Estimating the Credibility of the Co-operative Commonwealth Federation's Threat to Nationalize Oil Resources in Saskatchewan*

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September 2012

Abstract

We examine the validity of the commonly held view that the ideology and policies of the Co-operative Commonwealth Federation (CCF) governments in Saskatchewan (1944 - 1964) retarded the development of Saskatchewan's oil and gas resources. We develop a model to value land with an exhaustible resource under uncertainty. The uncertainty comes from a positive probability of expropriation with zero compensation. This research adds to the existing literature as the model results in the derivation of a simple equation that allows identification and estimation of the effect of expropriation risk, given appropriate data are available. The model is used to evaluate the effect of the CCF on the natural resource industry in Saskatchewan. The tenure of the CCF is used as a proxy for the perceived probability of expropriation. The results indicate the CCF government did affect expenditure on mineral rights in Saskatchewan. More precisely, the effect of the CCF was to reduce the discounting of current profits in determining the value of land, which decreased expenditures on land. The expropriation threat did not reduce investment in production, but did reduce willingness to pay for mineral rights relative to Alberta.

JEL Codes: N52, N92, Q48
Keywords: exhaustible resources, government policy, development of Saskatchewan

*We wish to acknowledge financial support from the Institute for Advanced Policy Research at the University of Calgary. We thank seminar participants at the University of Calgary and the Queen's University Economic History Conference.
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1 Introduction

Governments and their policies have the potential to significantly affect economic development. These policies can include preferential tax treatment, openness to foreign investment, and security of property rights. Without secure property rights, industries that require large amounts of capital relative to labour will be underdeveloped. Moreover, there is the possibility of expropriation: firms face the risk that they will not earn a return on their investment, or that the investment itself will be seized. This risk leads to lower levels of investment, and lower development, which has a detrimental effect on growth. In industries that use large amounts of labour relative to capital, insecure property rights can lead to over-development and over-extraction of resources (Bohn and Deacon, 2000). The risk that land or resources can be expropriated causes firms to extract faster. This can lead to suboptimal and possibly inefficient exploitation of the resource.

Political stability is an important determinant of secure property rights. It is often the case in developing countries that insecure governments are unable to enforce property rights effectively, or will themselves expropriate foreign investments. However, political stability is not the only determinant of secure property rights. Often, it is the political ideology of the government in question that will determine whether or not the government will choose to expropriate property or resources. There are several examples of this in recent world events. In Russia in 2004, Yukos was charged with tax evasion, which resulted in the forced sale of its assets. Yukos was subsequently purchased by the state-owned firm Rosneft.[1] Since early 2007, the Venezuelan government has been gradually nationalizing foreign-owned oil production.[2] In both cases, it is obvious that there is a threat of expropriation from the respective governments, but it is difficult to identify the probability of this threat being realized, or the effects it has on the economy due to other confounding factors. These include general political instability and poor data sources. Foreign investment has been shown to be very important for growth in developing countries, and the threat of expropriation reduces investment. Jones (1984) finds occurrences of expropriation by the Venezuelan government (1961-

[1]See the Council of Europe Resolution 1418 (2005): "The circumstances surrounding the arrest and prosecution of leading Yukos executives" at `http://assembly.coe.int/Documents/AdoptedText/TA05/ERES1418.htm`.

[2]See the article at "Factbox: Venezuela's state takeovers under Chavez" at `http://www.reuters.com/article/2011/04/26/us-venezuela-nationalizations-idUSTRE73P7N620110426`.

1978) were positively linked to foreign corporate income, and were negatively linked to changes in the economic growth rate.

The risk of expropriation, and its consequences, is an extreme version of the taxation policies employed by most governments. Lack of commitment to a tax structure is an example of expropriation. In this paper, a different type of non-commitment is studied, where a government is unable to commit to property rights. Several scholars and politicians argue that the ideology and policies of the Co-operative Commonwealth Federation (CCF) governments in Saskatchewan from 1944 to 1964, including an alleged expropriation threat, retarded the development of Saskatchewan's oil and gas resources (Richards and Pratt, 1979; MacKinnon, 2003). MacKinnon suggests that many business people and right-of-centre politicians feel the socialists in Regina rather than oil in Alberta had more to do with Saskatchewan's perceived under-performance. Since 1950, a significant portion of Western Canada's wealth has been generated by the oil industry, and the provinces have jurisdiction over mineral rights.[3] Provincial government policy could have a significant effect on the level of private investment in the resource sector, and consequently, the wealth of the province.

The literature demonstrates that the threat of nationalization and/or expropriation of assets without compensation can lead to underinvestment in the country where the threat is present, as well as sub-optimal extraction of resources.[4] As these outcomes could also arise from less extreme policies like higher tax rates, or other economic fundamentals of a resource economy, a more difficult challenge is quantifying the credibility of the threat. Quantifying the credibility allows us to determine whether or not the threat is the cause of poor economic outcomes. The purpose of this paper is to develop a model of land value when the land contains a natural resource stock, and there is a risk of government expropriation. An estimating equation is derived from the model, which allows identification of the effect of an expropriation risk. The model is taken to data from Saskatchewan and Alberta to evaluate the effect of the CCF on Saskatchewan's development. The question of interest is whether or not the expropriation risk was perceived as credible, and if

[3] While both Saskatchewan and Alberta produce oil and natural gas, the greater importance of energy resources for Alberta is clear. Alberta is the 9th largest producer of oil in the world and the 3rd largest natural gas producer. Within Canada, Alberta produces 55% of Canada's conventional crude oil. Saskatchewan is Canada's second largest producer of oil in Canada, producing 20% of Canada's conventional crude oil.

[4] See, for example Long (1975); Geiger (1989); Melese and Michel (1991); Konrad et al. (1994); Bohn and Deacon (2000); Jacoby et al. (2002).

so, what effect it had on the development of the petroleum industry in Saskatchewan.

A key assumption is that any credible expropriation threat would have been priced into the value of government land lease sales. Leases and exploratory permits in Saskatchewan are sold in first-price, sealed-bid auctions. This is a reasonable measure for quantifying an expropriation risk as the amount firms pay for land should reflect the net present value of expected profits from oil reserves it may contain. Moreover, Winter and Boyce (2011) predict that the response by firms to (expected) lack of commitment by the government should be to reduce the up-front payment. Expropriation is an extreme form of the lack of commitment discussed in Gaudet et al. (1995) and Winter and Boyce (2011), but the intuition remains the same.

We find the contemporaneous value of land depends on the value of land, profits, and the change in reserves in the previous period. The estimation results are inconclusive regarding a perceived risk of expropriation occurring in Saskatchewan during the threat period. However, subsequent analysis shows a positive risk premium during the tenure of the CCF. Through subsequent regressions, we find that the CCF had a positive effect on exploration effort and oil production in Saskatchewan. This suggests that the main effect of the CCF's early policies was to reduce the value of the fixed factor, land. Overall, it would appear that the CCF caused no harm to the long run development of the province's oil and gas resources.

The risk of expropriation has been studied in several contexts, with articles typically concentrating on government behaviour (Jones, 1984; Picht and Stüven, 1991), firm behaviour (Long, 1975; Melese and Michel, 1991) and a more macro-based analysis of investment responses (Eaton and Gersovitz, 1984; Geiger, 1989). Empirical articles, such as Jones (1984) and Davis (2001) focus on estimating probabilities of expropriation or predicting the effects of political actions. This paper is most closely related to Long (1975); Melese and Michel (1991); Bohn and Deacon (2000) and Davis (2001). Long (1975) studies how the threat of nationalization affects the extraction path of an exhaustible resource, finding extraction occurs faster under uncertainty, and starts at a higher rate, relative to the optimal extraction path with certainty. The issue of uncertainty in tax policy is visited by Melese and Michel (1991), who model the effects of expected tax reform on production of an exhaustible resource. In contrast, we empirically test how a threat of expropriation affects the value of land with an exhaustible resource. Expropriation can be considered equivalent to a tax rate of 100%. Bohn and Deacon (2000) model the effect of insecure ownership on investment and natural resource use. They conclude that the relationship between natural resource use and economic growth is likely to be resource-specific and depend critically on the capital intensity of resource extraction. Davis (2001) estimates the credibility of the African National Congress' threat to nationalize South African mineral assets in the 1990s. Davis finds the value of mines decreased but extraction levels were unchanged. The model presented in this paper is similar to that presented by Davis (2001), but is simpler and more tractable.

