Transaction Costs and the Value of Mining Claims

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ABSTRACT. *This paper examines the relationship between transaction costs and the value of full title to mining claims staked under the 1872 Mining Law. Miners can either acquire full title to their claims (known as a mineral* patent*) or mine unpatented claims. The costs of enforcing claim rights is lower when the claimant holds full title, but the patenting process is costly. The decline in claim disputes after the turn of the century reduced the value of full title, and the demand for patents decreased. An analysis of data from 12 western states for the period 1882–1932 is consistent with this argument.* (JEL Q31)

I. INTRODUCTION

The General Mining Law of 1872 is the last vestige of a federal land-management program that led to the privatization of 750 million acres of public land.[1] Although disposal of federal lands in the West is no longer a national priority, miners can still acquire outright title to these lands through the mineral *patent* provision of the Mining Law. A land patent is a government deed that conveys legal title of public lands to the patentee—and thus patented mining claims are private property. The patent price has not changed since 1872, and critics argue that patents are land giveaways in which billions of dollars worth of public resources pass into private hands for a pittance. As an example, in 1993 American Barrick paid less than $10,000 to patent claims in Nevada containing an estimated $10 billion worth of minerals.

Even with this apparent windfall, the motivation for patenting mining claims is not entirely clear. First, a patent is not necessary to mine on federal land (that is, firms can extract minerals from *unpatented* claims). In other words, American Barrick had the option to extract the minerals without paying anything to the federal government. Second, obtaining a patent is more than a matter of putting cash on the barrelhead. Administrative and legal expenses add to the costs of acquiring a patent, and today the purchase price of $2.50 or $5 an acre accounts for as little as three percent of the total costs of acquiring a patent (Jeannes 1990). So why do claimants incur the expense and bother of acquiring full title to their claims?

In this paper I address this question by applying a property rights framework to the patent decision during the era of large-scale land disposal. I explain why the primary benefit of the patent was that it reduced the costs of enforcing claim rights. Specifically, the security of patented title discouraged nuisance litigation, resolved boundary disputes, and cleared up a number of other ambiguities that may have prompted litigation. These lower enforcement costs, however, come at a price. In addition to the administrative and legal costs of the patent proceedings, state and local taxes apply to patented claims but not to federal lands. Therefore, the decision to patent depends on whether the benefits of patented title warrant the outlays necessary to acquire and maintain that title.

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[1] There are several systems that govern the transfer of mineral rights from federal lands to the private sector. The Mining Law covers hardrock minerals, including gold, silver, copper, lead, zinc, and uranium. Fossil fuels and a number of fertilizer minerals are governed by various leasing acts. ''Common variety'' minerals, such as sand and gravel, are sold through the provisions of the Materials Disposal Act of 1947 and the Surface Resources Act of 1955.

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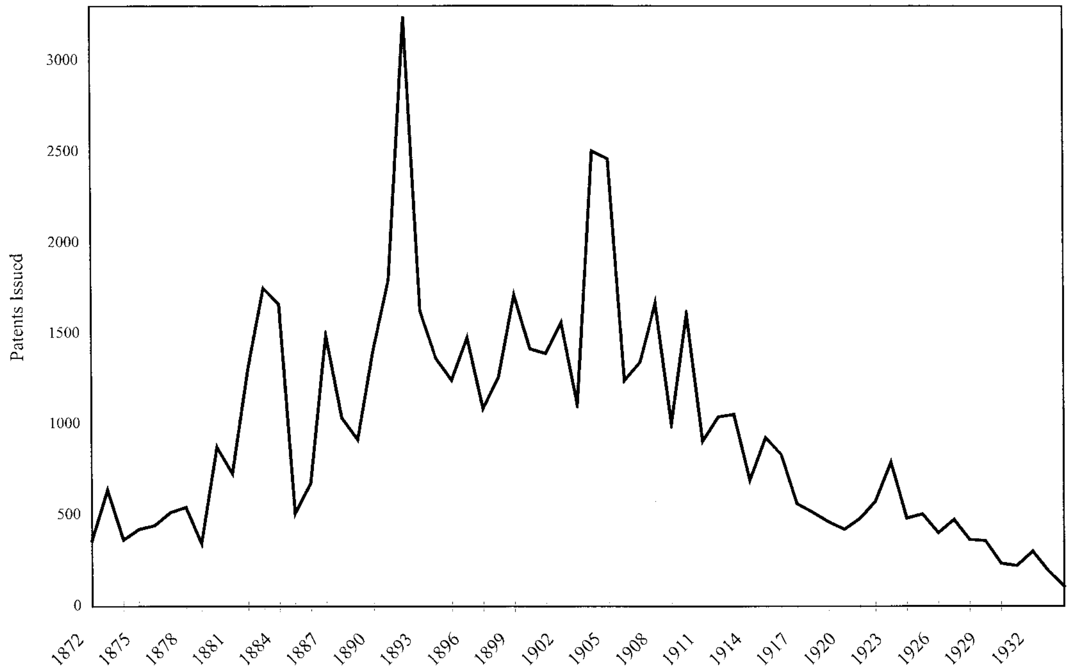

FIGURE 1
MINERAL PATENTS ISSUED, 1872–1934
Source: U.S. Department of the Interior, General Land Office

The application of the property rights framework also provides the key to an empirical puzzle associated with the history of mineral patents. Although thousands of patents were issued annually between 1872 and 1900, there was a steep decline in the number of patents issued following the turn of the century (see Figure 1). A conventional explanation is that the general shift in federal land-management priorities from disposal to retention accounts for the decline (Leshy 1987, 266).[2] It is argued that this shift increased administrative scrutiny of patent applications resulted in greater uncertainty and higher costs of the patenting claims. While this explanation has intuitive appeal, the decline in the annual number of mining claims patented preceded the shift in land-management practices by several decades.

