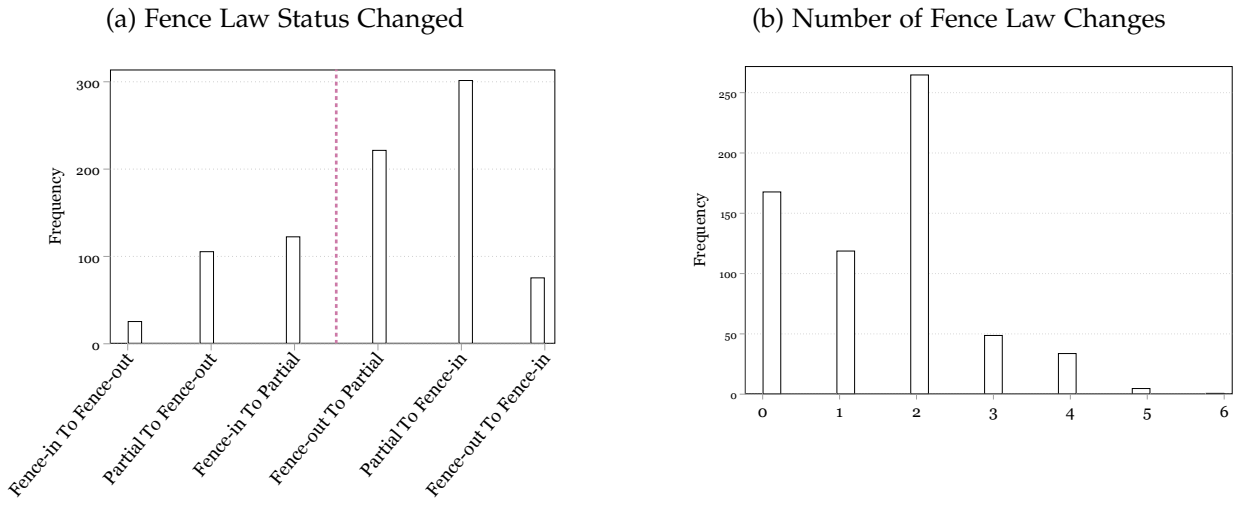
[19] This includes both the original 1862 Homestead Act and following amendments, such as the 1873 Timber Culture Act, the 1877 Desert Land Act, the 1909 Enlarged Homestead Act, etc.

[20] Appendix D plots the total number acreage covered by the land patent over time. It also presents the evolution of land transfer from the federal government to private holdings in each state over time.

count fence law changes between each pair. Changes in all six pairs are present in the data. In addition, a large number of counties changed the fence laws multiple times. Figure 4(b) shows the distribution of fence law changes after the initial adoption. Among the 658 counties in the sample, only 162 counties, or less than 25 percent, kept the original fence law. More than half of the counties in the sample changed the fence laws at least twice after the initial adoption.

In addition, the treatment timing is staggered, and the treatment effects are likely to vary over time. As discussed in 2.4, both the initial adoption and subsequent changes occurred at different points in time. The effects on agricultural production can also change over time as people adapt to the regulations. Recent studies (Goodman-Bacon, 2021; Sun and Abraham, 2021) point out that the traditional difference-in-differences estimation cannot recover the dynamic treatment effects with staggered adoption and heterogeneous treatment effects.

Figure 4: Treatment is a Non-absorbing State



Note: The count only includes regulations that lasted for more than two years. In figure (a), the dotted line seperates the regulation changes into two groups: increasing farmers' liability (left) and increasing ranchers' liability (right)

To address the problem, I limit the sample by the following three criteria:

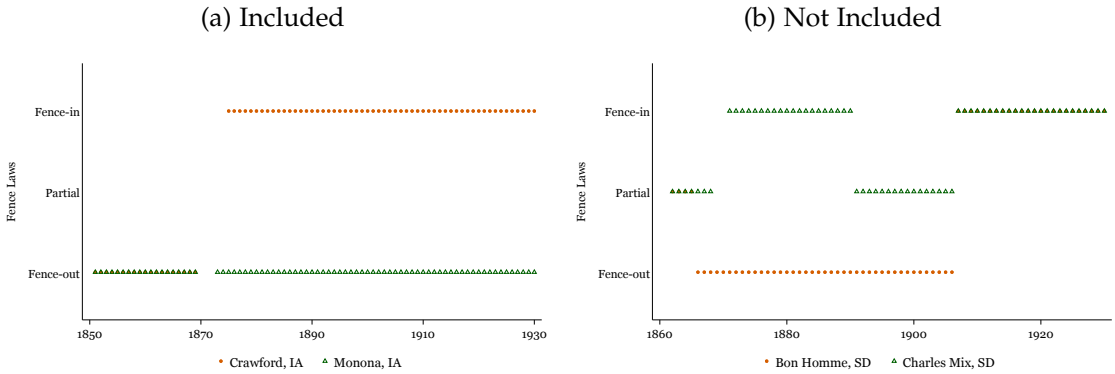
(1) Both counties had the same initial policy

(2) Only one county in the pair had one policy change

(3) The policy change lasted for at least 3 years

In other words, the analyses only use county pairs with "clean" controls and avoids scenarios with repeated treatment or when the control group later become treated. Figure 5 provides examples of the county pairs that are included or excluded from the analysis. This leaves 198 pairs of counties that satisfy the above conditions for the analysis.

Figure 5: Examples of Counties Pairs (Not) Included in the Sample



5.1 Main Specification

I use an event-study design to compare the adjacent counties that started off with the same regulation but only one experienced a single fence law change. The baseline specification is:

$$y_{cp\tau} = \alpha_{p\tau} + \sigma_c + \sum_{\tau} \beta^i_{\tau}(D^i_{cp} \times \text{Year since policy change} = \tau) + \epsilon_{cp\tau} \tag{4}$$

where τ represents the year since policy change, grouped by 10-year intervals. $y_{cp\tau}$ is the outcome for county c in pair p in period τ. The regression includes county fixed effects (σ_c) and border-pair by time fixed effects ($\alpha_{p\tau}$). D^i_{cp}, with $i \in \{\text{Farmers}, \text{Ranchers}\}$ are categorical variables indicating the direction of liability shifts, defined as:

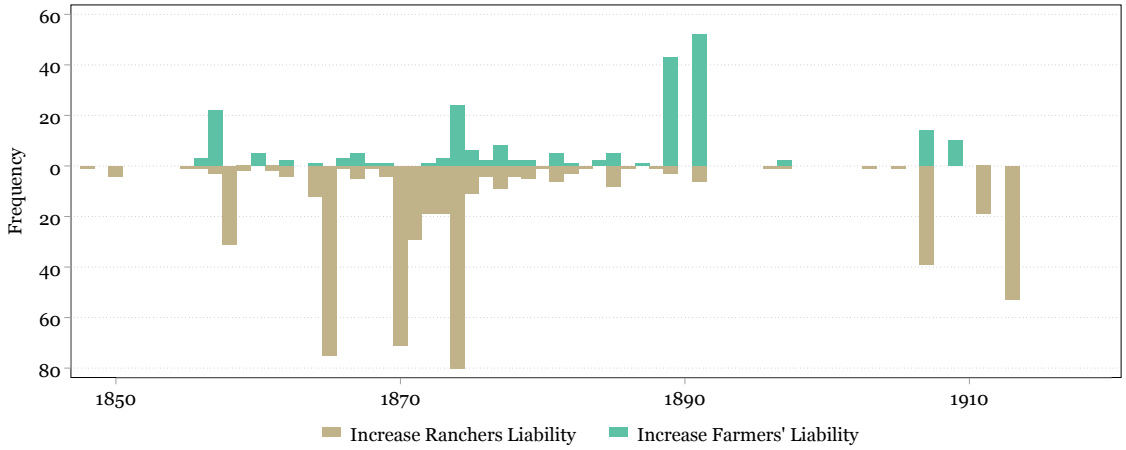
$$D^{\text{Farmers}}_{cp} = \begin{cases} 0 & \text{No Fence Law Change} \\ 1 & \text{Increase Farmers' Liability} \end{cases} \quad D^{\text{Ranchers}}_{cp} = \begin{cases} 0 & \text{No Fence Law Change} \\ 1 & \text{Increase Ranchers' Liability} \end{cases} \tag{5}$$

For each pair of adjacent counties, the coefficient β^i_{τ} captures the effect of adopting a specific fence law by comparing the outcomes of the one county whose fence law remained unchanged with the neighbor that started off with the same law but switched to a different fence law. Specifically, β^{Ranchers} compares counties that did not experience fence law change with the adjacent counties that shifted part or all of the liability to ranchers (e.g. changed from fence-out to partial or to fence-in). Similarly, β^{Farmers} captures the reverse change, comparing counties that did not experience fence law change to their neighbors that shifted more liability to farmers (e.g. changed from fence-in to partial or fence-out).