The layout of the paper is as follows. Section 2 discusses the history of the Saskatchewan resource industry and the CCF party. Section 3 develops the model and presents the empirical specification. Section 4 describes the data and analyses the results. Section 5 concludes.

2 History of the Early Petroleum Industry

In February 1905, the Canadian government introduced legislation that created two provinces out of the Northwest Territories. A North/South border was positioned that created two provinces roughly equal in size by area (650,000 square kilometres) and population (approximately 250,000). Ownership of mineral rights were transferred from the federal to provincial governments in 1930 (Boothe and Edwards, eds, 2003). The economies remained largely agricultural, and the incomes and populations of the two provinces were roughly equal until after the Great Depression. The provinces' shared experiences of economic devastation, drought and out-migration during the Great Depression impressed upon their governments the need to diversify their economies away from agriculture.

The approaches toward economic diversification would prove to be vastly different, particularly with respect to public policy toward the emerging oil and gas industry. The Social Credit government in Alberta favoured policies that encouraged external private capital to locate in the province. In Saskatchewan, the Co-operative Commonwealth Federation embarked on an economic program initially favouring nationalization and public ownership of natural resources and key industries. The resources of the province were to be developed to benefit the citizens of Saskatchewan, rather than "external capitalists" (Co-operative Commonwealth Federation, 1933).

Prior to the discovery of the large oil pool at Leduc in 1947, relatively little crude oil was produced in Alberta and virtually none in Saskatchewan.[5] Natural gas was produced in small quantities in Alberta but no substantial quantity of gas would be produced in Saskatchewan until the late 1950s. The market power of private energy producers played a substantial role in shaping public policy. The provincial governments lacked the necessary capital to develop the resources. Further, the risks inherent in oil and gas exploration proved unpalatable for provinces emerging from the debt problems of the 1930s, particularly as it was not obvious that there was an external market for oil (Hanson, 1958; Richards and Pratt, 1979; Johnson, 2004). Britnell (1953) expressed scepticism that the provinces would find an export market for their high cost oil. Finally, as domestic sources of capital were not well developed, external private capital that produced the oil had credible exit threats.

2.1 Alberta's Policies

In Alberta, the Social Credit government (1935-1971) sought to diversify the economy by building upon the nascent oil industry that had been established as a result of the small, and by then declining, production in Turner Valley. To do so, it sent assurances to the financial sector and the oil industry that the province would provide every incentive to risk capital. The government established a regulatory regime that emphasized private property rights and a generous royalty structure (Hanson, 1958; Richards and Pratt, 1979). Alberta had in place a relatively low royalty system for both oil and natural gas. In 1949 the Alberta legislature passed the Mines and Mineral Act, which took effect in 1951. An important element of the Act was to commit the provincial government to a maximum royalty rate on oil equal to 16.67% of gross production (Doern and Toner, 1985). This was a marginal increase above the previous maximum of 15% on oil, and the royalty on natural gas remained unchanged until 1962 (Alberta Royalty Review Panel, 2007). It was not until 1971, after the election of the Progressive Conservatives, that this low maximum royalty rate was raised to 23% of gross production. Dramatic increases in oil prices would soon

[5]In 1947, one million cubic metres of oil were produced in Alberta, mainly from the Turner Valley area. This is less than 6% of the amount produced in 1955. Saskatchewan produced only 83,000 cubic metres of oil in 1947.

cause the government to abandon this agreement and tie royalties to the price of oil in 1974 (Doern and Toner, 1985).

2.2 Saskatchewan's Policies

The CCF's approach to developing Saskatchewan's natural resources departed dramatically from that of Alberta's Social Credit party. While the CCF would not win an election in Saskatchewan until 1944, in 1934 and 1938 the CCF candidates campaigned on a platform of social ownership of all major industries. At the 1933 CCF National Convention, the party unveiled its *Regina Manifesto* which stated that the party sought to "replace the current capitalist system" with a social order based upon economic equality (Co-operative Commonwealth Federation, 1933). The Depression had instilled in the CCF leaders the idea that capitalism had failed; production was for profit and not for human need, and these two objectives could not be reconciled. Moreover, the CCF leaders believed that private corporations refused to produce to meet public need unless the returns were unreasonably high.

The CCF solution to these problems was a planned economy that placed key industries under public ownership or direction, the profits of which should go back to the people. Among other industries, the CCF called for natural resources to be developed for the public benefit, and "not for the private profit of a small group of owners [or] financial manipulators." However, the *Regina Manifesto* made clear that a policy of outright confiscation would not be pursued (Zakuta, 1964, p. 162). By 1944, the CCF's Natural Resources and Industrial Development Committee had identified the natural resource sector as the central candidate for social ownership (Johnson, 2004). The committee recommended that the government acquire those mineral rights that were privately owned, prevent further alienation of natural resources, and plan for the eventual and complete socialization of all natural resources.[6] The 1944 CCF election platform stated the party would proceed with public development and ownership of natural resources. However, the platform made no mention of the Committee's recommendation that privately owned resources should be restored to the province. The Committee also made mention of collecting royalties and taxes from privately

[6] Approximately 25% of mineral rights in Saskatchewan are privately owned.

owned enterprises, so it is not clear whether full socialization would ever occur.

In the 1944 election campaign, soon-to-be Premier Douglas and his colleagues were called on to defend and clarify the CCF's policy on socialization of industry and resources. From their responses, it appears that the main focus of the party was the development, rather than socialization, of resources. The Saskatchewan CCF Committee on Socialization of Industry and Natural Resources stated that "industry should not be socialized for the sake of socialization, but only under certain defined circumstances" (Johnson, 2004, p. 30). Douglas argued that social ownership should be expanded upon when needed to prevent monopoly and exploitation of the public, and that royalties and land rental regulations would be sufficient to capture a fair share of resource revenues (Johnson, 2004).

An interesting episode in Saskatchewan history occurred shortly after the 1944 election. Imperial Oil, Canada's major oil company, approached the CCF government with a proposal for a long-term contract that would give the company exclusive exploration rights over a large section of the province should it find commercial volumes of oil. While the government's own advisors suggested that turning down the offer would delay exploration and possible industrial development for many years and that the risks inherent in oil and gas exploration were inappropriate for a provincial government to take on, it nonetheless refused the offer and as a result, Imperial Oil allegedly boycotted the province. However, several companies, including Husky Oil, continued to invest (Richards and Pratt, 1979).

Despite the campaign promises, nationalization was a feature of CCF policy. From 1944 to 1948 the newly-elected CCF sought to promote Saskatchewan's economic diversification through nationalization and promotion of secondary manufacturing and natural resources. The Minister of Natural Resources began plans for the development of several government-owned factories (Johnson, 2004). The 1944 Natural Resources Act gave the Minister of Natural Resources power to "acquire any lands or works by purchase, lease or expropriation" as necessary to develop and utilize the resources of the province (Richards and Pratt, 1979, p. 110). The 1944 Mineral Taxation Act imposed a tax on undeveloped freehold mineral rights to encourage holders of the rights to allow the rights to revert to the province (Richards and Pratt, 1979). The stated reason for the Mineral

Taxation Act 1944 was to “compensate the people of the province for the depletion of these alienated minerals.” (Saskatchewan Department of Natural Resources and Industrial Development, 1949, p. 37). Failure to pay the mineral tax resulted in forfeiture of the mineral rights to the Saskatchewan government. A resolution adopted by the CCF party at its’ 1946 convention called upon the Government of Saskatchewan to place oil and natural gas “under social ownership, control and operation.” Similar resolutions were approved in 1947 and 1948. By October 1947, mineral rights in undeveloped areas had been seized by the Saskatchewan Department of Natural Resources.