An alternative explanation for the decline is that the benefits of title decreased. The western mining frontier was notorious for disputes and litigation, and frequent conflicts often led to high costs of defining and enforcing unpatented claim rights.[3] As claim disputes became less common, the costs of enforcing rights to unpatented claims decreased. Consequently, the benefits of title decreased and patent applications fell sharply. To evaluate this hypothesis I have

[2] The Taylor Grazing Act in 1934 effectively ended the era of large-scale federal land disposal. Between 1862 and 1934 it was typical for more than a million acres to be privatized each year under the Homestead Act alone (for instance, 2.8 million acres in 1934). Annual homesteaded acreage declined to less than 100,000 acres for each year after 1937. Gates (1968) is the standard reference for the history of public land law.

[3] The highest profile and most costly form of litigation involved *extralateral rights* of lode deposits, with litigation costs sometimes running into the hundreds of thousands of dollars (Spence 1970, 214–15). These cases, however, accounted for a small portion of mining disputes, however. For example, the 22-volume set of *Morrison's Mining Reports*, published from 1882 to 1906, contained 5,808 "important mining decisions." Of these decisions, only 115—less than two percent—were extralateral rights cases (Colby 1917, 311–12).

constructed a data set on claim disputes from the 12 major mining states and territories for the period 1882 to 1932. The transaction cost variables show that an increase in the costs of enforcing unpatented claim rights increased the demand for patented title.

Economic historians have recognized the central role of transaction costs and property rights to the development of the American West (Anderson and Hill, 1975, 1990, 1994). Not surprisingly, the nature of property rights and the costs of enforcing these rights played an important role in decisions to plant crops, graze livestock, harvest timber, and develop a mine site. The emphasis has recently carried over from historical to contemporary development issues, as economists analyze the links between secure land title and investment (Feder et. al. 1988; Feder and Feeney 1991; Besley 1995; Alston, Libecap, and Schneider 1996). This paper adds to these literatures, and also sheds light on the contemporary policy debate. In 1994 Congress placed a moratorium on the issue of patents, and Mining Law reform measures call for the abolition of the patent provision.

II. TRANSACTION COSTS AND THE VALUE OF TITLE

Property rights are the dimensions of control that agents have over assets—specifically, rights to use, derive income from, physically transform, and transfer control of an asset. The resources expended to define, enforce, and transfer these rights are transaction costs (Barzel 1989; Bromley 1989; Allen 1991). The importance of secure title can be illustrated by beginning with the assumption that transaction costs are zero (i.e., property rights are perfectly defined and enforced). The implication of zero transaction costs is that all of the attributes of an asset can be defined, enforced, and transferred at no cost. In such a setting landholders are *de facto* landowners, and formal title would literally be a formality. In the limiting case where transaction costs are zero the benefits of title are also zero. This assumption is obviously untenable: enforcing rights is often difficult, and restrictions on use rights and transferability are common. Such restrictions can prevent assets from being transferred to higher value uses, or limit the extent to which assets can be used as collateral. Where transaction costs are high the benefits of secure title can be substantial. Title can reduce enforcement costs, provide collateral for securing capital, and promote the market development. Of course, having title does not drive transaction costs to zero.

There is considerable theoretical and empirical support for the importance of title. For instance, Feder et al. (1988) and Feder and Feeny (1991) examine evidence on the relationship between land tenure and agricultural productivity in Thailand. These articles argue that titled land provides more security to borrowers and lenders, resulting in elevated demand and supply for investment funds. The development of appropriate public infrastructure, in particular, can reduce uncertainty in credit and land markets. Alternatively, Besley (1995) derives similar theoretical predictions with a straightforward neoclassical explanation in his examination of Ghana. If land title leads to lower foreclosure costs, it is easier for lenders to collateralize land. As a result, creditors can charge lower interest rates and investment expands. Alston, Libecap, and Schneider (1996) examine the supply and demand for title on the Brazilian Amazon frontier. They find that secure title reduces enforcement costs, provides collateral for securing capital, and promotes the development of land markets.

A salient characteristic in these cases is that the absence of formal title severely curtails the transferability of property rights, thus stymieing investment. In contrast, unpatented mining claims have long been recognized as secure property interests. An 1881 court decision, for instance, asserted that "a mining claim perfected under the law is property in the highest sense of that term" (*Belk v. Meagher* 104 US 279, 283 (1881)). Not only did robust markets develop for unpatented claim rights, there was also significant investment and development of mines on unpatented claims.[4] Therefore, the focus

[4] Montana Bureau of Mines and Geology (1935) shows development occurring on unpatented and patented claims alike. More recently, Jeannes (1990) "it

will be on the different costs of enforcing mineral rights to unpatented and patented claims.

III. INSTITUTIONAL SETTING AND PROPERTY RIGHTS STRUCTURE

In 1848, gold was discovered in California at about the same time that the United States acquired the territory from Mexico. The California territorial government abolished the Mexican mining codes, but did not establish any rules of its own. In response, miners formed local associations as a means to establish and enforce their own rules governing claim rights. These associations, however, proved to be an ineffective means for specifying rights to lode deposits (Umbeck 1981). Mineral lodes differed from the disseminated ore deposits characteristic of the gold placer deposits in California, as a single lode often extended beneath one or more adjacent claims. As a result, it was difficult to define rights based on surface boundaries. The legal morass and extensive litigation that followed the discovery of Nevada's fabulous Comstock Lode in 1859 led to demands for and implementation of territorial legislation and a body of common law that clarified procedures for defining and enforcing rights to the lodes (Libecap 1978).