Figure 6 illustrates the number of counties that changed the liability allocation in any given year, providing the primary source of identification variation in the empirical analysis. Initially, most counties required farmers to enclose their land against livestock trespassing. Consequently, earlier policy changes could only move in the direction of reducing farmers' liabilities. This trend was particularly pronounced before 1870, coinciding with the westward expansion that shifted

the agricultural production from ranching to farming. Figure 1(b) reflects the aggregate effects of these policy changes. From 1850 to 1870, the fraction of counties requiring farmers to enclose the land dropped from nearly 100% to less than 40%. After 1870, more policies started to increase farmers' liability. This change was primarily driven by switching from prohibiting livestock from "running at large" at all times to allowing certain exceptions, as opposed to reverting to the initial rule to require farmers to fence. The most common exception relieved rancher from trespassing liabilities during winter or daytime.[21] On aggregate, however, most regulations reduce farmers liability through out the period.

Figure 6: Number of Counties with Liability Shifts



Note: The count only includes regulations that lasted for more than two years.

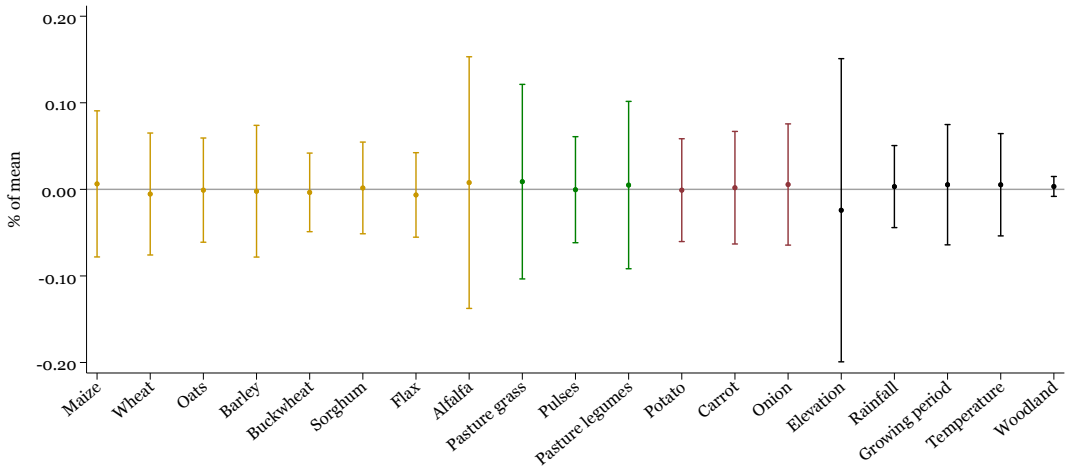
6 Estimation Results

6.1 Balance Test of Natural Endowment

I first show that adjacent counties have comparable natural conditions. This is to empirically test that, in the solutions to producers' problem (3), adjacent counties have the same crop-specific productivity A_c. I use the average agro-climatically attainable yield as a proxy for A_c. Because the attainable yield measure is a function of natural endowment, this measure is time-invariant. Therefore, as oppose to estimating the baseline model (4), I conduct a simple t-test to compare the average attainable yields and environment measures (rainfall, temperature, etc) across the borders. Figure 7 plots the coefficients of the balance test. For 14 types of crops and the environment measures, the differences across adjacent counties are not statistically different from zero. In other words, the crop-specific productivity A_c is indeed the same for adjacent counties.

[21] See Figure 9 for the detailed breakwon of policy changes for each of the six sub-groups.

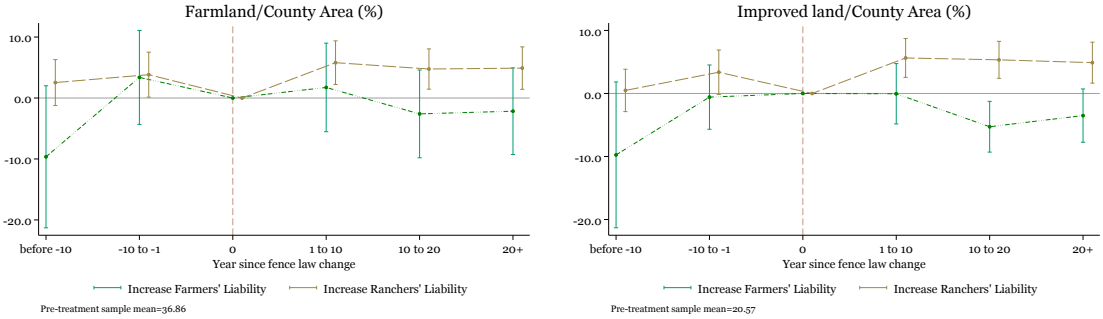
Figure 7: Adjacent Counties Have Comparable Natural Endowment



6.2 Land Use and Settlement

I start by analyzing whether shifting liabilities changed land use pattern. Estimates of equation (4) indicate that shifting fencing liabilities had asymmetric effects on land use. On the extensive margin, increasing ranchers' liability increased the acreage of farmland, while increasing farmers' liability had no effect (left panel in Figure 8). Farmland increased within the first ten years after shifting more liability farmers to ranchers, and the effects remained stable afterwards. Ten years after increasing ranchers' liability, the share of county area in farmland increased by 5.2 percent, or an 15 percent increase from the pre-treatment average. The average size of a county in the same is 1,373 square miles, meaning that increasing ranchers' liability would increase the farmland area by 68 square miles. The results are consistent with contemporaries' beliefs that the fencing cost was a big barrier to increase farming activities.

Figure 8: Land Use

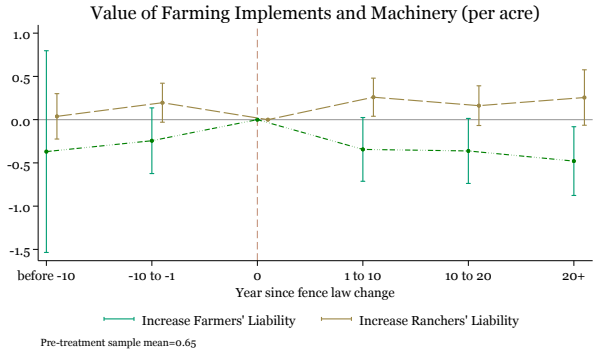


I further explore the changes in farmland by focusing on the changes in improved land. The Census defines improved land to be "all land regularly tilted or mowed, land pastured

anc cropped in rotation, land lying fallow [...]."[22] In other words, the improved lands were the primary land for agriculture production. Estimates show that almost all the increase in farmland were driven by increases in improved land (right panel in Figure 8). Increasing ranchers' liability increased the share of land areas in improved farmland by 4.9 percent, or 27 percent of the pre-policy change average. As suggested by (2), reducing farmers' liability increases the marginal product of the land. Shifting the liability from farmers to ranchers thus incentivize landowners to expand their production and increase the acreage in improved farmland.