On September 1, 1948, all forfeiture proceedings under the 1944 Mineral Taxation Act were stopped pending the resolution of court proceedings surrounding the Canadian Pacific Railway’s action to have the Act declared beyond the powers of the government (Saskatchewan Department of Natural Resources, 1950, p. 29). The Court of the King’s Bench decided in favour of the government of Saskatchewan on June 15, 1950, resulting in Canadian Pacific Railway (CPR) filing an appeal. The Court of Appeals found the tax on mineral rights to be within the government’s powers, and the tax on producing mineral rights to be beyond powers on June 11, 1951 (Saskatchewan Department of Natural Resources, 1951). CPR subsequently appealed once more, and the judgement of the Supreme Court of Canada (June 30, 1952) was that the Act was valid in all respects (Saskatchewan Department of Natural Resources, 1953). CPR served notice that the Supreme Court’s decision would be appealed to the Privy Council, but six months later dropped the appeal. Ten days after CPR’s appeal was dropped, the government of Saskatchewan announced that there would be no forfeitures during 1953 (Saskatchewan Department of Natural Resources, 1953). As a result of the disputed legality, the Saskatchewan Government passed an Order in Council allowing the return of forfeited mineral rights upon payment of the mineral taxes. As of March 31, 1950, 82% of the forfeited mineral rights had been revested, with the remainder being unclaimed (Saskatchewan Department of Natural Resources, 1951). Revestment of the mineral rights was completed by December 31, 1951, with 96.3% of the mineral rights restored to their original owners and the remainder retained by the Crown.

Despite the aggressive policies and positions of the CCF in its first term of government, debate over public versus private development of resources continued within the CCF, and by its second term in office, the party was backing away from its earlier direction of public ownership as capital market forces and moderates within the CCF had moved Saskatchewan into the same passive rentier role as Alberta (Johnson, 2004). Following its formation in 1946 for the purposes of economic planning and policy evaluation, the Economic Advisory and Planning Board (EAPB) recommended in late 1947 and again in early 1948 that Saskatchewan rely on private development of the province's mineral resources (Johnson, 2004).

After the 1948 election, and following the Leduc and Redwater oil discoveries in Alberta, the CCF was sensitive to criticism about the relatively slow pace of oil exploration in Saskatchewan. In an attempt to bring the oil majors like Imperial Oil back to the province, Premier Douglas sent letters to major and independent oil companies in which he stated that the province "has no intention of either expropriating or socializing the oil industry" (Richards and Pratt, 1979, p. 135-136). By the early 1950s the CCF had formally abandoned the nationalization option and by the mid 1950s the oil polices of the CCF had largely converged with those of the Social Credit government in Alberta. The moderation of the CCF in Canada from 1933 to the 1950s had been described as the "becalming of a protest movement" (Zakuta, 1964; Whitehorn, 1992). The party's official stand on the role of social ownership versus private enterprise moved from a prohibition of capitalism in 1933 to the aiding and encouraging of private business to fulfill its legitimate function in 1948. The distinction between the CCF and other parties diminished further through the 1950s (Zakuta, 1964).

Several potential explanations exist for the CCF's change in policy direction. First, the government was losing popularity through its first term. In the 1948 election, the CCF party went from forty-seven seats to thirty-one; one of the seats lost was that of Joe Phelps, the Minister of Natural Resources and an enthusiastic proponent of nationalization. Richards and Pratt (1979) and Johnson (2004) attribute these ambitious policy directions as primarily driven by Phelps. As well, by this time the failure of the publicly owned firms established by the CCF government had become apparent. Third, the CCF government faced a threat from the oil companies operating in the province regarding an agreement over the leasing of Crown reserves. The firms threatened to leave if the government went through with the agreement, which the industry felt was putting the government in the oil business. Financial necessity also encouraged the CCF government to converge towards Alberta's policies and approaches to resource development. American investors sent a clear message to the Treasurer that Saskatchewan government bonds would not be in demand if the CCF did not improve the province's credit position (Richards and Pratt, 1979).

Richards and Pratt (1979) argue that the slower growth of the oil and gas sector was the result of the "threat of nationalization" from the CCF. Alex Cameron, a Liberal (opposition) member of the Saskatchewan Legislature in 1950 alleged that "The major oil companies have been stung by government bureaucracy, loaded with excessive taxation and having to carry these leeches (CCF patronage land controllers) on their backs, have thrown in the sponge." (Tyre, 1962, p. 201). This conclusion seems to stem from the fallout from the CCF's rejection of Imperial Oil's offer in 1944. In a 1950 memorandum to Premier Douglas reporting on the discussions with Imperial Oil about the company's lack of activity in Saskatchewan and the prospects for the company becoming more active in the province, senior government officials reported that Imperial identified four reasons for not operating in Saskatchewan since 1945, one of which was a "fear of expropriation in Saskatchewan."[7]

Further support for this view came from the coincidence of the moderation in the CCF approach to resource development after 1948 and increasing exploration efforts in Saskatchewan. The province had its first major oil discovery in 1952 (Johnson, 2004). The relatively slower development of the oil and gas resources of Saskatchewan in the 1940s and early 1950s would have also reflected the fact that the vast majority of proven reserves of conventional oil were in Alberta. Saskatchewan's first commercial well was drilled in 1947, and production remained far below that of Alberta for many years. With Alberta's geological formations proven to hold commercial quantities of oil, it is not surprising that exploration in Saskatchewan may have held less appeal. Hanson (1958) describes how development of the Redwater oil discovery in Alberta drew resources away from further development of the Leduc oil field. This in part reflected the shortage of equipment for drilling in the late 1940s and early 1950s, which also means that that it is not surprising that resources would not go to Saskatchewan until these big Alberta fields were developed. Drilling in Alberta slowed down after 1951 as exploration and development efforts moved into Saskatchewan,

[7] D.H.F. Black, Government of the Province of Saskatchewan Department Memo to T.C. Douglas, October 11, 1950.

where some successes had occurred.

Despite the fact that any moves towards nationalizing Saskatchewan's oil resources were during the CCF's first term in government, it is uncertain whether the government's threat of expropriation was considered credible by investors, and if it was, whether the expropriation risk had a lasting effect on the development of the province's oil resources. The CCF rhetoric and actions like the Natural Resources and Mineral Taxation Acts signalled intent and capacity to expropriate, and it was not clear if the government would pay compensation. However, Canadian Pacific Railway's court action against the Mineral Taxation Act shows that industry could call on higher levels of government and the courts to enforce their property rights.

3 A Model of Land Valuation

In order to explore for, develop and produce natural resources, firms must first purchase the land the resources are upon or beneath, or pay for access to the resources and the right to extract. Throughout the discussion, land and mineral rights will be treated synonymously. Though it is often the case that surface rights are separated from subsurface rights, i.e., Crown lands in Alberta and Saskatchewan, the value of the land to the exploration firm is in the mineral rights rather than the surface uses of the land. Moreover, the nuisance payment made to the surface owner will be captured in a firm's operating costs.

The willingness to pay of a firm in a competitive market should be the discounted value of expected future profits from the extraction of the resource. Reece (1978, 1979) examines this in the context of optimal bidding for offshore oil leases in the United States. This willingness to pay can be complicated by uncertainty over expected profits. Uncertainty can come in the form of future price uncertainty, uncertainty over the magnitude of future costs, uncertainty over future tax rates, or from risk of expropriation. First, we develop a model of land value without uncertainty. This model is based on the explanation of optimal control theory and the maximum principle by Dorfman (1969), and adapted to include discounting. In Section 3.2, the model is expanded by adding an expropriation threat which involves a positive probability of a government expropriating the land (and hence the resources) without compensation to the firm.