Congress streamlined these camp customs and territorial laws with legislation in 1866 and 1870, and amended and codified these statutes with the Mining Law in 1872. Miners developed these rules in areas that had limited federal presence, and the resultant system predictably granted broad private discretion and required minimal involvement from land administrators—the General Land Office in the Department of the Interior.

The Mining Law provided *free access* to most unappropriated federal lands in the West, which allowed miners to explore for minerals, establish claim rights, and proceed with mineral development without governmental consent. Miners established rights through discovery and location.[5] After identifying a mineral deposit, miners established claim rights by marking claim boundaries, posting notice, and recording a claim with the county. This was known as *locating* a claim (claims were often called *locations* or *unpatented claims*). The maximum size for any single claim was approximately 20 acres, but claimants could stake or consolidate blocks of claims.[6] A miner that located a claim enjoyed exclusive rights to prospect, develop, and transfer rights to the mineral resources of the unpatented claim. Miners maintained these rights by completing $100 worth of annual *assessment work* (i.e., labor and improvements) on each claim. Claimants had the option to acquire outright title to both the land and minerals through the mineral patent provision. Consequently, the system is commonly called the *location* system or the *location/patent* system.

Enforcing Mineral Rights

The Mining Law left miners to resolve their disputes among themselves or through the courts, and disputes remained common even after the enactment of the Mining Law. A major problem was excluding others from "jumping" the claim. Because of active competition for claim rights, attempts to redistribute wealth, or differential beliefs about the current value of claims, third-party legal

would be inaccurate to overstate the vulnerability of title to a valid, perfected (unpatented) mining claim with respect to which the claim owner has strictly complied with all federal and state requirements . . . the fact that there are many major mines in commercial production today for which outside financing was arranged based entirely or substantially on unpatented ground certainly dispels the absolute necessity of a patent for financing." In 1990 federal lands accounted for 30% of gold, 29% of silver, and 24% of lead production. Estimates for 1993 range from $650 million to $1.8 billion in hardrock production from federal lands—that is, unpatented mining claims.

[5] Discovery is a common rule for allocating rights to unappropriated resource stocks (Lueck 1995). See Leshy (1987, Chapter 9) for an extensive account of the evolution of the discovery requirement under the Mining Law.

[6] The maximum allowable acreage depended on whether the claim was a lode or a placer. In 1872 claimants were limited to 160 acres, which prevented a single firm from monopolizing a site. The depletion of high-grade deposits and the developing scale economies in the mining industry brought about the need for greater tract sizes, and a series of court decision facilitated this need, and today there are no limits on the number of claims that an individual can stake and hold (Leshy 1987, Ch. 9).

challenges were ubiquitous. The assessment work requirement, in particular, was a common source of litigation. The scope of litigation included the time period within which assessment work could be completed, how the value of labor and improvements were to be estimated, whether work completed outside the boundaries of a claim could be counted, and what type of work qualified as assessment work. The courts, for instance, determined whether the following outlays could be counted toward assessment work: building of roadways, erecting buildings on mining claims, procuring and moving machinery, digging irrigation ditches, removing the water from a mine, paying a watchman, and building a smelting furnace (Lindley 1972, 1150–1222). Claimants that completed the annual work requirement were unlikely to lose claim rights in the courts, even where the work completed was of questionable importance to development (Lindley 1972, 1154).

Not all claims could be profitably developed, and as a result the $100 assessment work requirement, which accounted for approximately a month of labor in 1900,[7] often proved to be a burden: ''On those claims which were being actively worked a great deal more than one hundred dollars worth of work would be done annually; but on those claims which were not being actively worked, it required a well developed credulity to be able to find one hundred dollars worth of work or improvements in any one year'' (Davis 1937, 902). If the claimant completed the work in the course of developing a profitable claim, then that work was a component of production costs. Thus, the transaction costs associated with the work requirement were zero. If the claimant expended resources as a means to mitigate the possibility of forfeiting claim rights, then the outlays were transaction costs—the expenditure of resources to enforce property rights. Although such cases do not always provide a clear distinction between production costs and transaction costs, the decision to complete the assessment work for marginal claims depended on the need to maintain claim rights.

The alternative to holding an unpatented claim was to acquire outright title to the land and minerals by patenting the claim.[8] The more precise delineation of property rights provided by the mineral patent discouraged nuisance suits, resolved boundary disputes, and cleared up any number of ambiguities that may have prompted litigation (Costigan 1908, 306–7). There was no need for the claimant to complete assessment work on private land, and therefore the patent would extinguish further litigation over the assessment work. These factors suggest that the primary benefits of patented title related to costs of enforcing claim rights. Because patented claims are more secure than unpatented claims, it should also have been easier for firms to secure financing.

There were, however, substantial administrative and legal expenses associated with the acquisition of title. In addition to the purchase price for the land ($2.50 per acre for placer claims and $5 per acre for lode claims) patenting costs included payments to U.S. Deputy Mineral Surveyor ($50–75); U.S. Surveyor General office work ($30–35); application filing fee ($10); publication and notice of application ($20). These figures suggest the cost to patent 20 acres was $160–190 for a placer claim and $210–240 for a lode claim (Clark, Heltman, and Consaul 1897, 513; Costigan 1908, 679). The patent proceedings also typically required legal counsel (Van Wagenen 1918, 315–16).