In addition to acreage of improved land, I also analyze the changes in the value of farm machinery and equipment. One can view this as a proxy for continuous capital investment on the farm. Larger production scale, resulting from the increase in improved land, may require more sophisticated machinery to carry out the production activities. Figure 9 shows that shifting liability to farmers indeed reduced the average value of machinery on the farm in the long-run.

Figure 9: Capital Investment



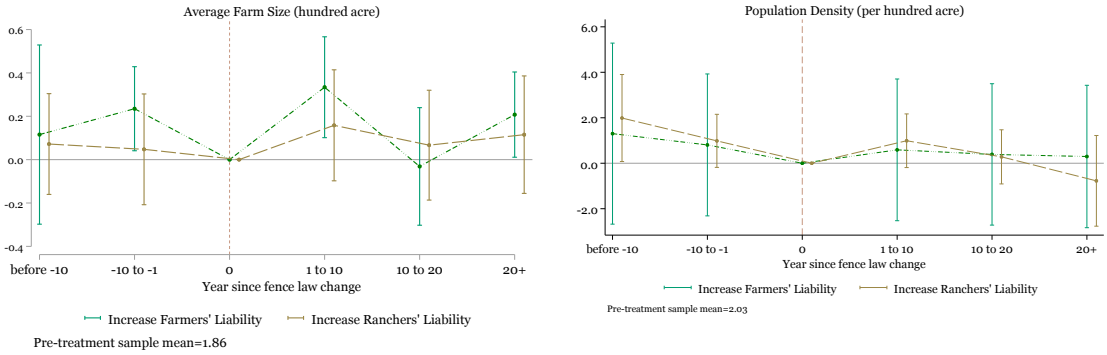
The primary policy concern behind the debate around fence laws is to attract settlement in the west and incentivize communities based on small family farms. Figure (1) in Figure 10 shows that there is a small and temporary increase in farm size when increasing farmers' liabilities. Because it is more efficient to enclose larger plots, requiring farmers to enclose land may incentivize some land consolidation. However, the effect is temporary and small in scale. In addition, contrary to the policy expectation, shifting the liabilities in either direction did not affect population density.

6.3 Output and Land Value

What were the economics effects of shifting liability rules? I start by looking at the aggregate effects on total output, productivity and land values. Because more land were converted to be improved land when increasing ranchers' liability, more output were produced (top panel in Figure 11). However, the increase were driven mostly by the changes in production scale, the average output per acre of farmland did not change until more than 20 years after the policy adoption (bottom left in Figure 11). Because the productivity of farmland did not increase for a

[22] Definition from *Abstract of the Census*, 1910, Chapter 4.

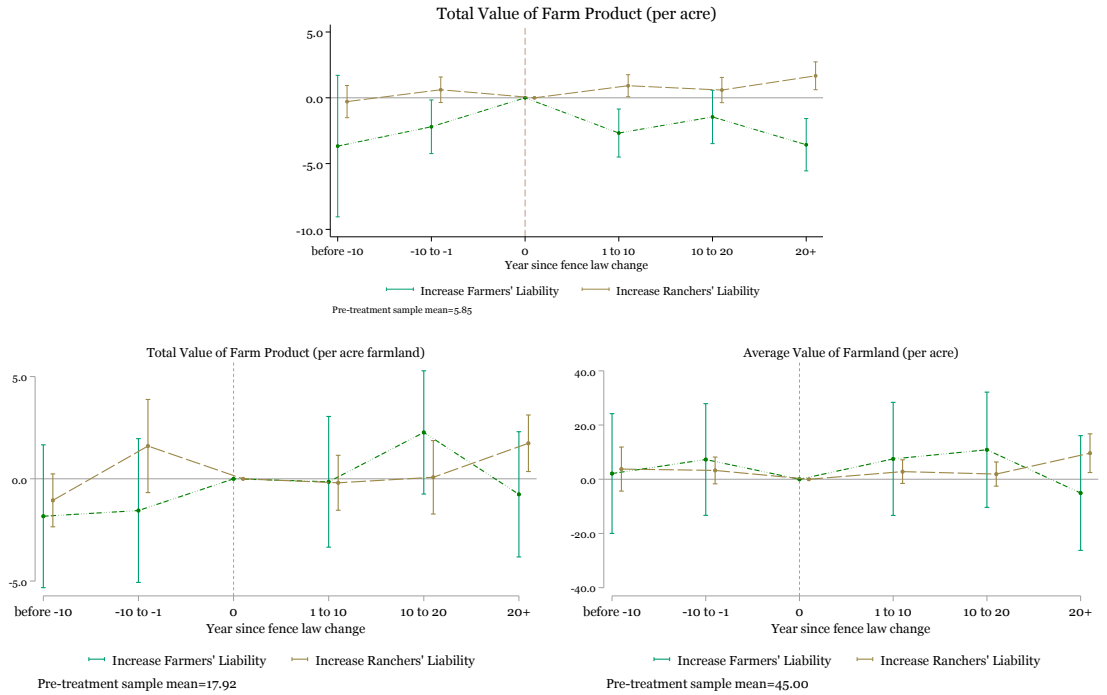
Figure 10: Settlement



long time, the farm value also did not change in respond to the liability shifts.

The results from settlement and productivity are consistent with the estimates on land use. Most of the effects were driven by the changes on the intensive margin. Existing land owners converted more marginal land for production, which required more capital spending for the increased scale. With limited return to scale, the average productivity remained largely constant, thus the per acre land value.

Figure 11: Productivity and Land Value

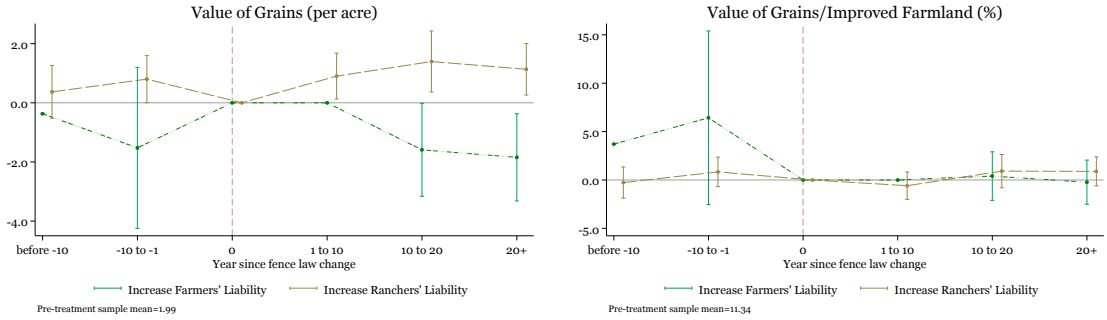


6.4 Grain vs Livestock Production

Liability rules may also affect the composition of output. As shown in the producers' problem in (2), the optimal land allocation between grain and livestock production is partially determined by the regulatory regimes. However, because the census did not report the land or labor allocation across different farm products, one cannot directly estimating the producers' choices. Instead, I compare the total output value from crops and livestock. As discussed in section 3, while the prices for the farm products varied over time, because all farmers were price takers in the product market, farmers in adjacent counties should face the same (expected) prices when making their production decisions. The differences in output values can only be driven by differences in quantities.

Figure 12 displays the estimates for the effects of liability shifts on grain production. The value of grains is defined as the total value of corn, wheat, barley, buckwheat, rye, and oats. Shifting liability from farmers to ranchers increased the value of grains per acre of land area. Consistent with the results from aggregate output, the increase in the value of grains was driven by the changes on the extensive margin, as the improved farmland area increased when reducing farmers' liability. There was no changes in productivity, measured by the value of grain output per acre of improved farmland (right figure in Figure 12). There was also no shifts in the composition of crops, as the share of output value from corn and wheat remained mostly unchanged (see Appendix Figure 1).