3.1 The Value of Land with an Exhaustible Natural Resource Stock

In a perfectly competitive market, the price a firm is willing to pay for land at an initial point $t = 0$ is the discounted present value of total profits that can be obtained from extraction of the resource. We assume resources are discovered without uncertainty, and we abstract from any other use value of the land. Denote $V_t(R_t, q_t)$ as the value of land at time t, where R_t is the stock of reserves and q_t is production of the resource. The discount rate for the firm is ρ.

In the initial purchasing period, the value of the land to the firm is

$$V_0(R_0, \vec{q}) = \int_0^\infty e^{-\rho t} \pi_t(R_t, q_t)\,\mathrm{d}t \tag{1}$$

Here, $R_0 > 0$ is the initial stock of reserves at $t = 0$, $\vec{q}$ is the vector of production decisions over the interval $[0, \infty)$, exhaustion (economic or physical) occurs as $t \to \infty$, and $\pi_t(\cdot)$ is profits in each period t. Profits are a function of reserves, production, prices and costs. We assume perfect competition, so that prices are exogenous and are not affected by extraction. We abstract from cost considerations, as the specifics of extraction costs do not affect the development of the model. The resource stock evolves according to

$$\dot{R} = \frac{\mathrm{d}R}{\mathrm{d}t} = f(R_t, q_t) = -q_t \tag{2}$$

Abstracting from the idea of exploration, each unit of land has only an initial resource stock R_0, which is known with certainty. Note that production decisions taken at any point in time influence the rate at which profits are earned and influence the rate at which the resource stock is changing, and therefore the resource stock at subsequent instances of time. Generalized to period t, the value of the land to the firm is

$$V_t(R_t, \vec{q}) = \int_t^\infty e^{-\rho\tau} \pi_\tau(R_\tau, q_\tau)\,\mathrm{d}\tau \tag{3}$$

Let $\mathrm{d}t$ be a short time interval beginning at time t; so short that the firm would not change its choice of q_t over the interval $(t, t + \mathrm{d}t)$ even if it could. Following the methodology in Dorfman (1969), the value of land becomes the sum of two parts. The first is profits over the interval $\mathrm{d}t$, which are determined by R_t and q_t. The second is discounted profits over the remaining time $(t + \mathrm{d}t, \infty)$.

$$V_t\left(R_t, \vec{q}\right) = \pi_t\left(R_t, q_t\right)\mathrm{d}t + (1 - \rho\mathrm{d}t)\int_{t+\mathrm{d}t}^{\infty} e^{-\rho\tau}\pi_\tau\left(R_\tau, q_\tau\right)\mathrm{d}\tau \tag{4}$$

The first-order Taylor series expansion of $e^{-\rho t}$ about $t = 0$ over the interval $\mathrm{d}t$ is $1 - \rho\mathrm{d}t$, yielding the additional discount term in equation (4). Equation (4) can be written in this way because q_t is assumed to be fixed over the interval $(t, t + \mathrm{d}t)$, and is allowed to vary from $t + \mathrm{d}t$ to infinity. Equation (4) states that if the amount of reserves available at time t is R_t and if the production policy $\vec{q}$ is followed from then on, then the value of the land from period t onwards consists of two parts:

1. The rate at which profits are earned during $\mathrm{d}t$ multiplied by the length of the interval $\mathrm{d}t$. This depends on the current reserve stock, the time period, and the current value of the decision variable, q_t.

2. The value of the integral at $t+\mathrm{d}t$, discounted by $1-\rho\mathrm{d}t$, which is precisely the same as in (3), but starting at $t + \mathrm{d}t$. The difference is that the integral in (**??**) has a starting reserve stock of $R_{t+\mathrm{d}t}$, not R_t. The reserve stock changes over the interval $\mathrm{d}t$ in a manner determined by q_t.

We can use the fact that the integral in (4) has the same form as in (3) to write

$$V_t\left(R_t, \vec{q}\right) = \pi_t\left(R_t, q_t\right)\mathrm{d}t + (1 - \rho\mathrm{d}t)\, V_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t}, \vec{q}\right) \tag{5}$$

One can think of the above as a Bellman equation for the firm's problem. Now suppose that the firm makes the optimal choice of $\vec{q}$ from period t onwards. That is, at each period $\tau \in [t, \infty)$ the optimal q_τ^* is chosen. The value of land that results from this optimal choice of $\vec{q}$ can be denoted as $V^*(\cdot)$, where

$$V^*\left(R_t\right) = \max_{\{q\}} V_t\left(R_t, \vec{q}\right) \tag{6}$$

Note that $V^*(\cdot)$ does not have $\vec{q}$ as an argument because it has been "maximized out." The maximum value that can be obtained beginning at date t with reserves R_t does not depend on $\vec{q}$

but is the value that can be obtained with those conditions from the best possible choice of q_t in each period.

Now suppose the production choice designated by q_t is followed in the short time interval from t to $t + \mathrm{d}t$, and that thereafter the best possible production policy is followed. By equations (5) and (6), the result of this can be written as

$$V_t\left(R_t, q_t\right) = \pi_t\left(R_t, q_t\right)\mathrm{d}t + \left(1 - \rho \mathrm{d}t\right) V^*_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t}\right) \tag{7}$$

The results of following such a production plan are the profits that accrue during the initial period t plus the maximum possible profits that can be realized starting from date $t + \mathrm{d}t$ with reserves $R_{t+\mathrm{d}t}$. The stock of reserves at $t + \mathrm{d}t$ results from the decision taken in the initial period t.

To find the optimal choice of q_t, differentiate the left hand side of equation (7) with respect to q_t and set it equal to zero:

$$\frac{\partial \pi_t\left(R_t, q_t\right)}{\partial q_t}\mathrm{d}t + \left(1 - \rho \mathrm{d}t\right)\frac{\partial V^*_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t}\right)}{\partial R_{t+\mathrm{d}t}} \cdot \frac{\partial R_{t+\mathrm{d}t}}{\partial q_t} = 0 \tag{8}$$

As $\mathrm{d}t$ is a very short time interval, $R_{t+\mathrm{d}t}$ can be approximated by $R_{t+\mathrm{d}t} \cong R_t + \dot{R}\mathrm{d}t$. That is, the amount of reserves at $t + \mathrm{d}t$ is equal to the reserve stock at t plus the rate of change in reserves during the interval $(t, t + \mathrm{d}t)$ multiplied by the length of the interval. Therefore,

$$\frac{\partial R_{t+\mathrm{d}t}}{\partial q_t} \cong \frac{\partial \dot{R}}{\partial q_t}\mathrm{d}t = \frac{\partial f\left(R_t, q_t\right)}{\partial q_t}\mathrm{d}t$$

By equations (1) and (6), $\frac{\partial V^*_{t+\mathrm{d}t}(R_{t+\mathrm{d}t})}{\partial R_{t+\mathrm{d}t}}$ is the rate at which the maximum possible profit from time $t+\mathrm{d}t$ onwards changes with respect to the amount of reserves available at time $t+\mathrm{d}t$. It is therefore the marginal value of reserves at time $t + \mathrm{d}t$. Denote the marginal value of reserves at time t by λ_t:

$$\lambda_t = \frac{\partial V^*_t\left(R_t\right)}{\partial R_t}$$

So we have

$$\frac{\partial V_{t+\mathrm{d}t}^{*}\left(R_{t+\mathrm{d}t}\right)}{\partial R_{t+\mathrm{d}t}}=\lambda_{t+\mathrm{d}t}\cdot\frac{\partial f\left(R_t,q_t\right)}{\partial q_t}\mathrm{d}t$$