Third-party challenges could lead to additional costs during the patent process. Within 90 days of the filing of a patent application, a rival interest (or interests) could assert rights to all or part of the tract of land contained in the application by filing an *adverse claim* in the Land Office. The contestant then had 30 days to take the case to court, where the winner secured land and mineral rights. Land Office officials could also challenge

[7] In New Mexico (1897) and Nevada (1900), for instance, state statutes stipulated that wage rates of $4 for an eight-hour day were to be used as a basis for evaluating whether assessment work had been completed.

[8] Claimants had to expend $500 in labor and improvements before patenting a claim. Thus, speculators could not locate and patent blocks of promising land without first making an investment in the claim development.

claim rights on the basis of a procedural mishap or in the absence of discovery, but such challenges were infrequent (Leshy 1987, 125–26).[9]

Finally, tax implications differed for unpatented and patented claims. State and local governments did not tax unpatented claims, which were part of the federal estate. Patented claims did not enjoy this exemption, and were taxed on the same basis as other private property—the assessed valuation based on acreage and the value of improvements (Van Wagenen 1918, 108). Thus, in addition to the costs of the patent process, patentees assumed a stream of present and future tax liabilities.

Transaction Costs and the Tradeoffs in the Patent Decision

There were a number of sources of transaction costs associated with enforcing unpatented claim rights. First, there were expected losses from forfeiture, especially if the assessment work had not been completed. Second, the threat of forfeiture led claimants to expend resources that did not further development in order to enforce their claim rights. Third, there were costs of negotiating or litigating claim disputes. A principal benefit of the patent was that these transaction costs were avoided.[10] On the other side, the costs of patenting were the purchase price of the land, the administrative costs and any uncertainty associated with the patent proceedings, and the state and local tax liabilities that applied to private property.

A significant implication of these tradeoffs is that as costs of enforcing rights to unpatented claims increased, the net benefits of the patented title also increased. To illustrate, consider the case where there was no chance of a claim dispute. In this case there was no possible costs of losing the land in a dispute, and therefore no bargaining or litigation costs. Moreover, the claimant would not have to complete the assessment work for an unprofitable claim to maintain rights if there was no chance that a rival claimant would overstake the land. In a zero transaction cost world, there would be no benefits of patenting.

This is consistent with the dynamics of many disputes (e.g., *Turner v. Sawyer* 150 U.S. 578 (1893) and *De Lamar v. Nesbitt* 177 U.S. 523 (1900)). Claimants engaged in litigation over unpatented claim rights often attempted to patent the claim as a means to resolve the issue. The opposing party would then file an adverse claim against a patent application to the land in question. Because the bulk of disputes involved unpatented claims, the expected costs of fighting one or more disputes over unpatented claims would be higher than future disputes over patented claim rights. Thus, if there was no possibility of a challenge to claim rights, then there was little incentive for a claimant to seek title. Once claim rights came into question, however, the claimant had the incentive to use the

[9] Examining the validity of mineral patent applications (i.e., whether a discovery had been made) was a low administrative priority in the Land Office. Overall, almost every patent application was approved by the Land Office. In California, for instance, there were, 5776 patent applications and 5557 mineral entries for the period 1882 to 1932 (an entry is a patent application that was approved).

[10] The use rights of the unpatented claim were restricted to mineral prospecting and development: patented claims were private property, and therefore use rights expanded considerably. Although Mining Law history is colored with stories of abuses, the incentive to acquire mining claims for non-mining uses during the land-disposal era was limited by the availability of cheaper alternatives. Under the Timber and Stone Act of 1878, for instance, individuals could purchase up to 160 acres of timberland at $2.50 per acre. Alternatively, claimants could acquire 160 acres of using the Preemption Act or the Homestead Act at $1.25 per acre (subject to residence requirements). To acquire the same amount of land through the Mining Law required locating at least eight claims, expending $500 per claim on development, incurring the administrative and legal expenses of the patent proceedings, and paying the premium price of $2.50 or $5 an acre. The exception was the reservation of the National Forests from disposal under these other land laws. As a result, the Mining Law became the only means to acquire title to these lands. The use of the Mining Law to acquire timber stands, however, was restricted by two factors. First, a court decision prohibited commercial timber harvesting from unpatented claims (*Teller v. United States* 113 F. 273, 280 8th Cir, 1901)). Second, it was easy for the Forest Service to identify and cancel patent applications where the land contained valuable timber stands. Between 1910 and 1937 the Forest Service in California was successful in 90% of the cases where it contested a patent application, invalidating 9,733 of 10,895 acres in question (Friedhoff 1944).

patent process to resolve current disputes, and also extinguish potential future disputes.

On the other hand, the net benefits of patented title decreased when the costs of acquiring or maintaining a patent increased. Increases in either the administrative costs of the patent process or in expected property tax liabilities increased the effective price of acquiring a patent, decreasing the quantity of patents demanded.

Metals prices and politics, particularly silver policies, had pronounced impacts on western mineral development. Even so, there is no clear prediction for how fluctuations in metals prices affect the patent decision. Although we expect agents to expend resources specifying rights to an asset when the value of that asset increases, the lower expected costs of disputes from patenting are always offset by the increase in tax liabilities associated with private land. The benefits of patent increased where costs associated with enforcing rights to an unpatented claim increased. In contrast, the benefits of title decreased when the costs of acquiring and holding a patent increased.