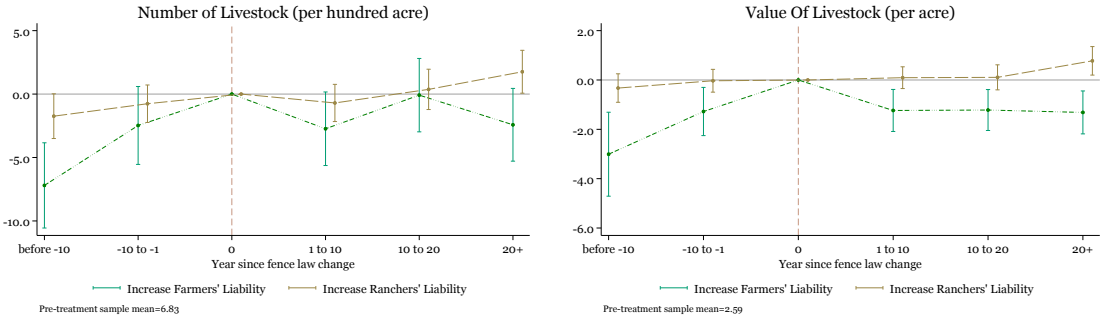
Figure 12: Grain Production



While shifting liability to farmers decreased grain production, contrary to the policy goal, it did not benefit ranchers. The left panel in Figure 13 shows that the density of livestock, measure as the total number of cattle, sheep, and swine, per hundred square acre, remained the same for adjacent counties regardless of the direction of liability shift. In addition, shifting the liability to farmers and allowing livestock to roam freely appear to reduced the value of the herds (right panel in Figure 13). This may be due to the fact that fences potentially can benefit livestock production by limiting the spread of infectious diseases, such as bovine tuberculosis, and improving breeding. Livestock owners, however, may not fully appreciate such benefit. Thus, when not required to enclose or restrain their herds, livestock owners would let the herd

run at large and ended up facing higher risks.

Figure 13: Livestock Production



6.5 Settlement Type and Land Concentration

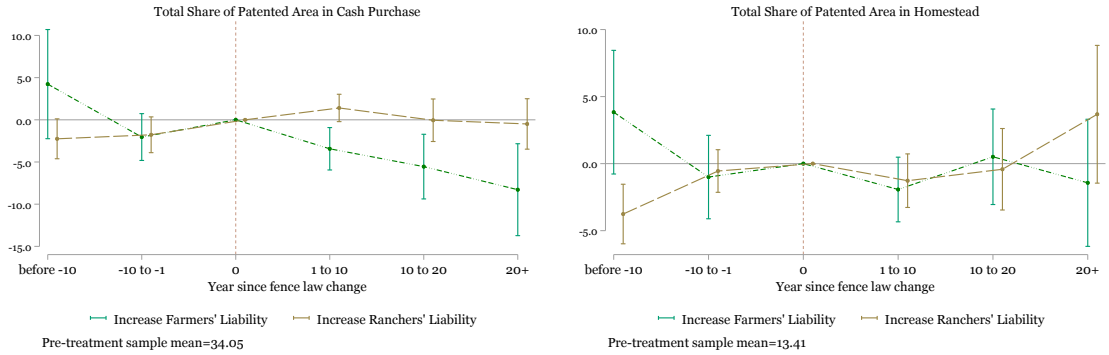
In this section, I use the land patent data from the Bureau of Land Management to analyze the evolution of settlement and land concentration. While the census provides detailed information on agricultural production, there are several limitations to the census data. First, the records only started when an area achieved statehood, while many fence laws were adopted under territorial governments, long before the census was available. Second, the farm sizes are aggregated at the county level. This masks changes in distribution over time, and does not include any information on the type of ownership, especially one whether a plot was acquired by homesteaders.

In contrast, because land patents were issued when a plot was transferred from the federal government to private ownership, the records were available long before areas were organized as states and entered the Census record. In addition, the data contains plot-level information on size, transaction date, and how the land was acquired. This provides a direct measure on the size of the plot for the initial transaction, and whether the land was acquired under the Homestead Acts or through cash purchases.

I estimate equation(4) separately for the share of land acquired under Homestead patent and cash purchases. Consistent with the argument from contemporary policymakers, increasing farmers' liability deterred settlement, but only through the cash purchases (Figure 14). Meanwhile, the shifts in liability rules had little effects on homesteaders. The results echos other research on the different characteristics of homesteaders versus other settlers (Mattheis and Raz, 2019). Land owners who purchased new plots with cash were likely to be more strategic on location and land quality, while homesteaders may face more financial constraint to begin with and had less choices.

In addition, while there were less land acquired through cash purchase, for those who decided to buy a plot, the size also became smaller. Figure 15 shows that increasing farmers liability reduced the median size of plots acquired through cash purchase by 5 to 10 acres, but increasing ranchers' liability did not have any effects on the plot size. In addition, regardless of the policy

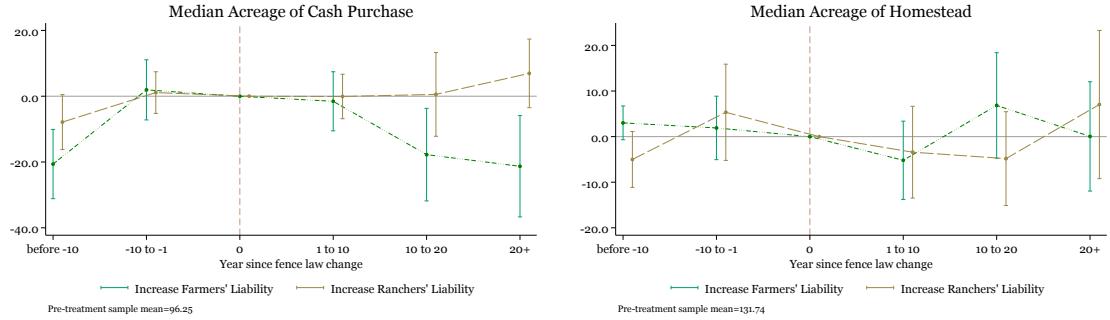
Figure 14: Share of New Plots: Cash Purchase versus Homestead



changes, the plot size acquired under homestead remained the same. This is unsurprising since median size of plot under homestead remained to be 160 acres, the maximum size granted by the law, until the 1920s. Appendix Figure 2 displays the estimates for the 25th and 75th percentile of the plot size. Increasing farmers' liability have negative effects on the size of cash purchased land for both the bottom and top quartiles, while it did not influence the homestead plot sizes.

Note that the land patent only recorded the initial transaction from the federal government to private ownership. This analysis summarizes the changes on the flow of new settlement. In contrast, results from the Census of Agriculture, as discussed in section 6.2 reflects the stock of all farms in any given county. The increase in homestead farms and potential consolidation through the private market can explain the differences in the results from the census data and land patent data.

Figure 15: Median Plot Size: Cash Purchase versus Homestead



7 Conclusion

This paper uses the spatial and inter-temporal variation in local fence laws to investigate the effects of liability rules on agricultural productivity. Comparing counties that changed the liability for livestock trespassing between ranchers and farmers, I show that shifting liability from farmers to ranchers increased agricultural development by incentivizing landowners to expand

farmland and employ more machinery. It also attracted more new land owners through cash purchases. However, the effects were not symmetric, and the benefit of shifting liabilities from farmers to ranchers was not offset by any reduction in livestock production.

Understanding the implications of liability rules has direct policy implications today. Growing evidence from the development literature suggests that property rights and liability rules may distort market allocation and create persistent inefficiency. This chapter complements the literature by providing empirical evidence to quantify the effect of a particular type of liability rule. The results highlight both the importance of liability rules, as well as the potential economic damage created by the institutional failure.