Inserting this result into (8) yields

$$\frac{\partial \pi_t\left(R_t,q_t\right)}{\partial q_t}\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)\lambda_{t+\mathrm{d}t}\frac{\partial f}{\partial q_t}\mathrm{d}t=0 \tag{9}$$

The marginal value of reserves, λ_t, changes gradually over time, and can be approximated with $\lambda_{t+\mathrm{d}t}\cong\lambda_t+\dot{\lambda}\mathrm{d}t$. That is, the marginal value of reserves at time $t+\mathrm{d}t$ is the marginal value at t plus the rate at which it is changing during the interval $(t,t+\mathrm{d}t)$ multiplied by the length of the interval. Therefore, after canceling the common element $\mathrm{d}t$, equation (9) becomes

$$\frac{\partial \pi_t\left(R_t,q_t\right)}{\partial q_t}+\left(1-\rho\mathrm{d}t\right)\left[\lambda_t)\frac{\partial f}{\partial q_t}+\dot{\lambda}\frac{\partial f}{\partial q_t}\mathrm{d}t\right]=0$$

Now, allow $\mathrm{d}t$ to approach zero. The third term becomes very small, as does $\rho\mathrm{d}t$, so we have (suppressing arguments)

$$\frac{\partial \pi_t}{\partial q_t}+\lambda_t\frac{\partial f}{\partial q_t}=0$$

Suppose that q_t is chosen to satisfy the above equations. So q_t is the optimal choice, and $V_t\left(R_t,q_t\right)$ will equal its maximum possible value, $V_t^{*}\left(R_t\right)$. In this case, equation (7) becomes

$$V_t^{*}\left(R_t\right)=\pi_t\left(R_t,q_t\right)\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)V_{t+\mathrm{d}t}^{*}\left(R_{t+\mathrm{d}t}\right) \tag{10}$$

The optimal value of land $V^{*}\left(\cdot\right)$ at $t+\mathrm{d}t$ can be approximated using a first-order Taylor series expansion around $\mathrm{d}t=0$, yielding $V_{t+\mathrm{d}t}^{*}\left(R_{t+\mathrm{d}t}\right)\cong V_t^{*}\left(R_t\right)+\dot{V}^{*}\mathrm{d}t+V_R^{*}\dot{R}\mathrm{d}t$, where V_R^{*} is the derivative of V^{*} with respect to the resource stock, i.e., the marginal value of reserves. Substituting the approximation into equation (10) and canceling like terms yields

$$\rho V_t^{*}\left(R_t\right)=\pi_t\left(R_t,q_t\right)+\left(1-\rho\mathrm{d}t\right)\left[\dot{V}^{*}+V_R^{*}\dot{R}\right]$$

Evaluating the above as $\mathrm{d}t \to 0$ and rearranging yields

$$\dot{V}^* = -\pi_t\left(R_t, q_t\right) + \rho V_t^*\left(R_t\right) - V_R^* f\left(R_t, q_t\right) \tag{11}$$

The above equation defines how the value of land changes as a function of profits in each period, the optimal value of land in each period, and the change in reserves in each period. The next section expands the model to allow for expropriation risk, and the effect this has on the optimal value of land.

3.2 The Value of Land with Uncertainty

Now suppose that there is some positive probability that land will be expropriated by the government in each period t. Define $H(t)$ as the probability that the land will be expropriated by time t. $H(t)$ is the cumulative probability density function of expropriation occurring. The instantaneous probability of expropriation, given that expropriation has not occurred yet, is

$$h\left(t\right) = \frac{H'\left(t\right)}{1 - H\left(t\right)}$$

as in Kamien and Schwartz (1971). Given that expropriation has not occurred at time t, $h\left(t\right)\mathrm{d}t$ is approximately the probability of expropriation occurring in the next increment of time $\mathrm{d}t$. The price a firm is willing to pay for a unit of land at $t = 0$ is now

$$V_0\left(R_0, \vec{q}\right) = \int_0^\infty e^{-\rho t}\mathbb{E}_t\left[\pi_t\left(R_t, q_t\right)\right]\mathrm{d}t \tag{12}$$

where $\mathbb{E}_t\left[\pi_t\left(\cdot\right)\right] = H(t)\pi_{E,t}\left(R_t, q_t\right) + \left(1 - H(t)\right)\pi_{N,t}\left(R_t, q_t\right)$. Here, $\pi_E\left(\cdot\right)$ denotes profits after expropriation has occurred, and $\pi_N\left(\cdot\right)$ denotes profits without expropriation. As in Section 3.1, R_0 is the initial resource stock, $\pi_t\left(\cdot\right)$ is net profits, and ρ is the discount rate. The equation of motion for the resource stock is as before, in equation (2). Equation (12) becomes

$$V_0\left(R_0, \vec{q}\right) = \int_0^\infty e^{-\rho t}\left[H(t)\pi_{E,t}\left(R_t, q_t\right) + \left(1 - H(t)\right)\pi_{N,t}\left(R_t, q_t\right)\right]\mathrm{d}t \tag{13}$$

Generalizing to period t, equation (13) can be written as

$$V_t(R_t, \vec{q}) = \int_t^{\infty} e^{-\rho\tau}\left[H(\tau)\pi_{E,\tau}(R_\tau, q_\tau) + (1 - H(\tau))\,\pi_{N,\tau}(R_\tau, q_\tau)\right]\mathrm{d}\tau \tag{14}$$

Again, let $\mathrm{d}t$ be a short interval of time beginning at time t such that the firm would not change its choice of q_t over the interval $t + \mathrm{d}t$. Equation (14) becomes

$$\begin{aligned} V_t(R_t, \vec{q}) \;&=\; \pi_t(R_t, q_t)\,\mathrm{d}t + (1 - \rho\mathrm{d}t)\,h(t)\mathrm{d}t \int_{t+\mathrm{d}t}^{\infty} e^{-\rho\tau}\pi_{E,\tau}(R_\tau, q_\tau)\,\mathrm{d}\tau \\ &\quad + (1 - \rho\mathrm{d}t)(1 - h(t)\mathrm{d}t) \int_{t+\mathrm{d}t}^{\infty} e^{-\rho\tau} H(\tau)\pi_{E,\tau}(R_\tau, q_\tau)\,\mathrm{d}\tau \\ &\quad + (1 - \rho\mathrm{d}t)(1 - h(t)\mathrm{d}t) \int_{t+\mathrm{d}t}^{\infty} e^{-\rho\tau}(1 - H(\tau))\,\pi_{N,\tau}(R_\tau, q_\tau)\,\mathrm{d}\tau \end{aligned} \tag{15}$$

The above equation states that if expropriation has not occurred by time t, and the amount of reserves available at time t is R_t and the production policy $\vec{q}$ is followed from then on, then the value of the land to the firm consists of three parts:

1. The rate at which profits are earned during $\mathrm{d}t$ multiplied by the length of the interval. This depends on the current reserve stock, the time period, and the current value of the decision variable q_t.

2. The second term is the discounted value of future profits after expropriation occurs multiplied by the probability of expropriation occurring over the interval $\mathrm{d}t$, conditional on not being expropriated at t.

3. The discounted value of the integral at $t + \mathrm{d}t$, as in equation (4). Notice that now the expression has an additional $1 - h(t)\mathrm{d}t$ multiplying it. This is the probability that the land is not expropriated over the interval $\mathrm{d}t$, given that it had not been expropriated at t.