IV. DESCRIPTION OF DATA AND VARIABLES

Although tradeoffs in the patent decision are at the individual level, the available data are aggregated at the state (or territory) level. Claim records were kept only at the county level until 1979, and thus there are no reliable data on unpatented claims.[11] Observations are from Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, and Washington for 1882 through 1932 and from Alaska for 1888 to 1932.[12]

The dependent variable is the number of patent applications filed within state i during year t ($Applications_{it}$). Summary statistics for *Applications* are in Table 1. The number of applications will be estimated as a function of metals production, metals prices, and several transaction costs variables. The estimates are generated with and without a time trend. The explanatory variables and their sources are summarized in Table 2.

Congress waived the assessment work requirement several times during the sample period, and *Waiver* is set equal to one in these cases. The first waiver was enacted during the depression years of 1893 and 1894 for all states except South Dakota. A second waiver covered all states during World War I (1917–1919). Finally, the work requirement was waived again from 1931 to 1937. The waiver decreased the cost of compliance with the work requirement for inactive claims. Thus, the expected signs for the wavier variables are negative.

A measure for the intensity of disputes, $Ratio_{it-1}$, is the rate of disputed patent applications. The inclusion of the variable is intended to proxy the level of disputes over unpatented claim rights. The variable is constructed as the ratio of adverse claims to patent applications in state i during period $t-1$. Summary statistics are in Table 3. There were instances where more than one party filed an adverse claim against a single patent application, and consequently *Ratio* exceeds one in some cases. Disputes in the previous period signaled claimants concerning the probability of dispute in the current period, and the lagged variable also mitigates potential endogeneity. The higher probability of dispute increased the value of title, and thus the expected effect is positive.[13]

Different levels of metal production across states are controlled for using current and lagged values of gold, silver, and copper

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[11] For the most part, the number of active unpatented claims that existed prior to the enactment of the federal recording requirement in 1979 is a mystery. The U.S. General Accounting Office (1974), for instance, cites an estimate that six million mining claims were filed between 1872 and 1962. Claimants filed fewer than one million claims in 1979, however. Even an exhaustive search of county records would not reveal whether an unpatented claim was active or abandoned.

[12] Data are for the Dakota territory through 1890, and for the state of South Dakota thereafter. I exclude Wyoming because of the dominance of disputes over oil claims for the latter years of the sample period (Gerard 1998).

[13] The *Ratio* variable literally measures disputed patent applications, not disputes over unpatented claims. The justifications for using *Ratio* are (1) it is the only consistent measure of claim disputes available; and (2) the rate of challenges to unpatented claims was likely to be highly correlated with the rate of challenges to patent applications.

TABLE 1
ANNUAL PATENT APPLICATIONS BY STATE/TERRITORY, 1882–1932

	N	Mean	Std	Min	Median	Max
Alaska	45	31	24	0	26	111
Arizona	51	68	43	0	58	195
California	51	113	43	33	109	213
Colorado	51	420	387	17	335	1583
Idaho	51	56	29	16	50	155
Montana	51	138	78	9	142	307
Nevada	51	57	62	4	37	273
New Mexico	51	32	20	2	28	96
Oregon	51	15	11	1	12	48
South Dakota	51	34	35	0	24	11
Utah	51	96	57	0	100	29
Washington	51	20	19	0	13	76
Total	606	90	159	0	44	1,583

Source: U.S. General Land Office.

TABLE 2
EXPLANATORY VARIABLES

$Gold_{it}$, $Gold_{it-1}$ = natural logarithm of gold output, in ounces, in state i during years t and $t - 1$.
Copper = natural logarithm of copper output, in pounds.
Silver = natural logarithm of silver output, in fine ounces.
$Waiver_{it}$ = years and locations where Congress waived the assessment work requirement.
$Ratio_{it-1}$ = ratio of the number of adverse claims filed to the number of patent applications filed within state i during period $t - 1$.
Copper Price = natural logarithm of the real copper price.
Lead Price = natural logarithm of the real price of lead.
Silver Price = natural logarithm of the real silver price.
Gold Price = natural logarithm of [\$20.67/Price Level (t)].
Time, 1882 = 1.

Notes: Patent applications and adverse claims are from the U.S. Department of the Interior's *Report of the Commissioner of the General Land Office to the Secretary of the Interior* and the *Annual Report of the Secretary*. Mineral production figures are from the U.S. Geological Survey *Mineral Resources of the United States*. Mineral prices and the wholesale price index are from Manthy (1978) and *Historical Statistics of the United States* (1979).

production. Increases in mineral output over time are expected to lead to more patent applications. Measures of wholesale prices and metals prices are also included. *Price Index* is the wholesale price index. An increase in the price level would decrease both the real cost of acquiring a patent as well as the nominal \$100 cost of completing assessment work. Therefore, there is no clear prediction for *Price Level*. Real prices of gold, silver, lead and copper are also included. The price of gold was fixed at \$20.67 an ounce, and thus the effective price of gold was (\$20.67/*Price Index*).[14] The other price variables are also constructed using nominal metals prices deflated by the price index. The metal prices are included to control for the change in claim value, and thus the prediction for the change in the metal price variables is ambiguous.

[14] The estimated model uses the natural logarithm of the explanatory variables, and *Price Index* and *Gold Price* are perfectly (negatively) correlated. In 1934 the federal government raised gold prices to \$35 per ounce on the theory that an increase in the gold price would lead to an increase in the general price level.