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Appendices

A State Session Law Data collection

Why Session Law Session laws compiled all the laws passed at each legislative session, which occurred annually or every other year. The session laws document the precise time and content of the regulatory change, for all the adoption, repeal, and amendments. In other words, the session laws provide a complete history of the regulatory changes. In comparison, statutory codes are published much less frequently (sometimes states did not revise the statutory code for decades), which only reflect a snapshot of the regulations at the time of publication. Because statutes usually do not track the evolution of each act, this does not provide the timing of each change and omits all the repealed acts. More importantly, many county-level regulations were adopted in the "Special Session", which were usually not included in the statutory revisions. Thus, the aggregated state statutes masked would mask a substantial number of county-level fence law variations.

Variable Construction All historical fence laws have been digitized and are available via HeinOnline Session Laws Library.[23] To locate the fence law in each session, I used multiple words to ensure results covered all potential fence-related issues. Specifically, I searched for "fence", "enclosure", "run at large", "trespass", "stock", "cattle", "hog", "horse", "mule", "animals" in each session and checked all the results to determined whether it is a fence-related act.[24]

For each act, I hand-code the variables that describe the fence laws based on the text. The main variable of interest is the assignment of liability: fence-in, fence-out, or partial. In addition, I also code additional requirements that can influence the cost of seeking compensation for damages. For example, whether the law required a third-party assessor to evaluate the damage, whether the injured landowner can hold and sell the trespassing animal for compensation, whether adjacent landowners need to share the cost for partition fences, or whether there are fines or criminal punishment in addition to the civil damage.

B Fence Law Sample Text

Below are the original text of the legislatures cited in 2.4.

[23] The only exception is Dakota Territory, which is available on North Dakota Legislative Council website (https://www.ndlegis.gov/assembly).

[24] I used "wild-card" terms in the actual search to include word-root variations. For example, I sued "fenc*", which would return results for "fence, fences, fencing".

B.1 Minnesota, 1850-1865

1850: Chapter LIII, "An Act to permit certain animals to run at large" Section 1. That all neat cattle, sheep, horses, (except stallions of the age of two years,) and hogs shall be permitted to run at large in this territory, at all times of the year, and the owner thereof shall not be liable for the damage which any such animal may do, unless the same be done upon enclosed ground, with a legal and sufficient fence, in which case such owner shall be liable in an action of trespass for all the damages done.

1865: Chapter L, "An Act to provide for distraining beasts doing damage during the night time"" Section 1. It shall be lawful for the owner or occupant of lands to distrain all beasts doing damage upon his or her lands during the night time, from eight o'clock in the evening until sunrise; and when any such distress shall be made, the person distraining shall keep such beasts in some secure place other than the public pound until his damages shall be appraised, and within twenty-four hours after such distress, unless the same shall be made on Sunday, in which case before the Tuesday morning thereafter, he shall apply to a justice of the peace of the town, who shall appoint three disinterested inhabitants of such town to appraise the damages.

Section. 2. It shall be lawful to make such distress at any time before such beast doing damage as aforesaid shall have escaped from said lands, and without regard to the sufficiency of the fences on such lands.

Section. 10. In case the owner or occupant of lands when owner liable shall not distrain the beasts doing damage as provided in this act, then the owner of such beasts shall be liable in an action at law for all damages done by such beasts during the night time, without regard to the sufficiency of the fences on the lands in which damage is done.

B.2 Colorado, 1859-1864

1859: Chapter XXLLL, "An Act concerning enclosures and trespassing animals" Section 1. That any structure, hedge or ditch, in the nature of a fence, used for purposes of enclosure, which is such as good husbandmen generally keep, and as shall on the testimony of practical agriculturists appear to be sufficient, shall be deemed a lawful fence.

Section 2. If any domestic animal break into an enclosure, the person injured thereby shall receive the amount of damage done, if it should appear that the fence through which said animal broke, was lawful; but not otherwise.

1864:"An Act for the protection of farmers against the depredations of stock in the counties of Douglas and Wald" Section 1. That no person farming or cultivating land within the limits of Douglas and Weld counties shall be required to fence or enclose the same against any stock running at large or herded within said counties. All persons owning or having charge of stock, whether cattle, horses, mules, asses, sheep or hogs, shall be required to herd or confine the same

in secure enclosures during the season for growing crops, from the time of planting until said crops are gathered. The owner or any other person having charge of any stock that may be kept within the limits of the counties named in section first of this act, from and after the adoption of this act, shall he liable for all damages which may be done any crops planted, growing, or standing in the fields, or gathered in stacks or cribs; Provided, That such damage or destruction have been caused by the carelessness or neglect of such owners or agents. That in case of any crops being injured or destroyed by any animal or animals, as in violation of this act, the owner or agents of such crops may seize such animal or animals so found trespassing and hold the same as security for the payment in full for damages sustained by such owner or agent, such damages shall be adjudged and collected b. an action of debt, before any court of competent jurisdiction within the county where such damage may have been done.

B.3 Territory of New Mexico, 1851

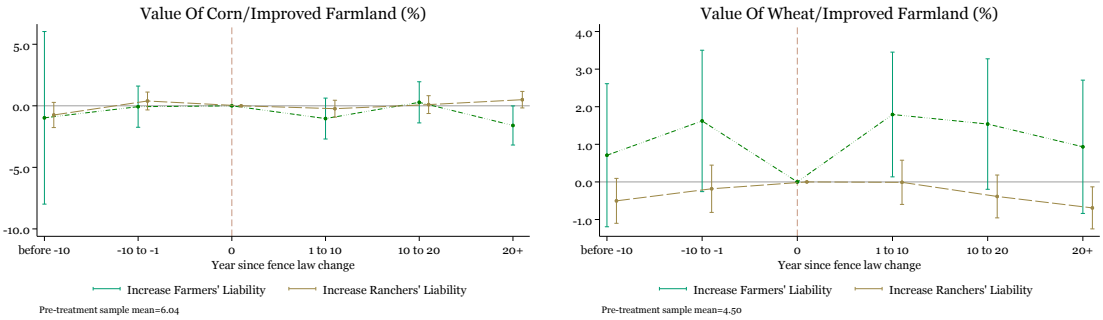
Unlike other Plain states, New Mexico already had considerable farming development when the territorial government was formed in 1851. Therefore, New Mexico is the only state included in the preliminary analysis where first established fence-in rule. In 1851, the first legislative assembly of the Territory of New Mexico, the legislators explicitly cited the high fencing cost as a reason not to enclose cultivated land[25]

> It being impracticable or absolutely impossible for the fields in the territory to be fenced in, all animals shall be kept under a shepherd, so that no injury may result to the fields; and in case any damage should result, they shall be paid by the persons causing it.