For simplicity, we assume that when expropriation occurs, it is full and without compensation, so that $\pi_{E,t}(R_t, q_t) = 0$. Let $\pi_{N,t}(R_t, q_t) = \pi_t(R_t, q_t)$ for all t. These assumptions simplify equation

(15) substantially, leaving us with

$$V_t\left(R_t,\vec{q}\right)=\pi_t\left(R_t,q_t\right)\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)\left(1-h(t)\mathrm{d}t\right)\int_{t+\mathrm{d}t}^{\infty}e^{-\rho\tau}\left[\left(1-H(\tau)\right)\pi_\tau\left(R_\tau,q_\tau\right)\right]\mathrm{d}\tau \tag{16}$$

We can use the fact that the second integral in (15) has the same form as equation (14) to write

$$V_t\left(R_t,\vec{q}\right)=\pi_t\left(R_t,q_t\right)\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)\left(1-h(t)\mathrm{d}t\right)V_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t},\vec{q}\right) \tag{17}$$

As in Section 3.1, assume that the firm chooses q_t in period t, and makes the optimal choice of $\vec{q}$ from period $t+\mathrm{d}t$ onwards. By equations (6) and (17), the result of this production path can be written as

$$V_t\left(R_t,q_t\right)=\pi_t\left(R_t,q_t\right)\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)\left(1-h(t)\mathrm{d}t\right)V^*_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t}\right) \tag{18}$$

The result of following such a production plan are the profits that accrue in period t, plus the maximum possible expected profits that can be realized at time $t+\mathrm{d}t$, given that expropriation has not occurred, with a reserve stock of $R_{t+\mathrm{d}t}$. To find the optimal choice of q_t, differentiate the left hand side of equation (18) with respect to q_t and set it equal to zero:

$$\frac{\partial\pi_t\left(R_t,q_t\right)}{\partial q_t}\mathrm{d}t+(1-\rho\mathrm{d}t)(1-h(t)\mathrm{d}t)\frac{\partial V^*_{t+\mathrm{d}t}\left(R_{t+\mathrm{d}t}\right)}{\partial R_{t+\mathrm{d}t}}\frac{\partial R_{t+\mathrm{d}t}}{\partial q_t}=0 \tag{19}$$

As before, we approximate $R_{t+\mathrm{d}t}$ using $R_{t+\mathrm{d}t}\cong R_t+\dot{R}\mathrm{d}t$. As only $\dot{R}$ is a function of q_t, this yields

$$\frac{\partial R_{t+\mathrm{d}t}}{\partial q_t}\cong\frac{\partial\dot{R}}{\partial q_t}\mathrm{d}t=\frac{\partial f\left(R_t,q_t\right)}{\partial q_t}\mathrm{d}t$$

Furthermore, we know from equations (6) and (12) that $\frac{\partial V_t^*(\cdot)}{\partial R_t}$ is the rate at which maximum possible expected profit changes with respect to the resource stock available, and is therefore the marginal value of reserves, which was defined as λ_t. So we can write equation (19) as

$$\frac{\partial\pi_t\left(R_t,q_t\right)}{\partial q_t}\mathrm{d}t+\left(1-\rho\mathrm{d}t\right)\left(1-h(t)\mathrm{d}t\right)\lambda_{t+\mathrm{d}t}\frac{\partial f}{\partial q_t}\mathrm{d}t=0 \tag{20}$$

The marginal value of reserves changes gradually over time, and is approximated using $\lambda_{t+\mathrm{d}t}\cong$

$\lambda_t + \dot{\lambda}\mathrm{d}t$. So the marginal value of reserves at time $t + \mathrm{d}t$ is the marginal value at t plus the rate at which it is changing over the interval from t to $t + \mathrm{d}t$. After canceling the common element $\mathrm{d}t$, equation (20) becomes

$$\frac{\partial \pi_t (R_t, q_t)}{\partial q_t} + (1 - \rho \mathrm{d}t)(1 - h(t)\mathrm{d}t)\left[\lambda_t \frac{\partial f}{\partial q_t} + \dot{\lambda}\frac{\partial f}{\partial q_t}\mathrm{d}t\right] = 0$$

Now allow $\mathrm{d}t$ to approach zero. The third term becomes very small, as do $\rho \mathrm{d}t$ and $h(t)\mathrm{d}t$. The above equation becomes

$$\frac{\partial \pi_t}{\partial q_t} + \lambda_t \frac{\partial f}{\partial q_t} = 0$$

Suppose that q_t is chosen to satisfy the above. This means q_t is the optimal choice, and $V_t (R_t, q_t)$ will equal its maximum possible value, $V_t^* (R_t)$. Hence, equation (18) becomes

$$V_t^* (R_t) = \pi_t (R_t, q_t)\,\mathrm{d}t + (1 - \rho \mathrm{d}t)(1 - h(t)\mathrm{d}t)\, V_{t+\mathrm{d}t}^* (R_{t+\mathrm{d}t}) \tag{21}$$

Note that because q_t is chosen optimally, production changes in response to the expropriation risk. The optimal value of land, $V^*(\cdot)$, at $t + \mathrm{d}t$ can be approximated using a first-order Taylor series expansion around $\mathrm{d}t = 0$ as

$$V_{t+\mathrm{d}t}^* (R_{t+\mathrm{d}t}) \cong V_t^* (R_t) + \dot{V}^* \mathrm{d}t + V_R^* \dot{R}\mathrm{d}t$$

Substituting this approximation into equation (21) yields

$$V_t^* (R_t) = \pi_t (R_t, q_t)\,\mathrm{d}t + (1 - \rho \mathrm{d}t)(1 - h(t)\mathrm{d}t)\left[V_t^* (R_t) + \dot{V}^* \mathrm{d}t + V_R^* \dot{R}\mathrm{d}t\right]$$

Evaluating the above as $\mathrm{d}t \to 0$ and canceling like terms gives

$$(\rho + h(t))\, V_t^* (R_t) = \pi_t (R_t, q_t) + \dot{V}^* + V_R^* \dot{R}$$

Rearranging the above equation, we can find an expression for $\dot{V}^*$, the change in the value of a unit of land, as a function of profits, land value and the change in reserves:

$$\dot{V}^* = -\pi_t(R_t, q_t) + (\rho + h(t))\, V_t^*(R_t) - V_R^* \dot{R} \tag{22}$$

The above equation could be used as the basis for an empirical specification to identify the effect of an expropriation risk on land value. However, this strategy would be subject to an endogeneity problem. A discrete approximation of $\dot{V}^*$ is $\dot{V}^* = V_{t+1}^*(R_{t+1}) - V_t^*(R_t)$. If this were used as the dependent variable, we would have $V_t^*(R_t)$ on the right hand side and the left hand side of the regression equation. Rewriting (22) using this discrete approximation for $\dot{V}^*$ yields

$$V_{t+1}^* = -\pi_t(R_t, q_t) + (1 + \rho + h(t))\, V_t^*(R_t) - V_R^* \dot{R}$$

Lagging the above equation one period gives us the final specification, which can be used as the basis for a reduced form estimation equation.

$$V_t^* = -\pi_{t-1}(R_{t-1}, q_{t-1}) + (1 + \rho + h(t-1))\, V_{t-1}^*(R_{t-1}) - V_R^* \dot{R} \tag{23}$$

Under perfect information, $h(t)$ will be the actual probability of expropriation occurring. If the firm lacks information, or has beliefs that are biased in any way, then the expropriation probability $h(t)$ will be the *perceived* probability of expropriation. Equation (23) can be used to specify an estimating equation that can identify the probability of expropriation, $h(t)$, occurring over the interval $(t, t + \mathrm{d}t)$. This is a key feature of the model, and is possible because the parameters ρ and $h(t)$ are additively separable. By comparing the estimated coefficient on profits in a period when there is an expropriation threat to a period when there is no perceived threat, the effect of an expropriation risk, $h(t)$, can be identified. The methodology is further explained in Section 3.3.