TABLE 3
ANNUAL RATIO OF ADVERSE CLAIMS TO PATENT APPLICATIONS, 1882–1932

	N	Mean	Median	Max[a]
Alaska	45	.29	.06	5.57
Arizona	51	.10	.06	1.00
California	51	.08	.07	.25
Colorado	51	.16	.11	.73
Idaho	51	.12	.10	.33
Montana	51	.10	.10	.24
Nevada	51	.13	.08	.70
New Mexico	51	.11	.07	1.08
Oregon	51	.09	0	2.00
South Dakota	51	.13	.06	.61
Utah	51	.17	.15	.58
Washington	51	.09	.05	1.00
Total	606	.13	.08	5.57

Source: General Land Office.
[a] Minimum values ranged from 0 to 0.02.

The inclusion of a time trend might pick up several effects. For instance, a productive site could be operated for years, and improvements in mining technology often allowed for the profitable working of abandoned projects and waste piles. The introduction of the cyanidation process in 1890, for instance, led to extensive reworking of thousands of previously mined sites (Young 1970, 285). A site could only be patented once, and over time many of the most promising sites were transferred to private ownership. Therefore, there should be fewer patent applications over time. In addition, private contracting efforts and increased precision of the common law (as evidenced, for instance, by the clarification of what constituted assessment work) might have reduced the intensity of claim disputes over the course of the period. Another possibility is that continued western settlement and development brought more reliable courts for dispute resolution, reducing the costs of establishing and enforcing rights. The reduction in enforcement costs for unpatented claims, which were dependent on interpretation of local rules, may well have been larger than for patented claims. There is no way to distinguish between these alternatives, but each of these factors suggests a negative time trend.

Although there are no direct measures for the costs of the patent proceedings, the Land Office began to hire mineral examiners in 1917. If hiring these examiners reflects the changing attitudes toward disposal of the public domain, then there would be greater administrative scrutiny of the validity of patent applications (Leshy 1987, 125–26). As a result, both the cost and the uncertainty of the patent process would increase. Thus, I include a dummy variable to determine whether levels of patent applications were lower for the period after 1917.

V. ESTIMATION PROCEDURES AND RESULTS

Unfortunately, I cannot directly estimate the patent decision using a discrete choice model because disaggregated claims data do not exist.[15] A grouped logit or probit specification with the dependent variable as the ratio patent applications to the stock of unpatented claims would be the equivalent model for aggregated data, but data on the stock of unpatented claims are limited. So while the patenting rate is the appropriate dependent variable, I estimate the model using the level of patent applications.

The underlying assumption is that the stock of unpatented claims is relatively stable over time. Because of the great expansion of western mineral production during this period, it is plausible that the stock of unpatented claims was increasing. Patented claims, however, were removed from the stock of unpatented claims (and also from

[15] I tried unsuccessfully to disaggregate the data. Unfortunately, Land Office level data for patent applications, adverse claims, and claim size cannot be directly linked to county production figures because of overlapping jurisdictions. To illustrate, Teller county in Colorado was a prominent source of mineral production, and it was located in two Land Office districts: Leadville and Pueblo. The Pueblo Land Office, however, also served the mineral-producing counties of Pueblo, Saguache, Herfano, and Fremont. Many of these counties were also located within the jurisdiction of more than one Land Office (e.g., Saguache was in the Gunnison Land Office, along with the mineral-producing counties of Gunnison, Ouray, Mineral, Hinsdale, and Chaffee). This gives 3 Land Offices and 10 counties, but no way to attribute production to the specific Land Offices.

federal ownership), and so it is not clear that the underlying assumption is legitimate. There is, however, almost no information on the stock of unpatented claims. If the stock was increasing, the coefficients underestimate the effects of the explanatory variables on the patenting rate.[16]

The data are a cross-sectional, time-series, and the dependent variable is a count of the number of mineral patent applications in state *i* in period *t*. Pakes and Griliches (1980) and Hausman, Hall, and Griliches (1984) develop estimation procedures for data with these characteristics in their examination of the number of patents for inventive activity. I follow their preliminary strategy of specifying a log-log functional form for the equations. There is a problem with using logged data where variables take on a value of zero. In 17 cases where the number of patent applications was zero, the dependent variable is set equal to one (where the natural logarithm of one is zero). In these cases a dummy variable, *Zero Applications*, is assigned to observations where the number of applications was zero. The dummy variable differentiates between values of 0 and 1. Although other estimation procedures, such as Poisson and negative binomial specifications, explicitly account for the counting properties of the data, the continuous approximation should suffice where the dependent variable is disperse and takes on large values.

The estimates are obtained with a fixed-effects model, which estimates a common vector of slope coefficients, and accounts for unobserved differences across states using state-specific intercept terms. Kennedy (1994) suggests that cases where the data exhausts the population, the fixed effects specification is more appropriate than a random effects model because it produces results conditioned on the units in the data set. This is my rationale for presenting the fixed effects results.[17]

Results

Because the inclusion of a trend variable often accounts for much of the variation in time series regressions, the panels are estimated with and without the time trends. Table 4 reports the results.[18] The signs of the estimated coefficients of the metal production variables are generally positive and statistically significant, indicating that increases in production levels over time resulted in more patent applications.[19]

The estimated coefficients for $Ratio_{it-1}$ and $(Ratio_{it-1})^2$ show a positive relationship between the rate of claim disputes and the level of patent applications over time. An increase in disputes—and the transaction costs of enforcing rights—increases patent applications. The marginal effects are positive where $Ratio_{it-1} < 1.91$, which was the case for all but two of the 594 observations. More important, the parameter estimates are not sensitive to the inclusion of the time trend. Figure 2 plots patent applications and the ratio of adverse claims to applications for the sample period. There appears to be a substantial downward trend after 1900. The intensity of disputes declined steadily over the course of the period, and as a result the demand for patents also decreased.