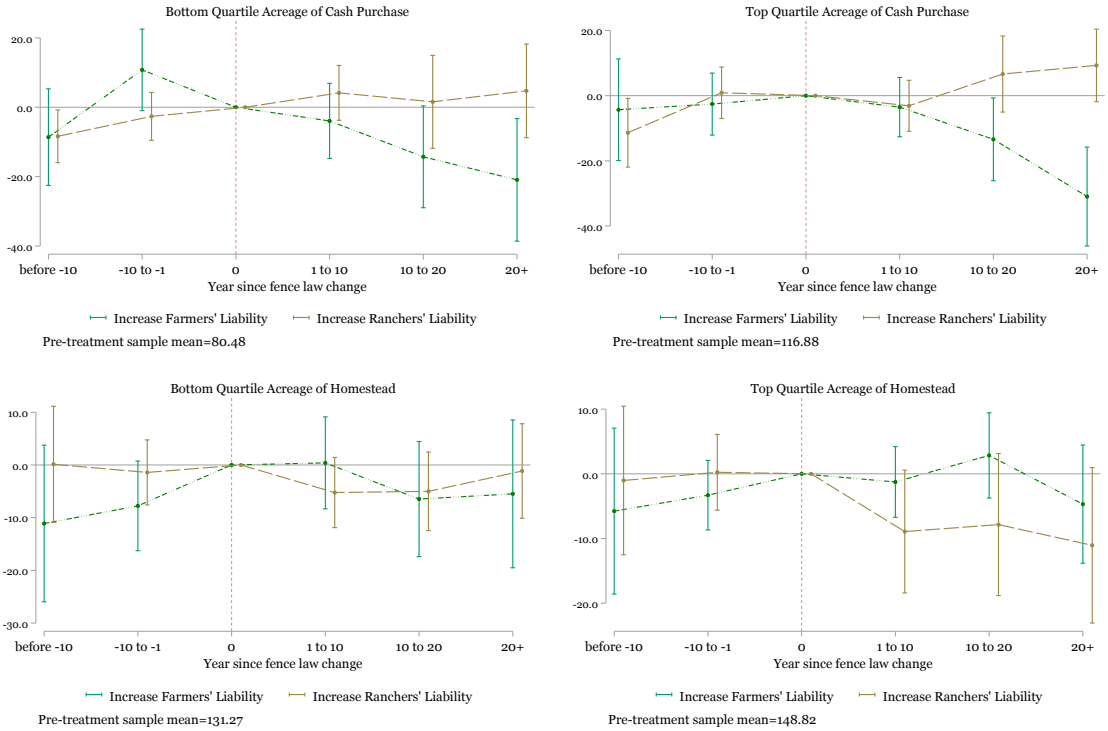
[25] "An Act Relative to Water and Ditches and Other Branches of Agriculture", Laws of the Territory of New Mexico, Passed by the First Legislative Assembly, 1851

C Additional Results

Appendix Figure 1: Composition of Grain Production



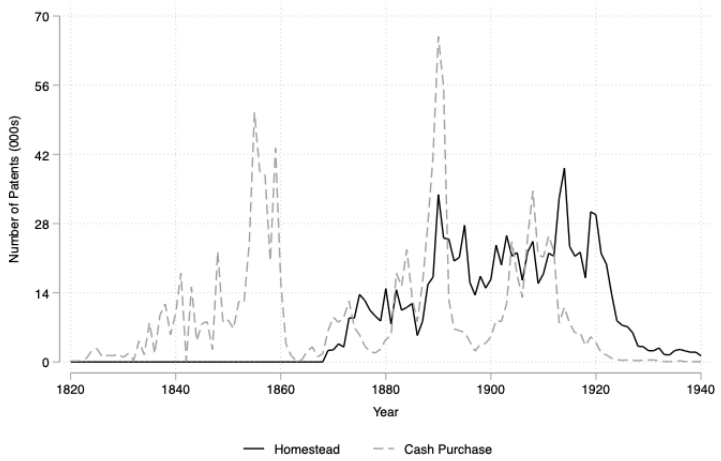
Appendix Figure 2: Plot Size by Quartile: Cash Purchase versus Homestead