3.3 Estimating Equation

The final equation in Section 3.2 can be adapted to provide a linear empirical specification that allows identification of the effects of an expropriation threat, given the appropriate data. In developing equation (23) into an empirical specification, the parameters ρ, $h(t)$, and V_R^* become coefficients to be estimated. It is important to note, however, the even though the parameter $h(t)$ reflects the probability of expropriation, the interpretation of the coefficient is the *effect* of the expropriation risk rather than the estimated probability. This is because the estimated parameter will be sensitive to the units of measurement, and cannot be bounded between zero and unity. In the derivation above, V_R^* is not a constant, and is a function of time. In the empirical specification, V_R^* is assumed to be constant, and the coefficient will be the average of the marginal value of reserves.

We assume that $h(t) = 0$ when there is no presence of an expropriation threat by the government. As such, in order to model this reality properly in an econometric setting, this requires the use of a dummy variable which is one when there is a threat present, and zero if there is not. Equation (23) becomes

$$V_{i,t} = \alpha + \eta\pi_{i,t-1} + (1+\rho)V_{i,t-1} + hD_{i,t-1}V_{i,t-1} + V_R\dot{R}_{i,t} + \gamma X_{i,t-1} + \epsilon_{i,t-1} \tag{24}$$

Here, i indexes location and t indexes time. In the above specification, $D_{i,t-1}$ is the dummy variable representing the presence of an expropriation threat, and $X_{i,t-1}$ are location and time-specific characteristics of the land. Profits can be approximated using a translog function, or some other suitable general functional form. Davis (2001) approximates profits by calculating $(P - AC) * Q$. Though in the model we abstracted from the possibility of reserve additions through exploration (by imposing $\dot{R} = -q_t$), we relax this assumption and define the change in reserves as additions through exploration, net of production, in each period. The change in reserves at time t is approximated using production and reserve additions from exploration at $t-1$. The hypotheses from the theoretical model are that $\eta = -1$ and $V_R < 0$. A simplifying assumption is to assume h is constant during the threat period. One can think of h as the average effect during the time there is an expropriation risk. Allowing h to vary with time would require within-period variation in the variables of interest in the jurisdiction with the expropriation risk. Unfortunately, due to the nature of the data – discussed further in Section 4.1 – this restrictive assumption must be maintained.

A potential issue with estimation of equation (24) is serial correlation due to the lagged dependent variable on the right hand side. Griliches (1961) notes that serial correlation can be thought of as an omitted variable problem, where the lagged error term is the omitted variable and it's exclusion biases the coefficient estimates. In all regressions, a robust error variance matrix is used to correct for potential serial correlation.

The value of an exhaustible asset, such as a mine or a pool of oil, is a function of current and past prices, costs and production, as well as future prices and costs, and future production, which depends on the current reserve levels. Being able to directly estimate the loss in asset value as a result of an expropriation threat requires very specific data. In any politically unstable environment, it is difficult to find data without error. In a developing country, few resources are devoted to data collection, posing further problems for this research path. The ideal data set would involve information on the value of each unit of land in each period. This could be approximated by the market value of the firm, if the firm owns a single asset, as in Davis (2001). The approach used here is to consider the value of land in two jurisdictions, Alberta and Saskatchewan, over time. Alberta is the risk-free alternative for investors, as is Saskatchewan in the post-CCF period.

4 Empirical Analysis

4.1 Data Description

The market value of land purchased by a firm for the purpose of natural resource production would ideally be observed from market transactions by firms. The market value of petroleum firms in Alberta and Saskatchewan would be difficult to use for this sort of exercise as many large firms have investments and interests in other nations. In addition, any between-firm sales of land may involve different geographical areas, making the value of a specific tract of land difficult to determine. To compound these difficulties, firm-specific data is unavailable for the time period in question. Instead, the value of a unit of land in each province is proxied by yearly expenditures on land by the petroleum industry.

The data used is yearly observations by province, from 1947 to 2006. The majority of the data is constructed from the *Statistical Handbook* produced by the Canadian Association of Petroleum

Producers (CAPP). Details are reported in the Data Appendix. For most variables of interest in our study there is annual data for 1947 to 2006. Table 1 contains summary statistics and variable definitions.

We define the threat period with a positive probability of expropriation as 1944 to 1952. We choose 1952 as the cut-off point because it was near the end of 1952 that the legal proceedings by Canadian Pacific Railway against the Saskatchewan government were resolved. However, if the threat period was defined as 1944 to 1948, we would be limited by the few observations in this threat period definition, as the data begins in 1947. Further, this period coincides with few commericial oil discoveries in Saskatchewan, making it difficult to determine if the effect arose from the expropriation threat or just the higher risk that there would be no oil to find. An alternative specification for the threat period is considered, the period where the CCF government held power in Saskatchewan (1944-1964). The historical literature on this topic suggests the CCF's policy actions in its first term left a lasting reputation for the government. To strengthen the possibility of identifying the threat of expropriation in Saskatchewan, Alberta is included under the assumption of a jurisdiction recognized by oil companies as a risk-free alternative.

In equation (24), the variable V_{it} is the value of a unit of land in province i at time t. It is approximated by the value of annual expenditures on land to acquire mineral rights by the petroleum industry. The preferred measure is per unit, such as the average price per hectare for mineral rights. This variable is available from 1955 onwards, necessitating the use of the extended threat period. We approximate aggregate profits with $(p_{it} - c_{it}) \cdot q_{it}$, where p_{it} is the price of crude oil in province i, c_{it} is the average cost of production, and q_{it} is aggregate production. The dummy variable for Saskatchewan, S_i, captures the average difference in the value of land sales in Saskatchewan compared to Alberta after controlling for the quantity and profitability of oil reserves. Interacting the dummy variable for Saskatchewan with land value, V_{it}, reveals the difference in the risk-free rate of return between Saskatchewan and Alberta. There are several policies and events that may have affected the petroleum industries in Saskatchewan in Alberta. These are discussed in Section 4.3. Dummy variables for these events and other controls are displayed in the bottom half of Table 1.

Table 1: Summary Statistics

	Mean	Standard Deviation	Min	Max
Expenditure on land (million 1947 $)	50.441	59.34992	0	295.794
Price per hectare of land (1947 $)	24.499	25.107	0	126.347
Reserves (million m^3)	380.402	389.559	0.003	1,442.838
Profits (million 1947 $)	-65.682	407.182	-2,334.570	437.064
CCF1 (0,1) (1947 - 1952)	0.065	0.247	0	1
CCF2 (0,1) (1947 - 1964)	0.162	0.369	0	1
Profits*CCF1 (million 1947 $)	-0.0977	0.725	-7.681	0.148
Profits*CCF2 (million 1947 $)	2.162	10.3897	-8.483	58.363
Saskatchewan (0,1)	0.5	0.502	0	1
OPEC1 (1973 - 1985)	0.210	0.409	0	1
OPEC2 (1986 - 2006)	0.339	0.475	0	1
Prorationing in Alberta (1949 - 1973)	0.466	0.501	0	1
National Energy Program (1980 - 1982)	0.048	0.215	0	1
National Oil Policy (1961 - 1972)	0.210	0.409	0	1
Lougheed Royalty Renegotiation (1971 - 1972)	0.016	0.126	0	1
Blakeney Royalty Renegotiation (1975 - 1982)	0.065	0.247	0	1
TSX 300 Composite Index (1947=100)	962.581	1048.186	94	4431

N: 122

4.2 Preliminary Analysis

The specification given by (24) indicates the value of land (or mineral rights) in time t is a function of profits in $t-1$, the discounted value of land in the previous period, the change in the reserve stock in the previous period, and other potential factors that may influence the economic climate a firm is operating in. The effect of the discount rate, ρ, is to increase the weight on V_{t-1} in determining current value. *Ex ante*, the expected effect of an expropriation risk would be to make current profits matter more, as the likelihood of a firm being able to extract current reserves in the future would decrease. Recall that V_R is the marginal value of the stock of reserves in determining the value of land. As $V_R R(t)$ enters negatively in equation (24), the interpretation of V_R is that an increase in the stock of reserves decreases the current value of land.