The coefficient estimates for the *Waiver* variables are consistent with the hypothesis that the expected value of title was a function of the costs of holding the claim. The coefficient estimates for the first two waivers show

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[16] One estimate, pieced together from various sources, is that between 1937 and 1952 the stock of unpatented claims increased by 9% in the National Forests in California, even though 9,400 acres were patented.

[17] In practice, the fixed and random effects specifications elicited almost identical estimates. Moreover, the results of time-series, cross sectional models (both linear and log-log) with heteroscedastic and autocorrelated error structures elicited qualitatively similar results to the log-log, fixed effects model.

[18] The coefficient estimates for the fixed effects use Alaska as a baseline. Six of the eleven coefficients are significant at the 10% level or higher when the time trend is included, and fiver are significant when the trend variable is omitted. The state of Montana has the lowest estimated effect (−0.65) relative to the Alaska baseline; whereas Washington has the highest estimated coefficient (0.56). There does not appear to be systematic relationship between overall patent activity and the sign and significance of the fixed effects. Colorado, for instance, had by far the most patent applications, yet the coefficient is not significantly different than zero.

[19] The coefficient estimates were similar for models where lagged production variables were omitted, while estimates of two-period lags were not statistically significant.

TABLE 4
MODEL ESTIMATES

Dependent variable: Ln (Applications$_{it}$) *t*-statistics in parentheses		
Ln (Gold$_{it}$)	−0.03	−0.03
	(0.54)	(0.62)
Ln (Gold$_{it-1}$)	0.19	0.17
	(3.40)*	(2.90)*
Ln (Silver$_{it}$)	0.21	0.22
	(3.87)*	(3.94)*
Ln (Silver$_{it-1}$)	0.09	0.07
	(2.13)**	(1.53)
Ln (Copper$_{it}$)	0.04	0.04
	(3.70)*	(3.36)*
Ln (Copper$_{it-1}$)	0.02	0.02
	(1.72)***	(1.77)***
Ln (Gold Price$_{t-1}$)	−0.04	−0.03
	(1.66)***	(0.10)
Ln (Silver Price$_{t-1}$)	−0.79	0.87
	(2.68)*	(7.36)*
Ln (Copper Price$_{t-1}$)	0.34	0.14
	(1.84)***	(0.80)
Ln (Lead Price$_{t-1}$)	0.58	0.57
	(2.82)*	(2.66)*
Ratio$_{it-1}$	0.37	0.47
	(1.84)***	(2.30)**
(Ratio$_{it-1}$)^2	−0.10	−0.11
	(2.24)**	(2.55)**
Waiver (1894–1895)	−0.39	−0.44
	(2.77)*	(3.07)*
Waiver (WWI)	−0.55	−0.52
	(3.87)*	(3.56)*
Waiver (1931–1932)	−0.10	0.15
	(0.58)	(0.85)
Year = 1918–1932	−0.27	−0.33
	(1.64)	(1.95)***
Time	−0.06	
	(6.12)*	
Zero Applications	−2.18	−2.15
	(12.70)*	(12.17)*
N	594	594
Adjusted R^2	0.80	0.79
	$F_{29,564}$ = 83.29*	$F_{28,565}$ = 79.92*

* Significant at 99% level; **significant at 95% level; ***significant at 90% level

a 35 to 37% reduction in applications during waiver years. In effect, the decrease in holding costs decreased both the benefits of title and the demand for patents. Visually, the effect is especially pronounced in 1894 and 1895, and again in 1918 and 1919 (see Figure 2). The spike in *Ratio* during the first waiver years perhaps indicates that the only claims where patent applications were filed had ongoing litigation over unpatented claim rights.

The coefficient estimates for *Lead Price* and *Copper Price* were positive, indicating that the level of applications increased when base metal prices increased. As the asset value appreciates, claimants were more willing to expend resources to secure rights. The positive sign, however, was not universal. The sign of the *Silver Price* coefficient was sensitive to the inclusion of the time trend, likely due to the high correlation between the two variables. The estimates for *Gold Price* and *Price Index* were not statistically significant, possibly due to the confounding effects picked up in these variables.[20]

The estimates for *Time* suggest a 6% annual decrease in the rate of patent applications. Explanations for this trend may include the privatization of many of the most productive lands[21] and the decrease in disputes over the course of the period. The estimated effect of the dummy variable for 1918–1932 was also sensitive to the incision of the time trend. When the trend variable is included, the coefficient is not statistically different than zero. When the trend is not included, the coefficient is significant at the ten percent level, and suggests a 30% reduction in the level of patents after 1917.

Why Did Patenting Decline?

The results are consistent with the hypothesis that applications declined prior to 1932 largely because the *benefits* of secure title decreased. Claimants chose whether or not to

[20] The price variables were the least robust across alternate specifications (e.g., linear) and error structures. The signs and significance levels of *Silver Price* in particular were sensitive to the model specification.

[21] I tried two other ways of measuring the depletion effect. Estimated coefficients for variables measuring the cumulative number of patents issued and the cumulative acres patented within each state were not statistically significant. I also examined the possibility that the number of patents decreased because the acreage encompassed in patent applications increased. I tested this by estimating a model with *Entry Acres* as the dependent variable. The simple correlation between *Entries* and *Applications* is .97, indicating that *Entry Acres* is a reasonable approximation for the amount of acreage encompassed in patent applications. The signs and magnitudes of the estimated coefficients were similar for most of the explanatory variables where *Applications* was the dependent variable.