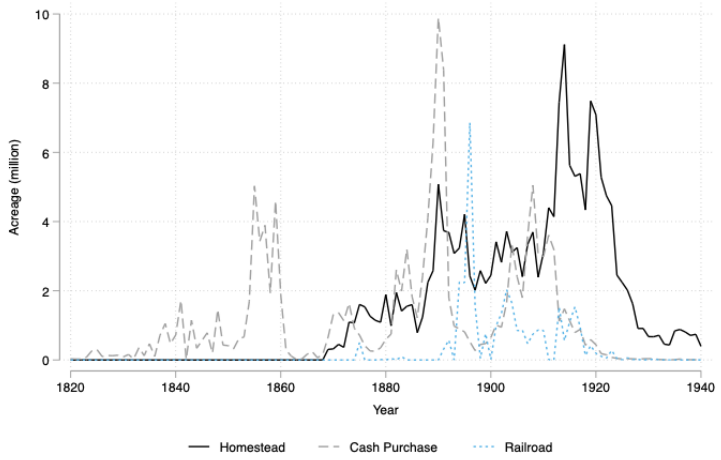
D Land Patent Data

Appendix Figure 3: Evolution of Land Patent

(a) Count of Patent Issued Per Year

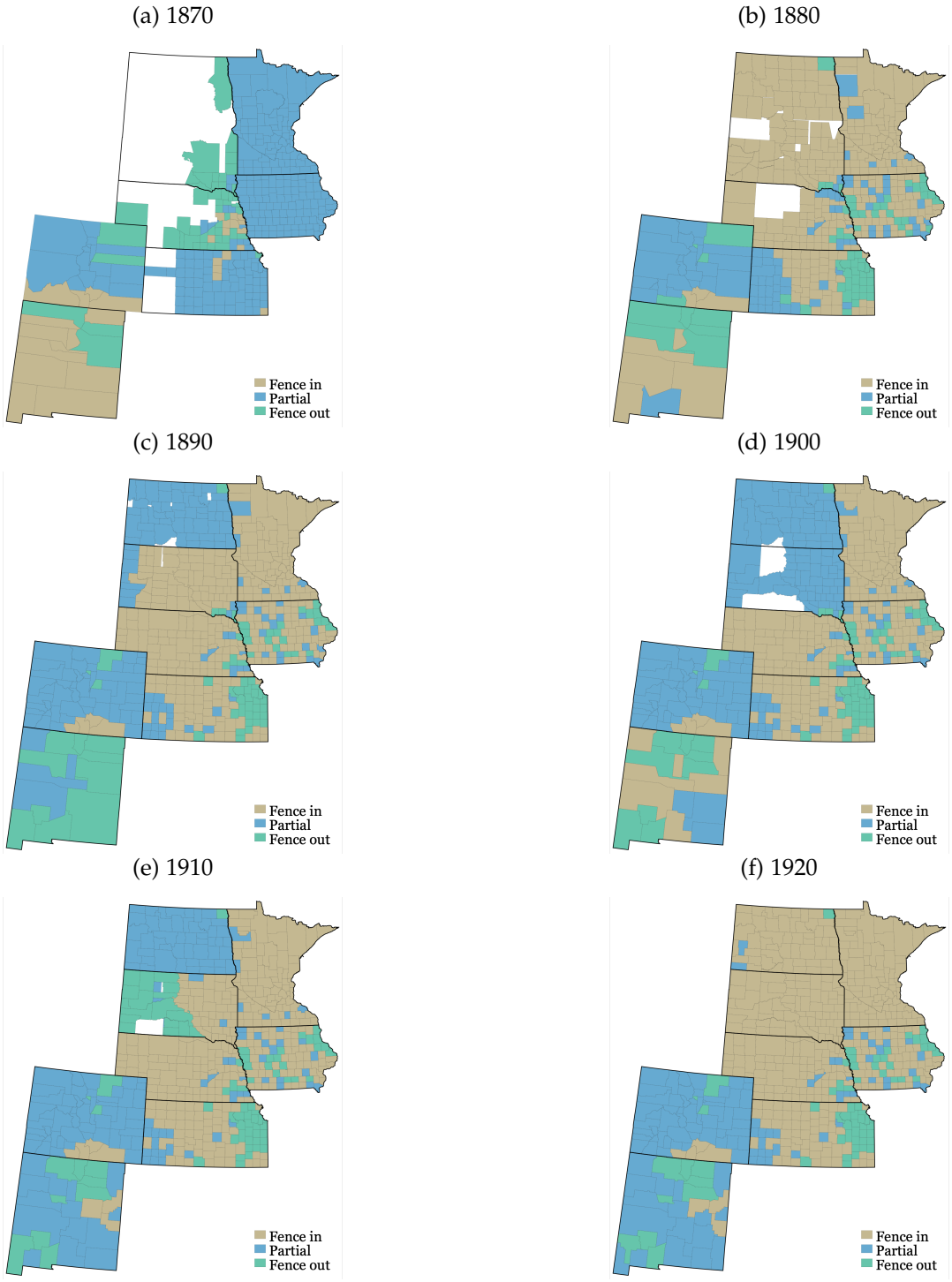


(b) Total Patented Area Per Year



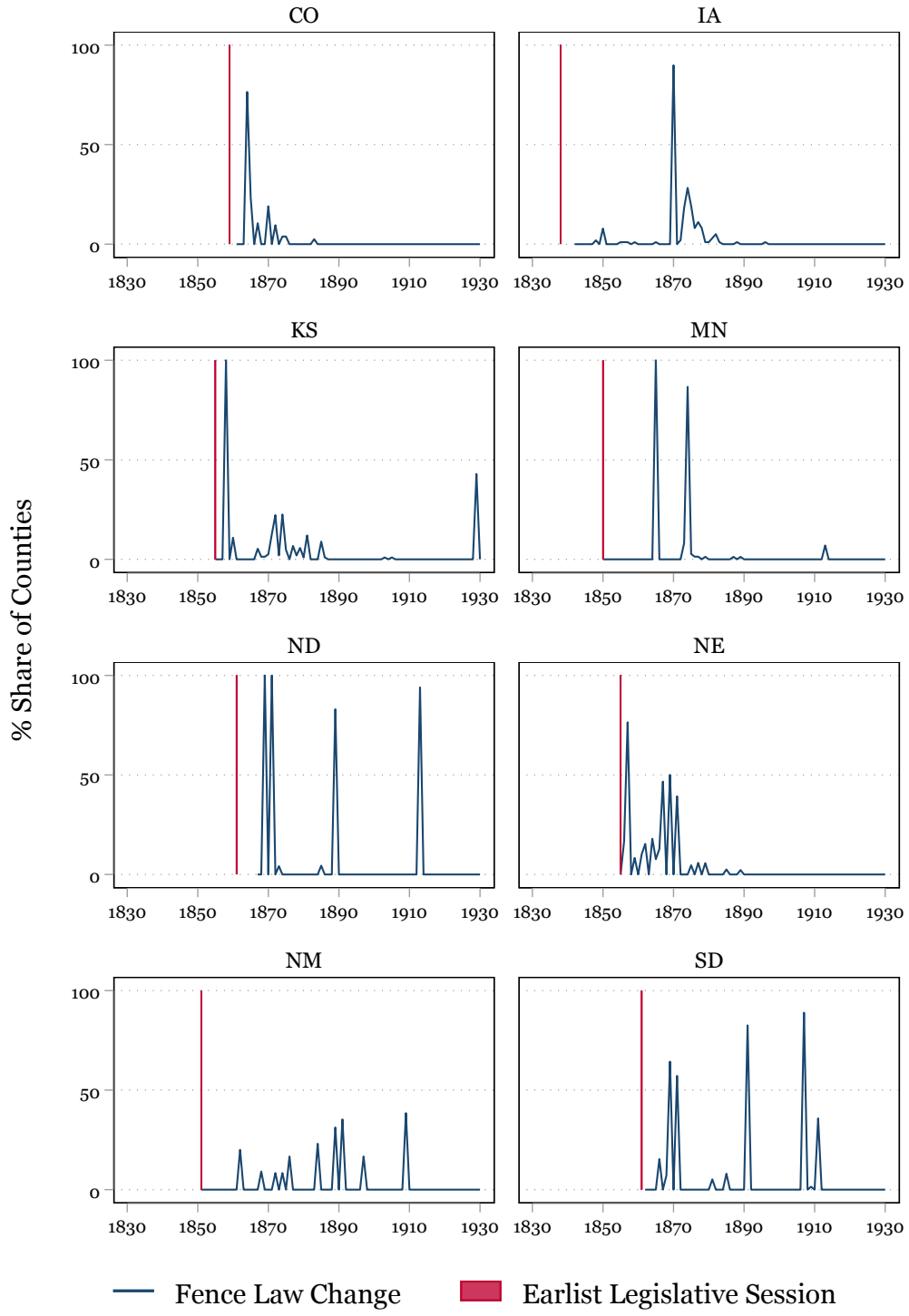
E Spatial Distribution of Fence Laws over Time

Appendix Figure 4: Evolution of Fence Laws

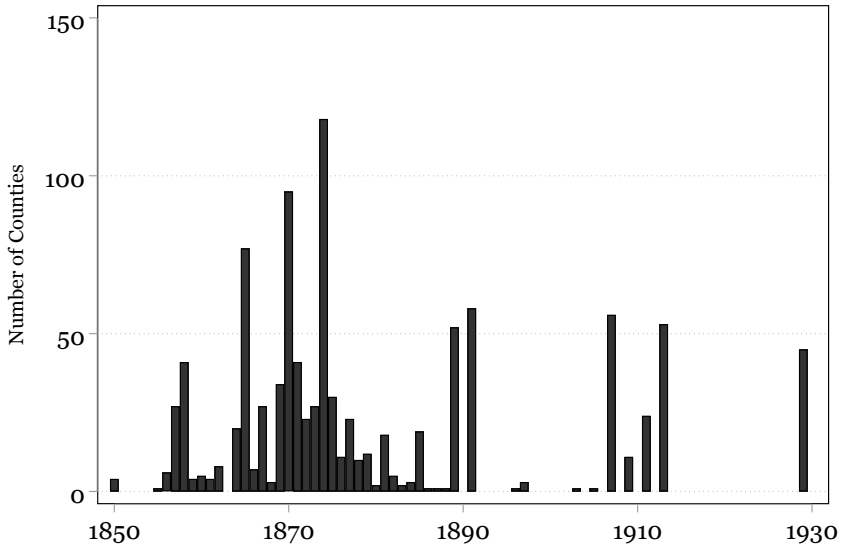


Note: County borders using decennial census definition. Empty spaces include Indian reservations and unorganized counties.

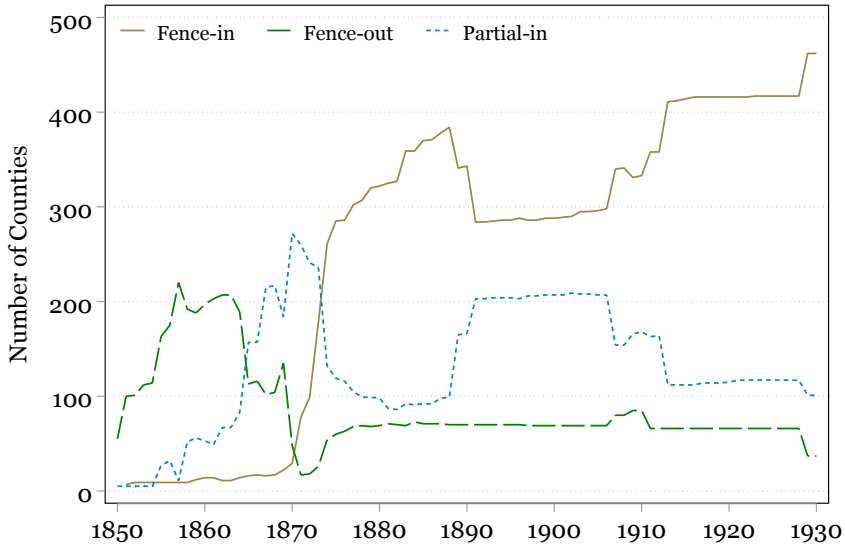
Appendix Figure 5: Share of Counties with Fence Law Changes, by State