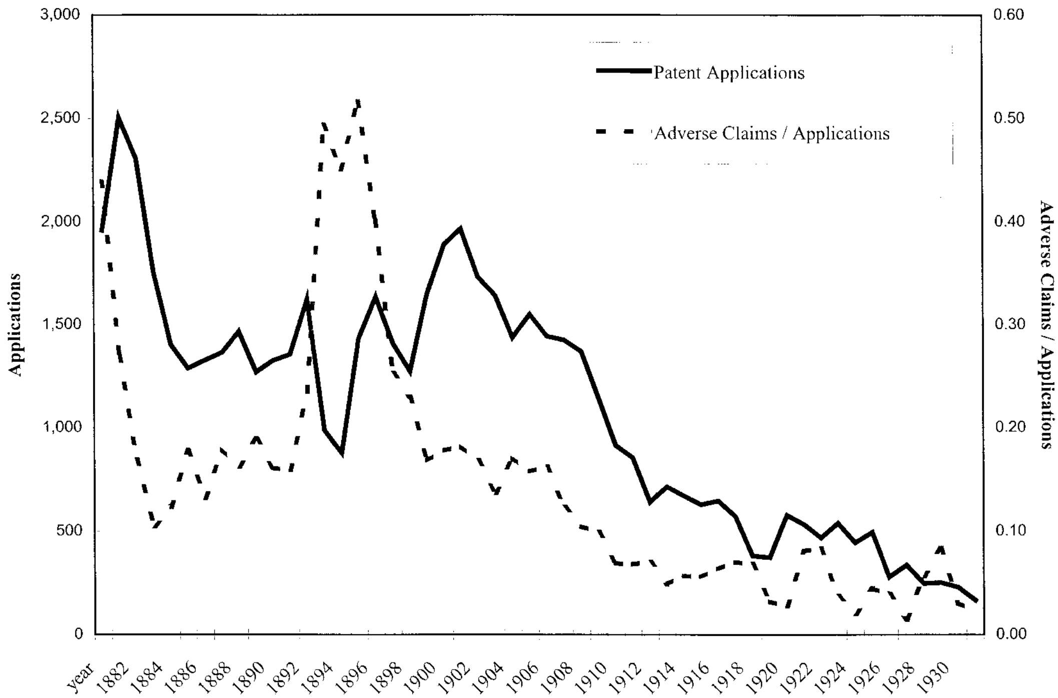

FIGURE 2
Patent Applications and the Ratio of Adverse Claims to Applications, 1882–1932

apply for a patent based on the benefits and costs of acquiring title, and the results suggest that benefits were higher when disputes were frequent. As disputes became less common, the benefits of title declined. Claimants likely produced from unpatented claims or became more lax in their performance of assessment work on marginal claims rather than incur the expenses of the patent proceedings.

The conventional wisdom, however, is that patent applications declined because patenting *costs* increased. According to Leshy (1987, 266):

> The decline in patenting is explained by . . . limitations placed on the applicability of the Mining Law through withdrawals, and a government-wide shift in orientation from land disposal to land retention (manifested in such things as providing agencies with authority to contest claims and applying a more exacting standard of proof of discovery).

The logic of this analysis is that the net benefits of title decreased as patenting costs increased, and the empirical evidence lends some support to this contention. Clearly, there is more to the story. By the time the administrative authority to contest unpatented claims was solidified in 1920, the downward trend of patent applications had already begun.[22] The explanation also attributes the steep drop-off in patents in the 1930s "when the policy of retention took firm hold" (Leshy 1987, 266), thus ignoring the probable impacts of the extended assessment work waivers. Congress waived the work requirement from 1931 to 1938, and again from 1941 through 1950. The waiver effect may have been compounded if claimants began to incorporate expectations of a waiver into their decision calculus.

[22] In *Cameron v. United States* 252 U.S. 450 (1920), the Supreme Court nullified unpatented claims that (then Arizona Senator) Ralph Cameron had staked and maintained at access points of the Grand Canyon. Until *Cameron* the agency authority to contest and cancel unpatented claim rights was not clear.

VI. CONCLUSION

Property rights over assets are the rights to use, derive income from, and exchange rights to an asset. The degree of control an agent has to an asset—and thus the value of that asset—depends on the transaction costs of specifying and enforcing property rights. Secure title often lowers these costs. The value of title depends on (1) the relative costs of enforcing rights to titled and untitled land; and (2) the costs of securing and maintaining title.

In many cases, of course, property rights to untitled lands, including unpatented mining claims, are tenuous. While the empirical content of this paper concerns private disputes, today costs are more likely to be related to legislative or administrative changes. During the early 1990s, for instance, Congress contemplated imposing a production royalty. Such a tax, however, could not be imposed retroactively on patented holdings, and the value of patented land increased relative to unpatented land. As a result, many firms operating from unpatented claims chose to patent their holdings. The patent and production royalties are not the only targets of reform. Critics also argue that the Mining Law allows for too little administrative discretion over mining activity and lacks adequate environmental protection measures, and there has been pressure to overhaul the Mining Law. Because there is a good deal of uncertainty in the current legislative environment, firms have the incentive to patent claims in order to secure the long-term value of rights to extract and produce minerals now in federal stewardship.

There are a number of reasons why the patent has been used less frequently since the early part of the century. Privatization of many of the most productive lands and changes in institutional conditions limited the scope of the Mining Law. Nevertheless, federal lands in the western United States are a major source of domestic mineral potential, and the patent may still serve an important role in fostering development. Mineral development decisions often cover long planning horizons, while legislative, administrative, and market conditions can change year to year. Thus, the patent provides the means for securing financing or reducing the uncertainty of the planning horizon in an otherwise uncertain environment.

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