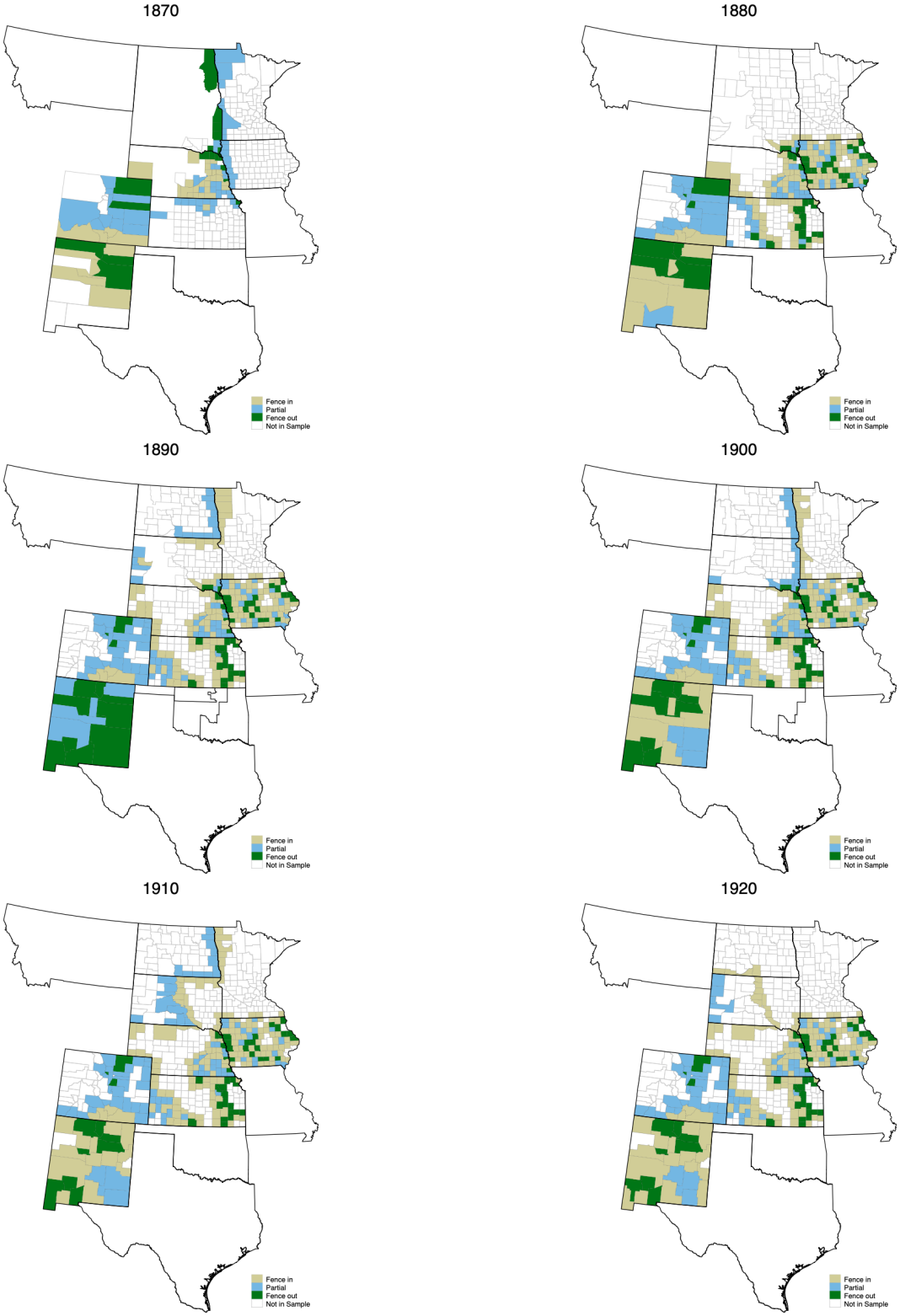
Appendix Figure 6: Number of Counties with Fence Law Changes



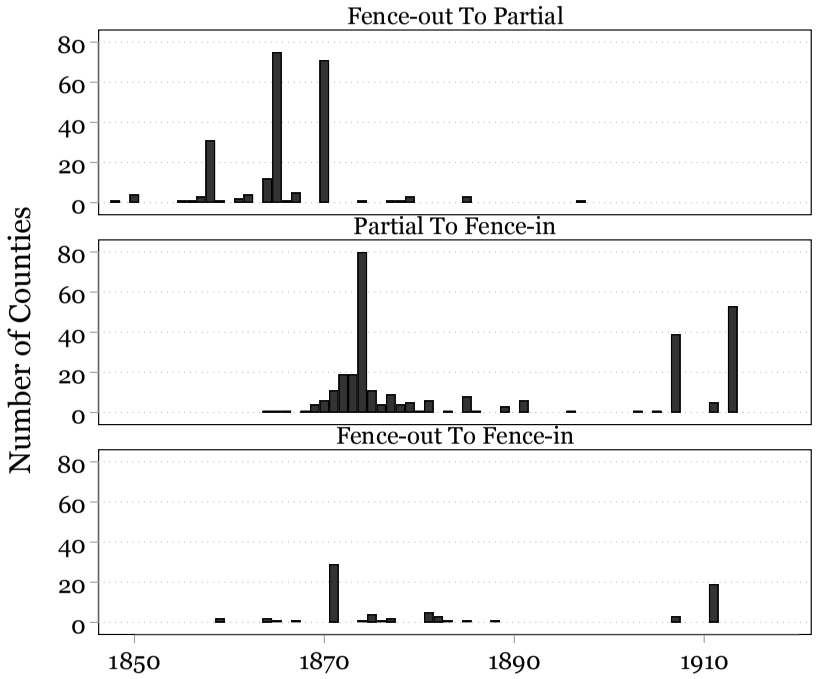
Appendix Figure 7: Number of Counties under Each Type of Fence Law



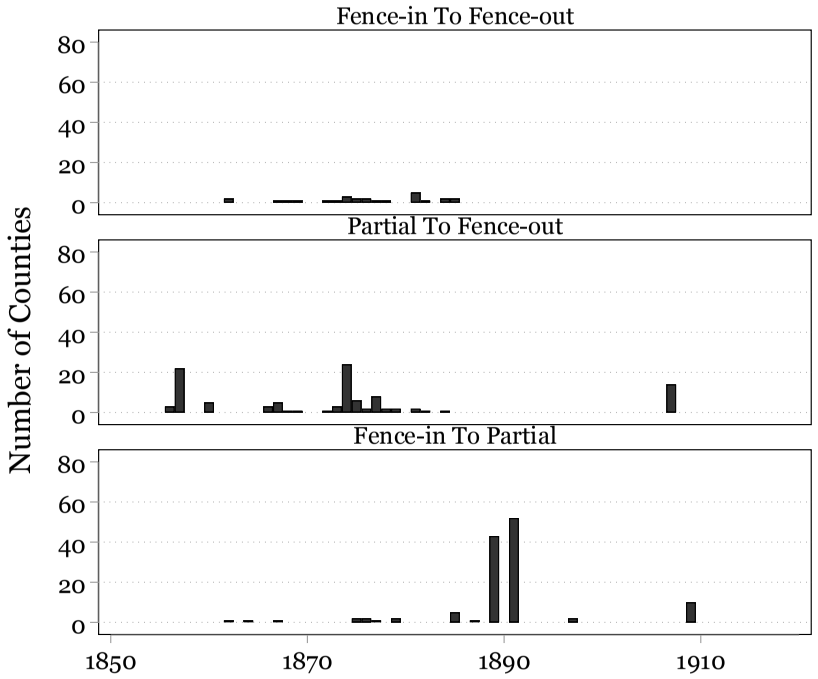
Appendix Figure 8: Adjacent Counties with Different Fence Laws



Appendix Figure 9: Frequency of Liability Shifts



(a) Increase Farmers' Liability



(b) Increase Ranchers' Liability

Note: The count only includes regulations that lasted for more than two years.