As discussed in Section 4.1, there are two potential measures of the value of land. These are aggregate expenditures of the petroleum industry on land and the price per hectare paid for mineral rights. The price per hectare has intuitive appeal as it is a per unit measure; however, records of this from CAPP begin only in 1955, which may preclude identification of an expropriation risk using that measure. Table 2 displays regression results for the base specification when the dependent variable is expenditure on land. Table 3 shows the base specification results for price per hectare.

Table 2: Effect of the CCF on Expenditures on Land

Dependent Variable: Yearly Expenditures on Land (million 1947 $)	(1)	(2)	(3)	(4)	(5)	(6)
Constant	8.767***	35.381***	9.047**	35.382***	9.865***	35.390***
	(3.320)	(10.621)	(3.464)	(10.676)	(3.758)	(10.668)
$1+\rho$ (million 1947 dollars)	0.865***	0.664***	0.863***	0.664***	0.856***	0.664***
	(0.086)	(0.128)	(0.083)	(0.128)	(0.089)	(0.128)
h (million 1947 dollars)			-1.555*	-0.040	-0.827**	0.213
			(0.883)	(0.399)	(0.377)	(0.243)
Profits (million 1947 dollars)	0.016	0.015	0.015	0.015	0.015	0.015
	(0.20)	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)
Change in Reserves (million m^3)	-0.140*	-0.189**	-0.141*	-0.189**	-0.139*	-0.190**
	(0.082)	(0.087)	(0.083)	(0.088)	(0.082)	(0.088)
Saskatchewan (0,1)		-32.028***		-32.021***		-32.380***
		(9.429)		(9.446)		(9.532)
R^2	0.7157	0.7500	0.7160	0.7500	0.7169	0.7501
F-stat	36.01	95.75	56.05	86.47	61.40	76.46

Notes: $N = 122$. Columns (3) and (4) have $CCF = 1$ for 1947 - 1952; Columns (5) and (6) have $CCF = 1$ for 1947 - 1964. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Columns (1) and (2) in Table 2 report results for the specification with no expropriation threat. A dummy for Saskatchewan is included as average expenditure on land is $50.4 million dollars for the full sample and $9.2 million dollars in Saskatchewan, indicating substantial differences in either demand for mineral rights or the value of mineral rights in each province. The coefficient on the dummy for Saskatchewan is statistically significant, suggesting its inclusion is important. The interpretation of the coefficient $1+\rho$ is an increase in previous expenditure of 1 million dollars increases current expenditure on land by $0.7 million dollars. However, as $1+\rho < 1$, this implies an increase in the discount rate ρ decreases the effect of previous expenditure on current expenditure on land. Columns (3) through (6) introduce the expropriation risk into the specification. Note the estimates of ρ are consistent across specifications. Standard errors for ρ are calculated using the delta method, and while $1+\rho$ is statistically significant, ρ is not.

In column (3), the parameter h is introduced with the threat period from 1947 to 1952. As $\hat{h} < 0$, the effect of the expropriation risk is to reduce future expenditure on land, by more than $1+\rho$. The point estimate in column (5) is smaller, but still negative and greater in magnitude than the point estimate for $1+\rho$. This parameter estimate indicates the CCF had a significant negative effect on expenditures on land in Saskatchewan. Inclusion of the dummy for Saskatchewan reduces the magnitude of the estimated coefficient as well as the estimated standard errors for $\hat{h}$, and the coefficient is no longer statistically significant. Intuitively, the dummy for the presence of the CCF and a dummy for Saskatchewan are correlated, so inclusion of the control for Saskatchewan removes the variation in V_t that is explained by Saskatchewan.

The estimates of h are identified with very few data points, so it is not surprising there may be loss of precision with the addition of control variables. The results in columns (3) and (5) indicate there was an effect from the CCF that lasted beyond the initial threat period, but it is difficult to disentangle this effect from lower expenditure in Saskatchewan. Moreover, expenditure on land is an aggregate measure of the demand for mineral rights. In reality, there are two margins of adjustment: changes in the volume of land acquired and and the price per unit of land. The indeterminacy in expenditure on land is potentially confounding the results.

Table 3: Effect of the CCF on Price per Hectare of Land

Dependent Variable: Average Yearly Price per Hectare (1947 \$)

	(1)	(2)	(3)	(4)
Constant	3.874***	4.522*	4.285***	4.651*
	(1.422)	(2.496)	(1.542)	(2.503)
$1+\rho$	0.856***	0.851***	0.849***	0.846***
	(0.070)	(0.074)	(0.072)	(0.075)
h			-0.871**	-0.814**
			(0.347)	(0.406)
Profits (million 1947 dollars)	-0.004	-0.004	-0.004	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)
Change in Reserves (million m^3)	-0.068*	-0.068*	-0.067*	-0.067*
	(0.037)	(0.037)	(0.037)	(0.038)
Saskatchewan (0,1)		-0.981		-0.595
		(2.522)		(2.630)
R^2	0.7976	0.7979	0.7989	0.7990
F-stat	63.99	48.40	76.44	62.03

Notes: $N = 102$. Columns (3) and (4) have $CCF = 1$ for 1955 - 1964. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As in Table 2, columns (1) and (2) in Table 3 show results for the specification restricted to $h = 0$. The estimated coefficient $1 + \rho$ is the same sign and magnitude as in the previous table. In this specification, however, the estimates of ρ are statistically significant, and it appears the discount rate of firms is approximately 15%. It should be noted that the estimate of $1 + \rho$ is sensitive to the units used; the proper interpretation of $1 + \rho$ is that there is a less than one-to-one relationship between the previous price per hectare and the current price per hectare.

These results indicate discounting has a similar effect on the price paid per hectare compared to aggregate expenditures. Comparing columns (1) and (3), we see that both $\hat{\rho}$ and $\hat{h}$ are statistically significant and have the same effect as reported in Table 2. As with annual expenditures on land, the average of price per hectare is different for the full sample ($24.50) compared to Saskatchewan ($16.49). The inclusion of the Saskatchewan dummy yields an inflated constant term and an insignificant coefficient on the dummy. This indicates that after controlling for other factors that influence price, there is no significant difference between the average price per hectare in Alberta and Saskatchewan.

Estimation of ρ and h is not sensitive to the inclusion of control variables in this specification. The effect of the expropriation risk is to reduce the price per hectare paid for mineral rights by approximately $0.87 cents per every dollar spent. This effectively negates the effect of the previous price paid in determining the current price for land during the CCF tenure.

4.3 Robustness Checks

There are several policies and events that likely impacted the petroleum sectors in Saskatchewan and Alberta. The effect of royalty "renegotiation" in Alberta under Premier Lougheed (1971 - 1972) is controlled for using a dummy variable.[8] A dummy variable from 1975 - 1982 captures the effect of Premier Blakeney increasing royalty rates in Saskatchewan relative to Alberta. The Toronto Stock Exchange Composite 300 Index is included, to pick up economy-wide effects and economic changes over time. The remaining dummy variables account for federal policy regimes

[8] When he became Premier of Alberta in 1971, Peter Lougheed was able to enact radical changes to Alberta's royalty structure so that Alberta could capture a greater share of resource rent. Lougheed unilaterally re-wrote Alberta's royalty policies to capture more of the resource rents, and aggressively developed a public presence in the resource industry. Weir (2003) calculates that between 1975 and 1982, Alberta's effective royalty rate averaged 31%. With the effects of the 1980 National Energy Program and declining world oil prices, royalty rates fell to an average of 23% between 1983 and 1991 and to an average of 17% from 1992 to 2000. Saskatchewan also increased royalty rates after the OPEC oil shock. The NDP government of Allan Blakeney in Saskatchewan had a mean annual effective royalty rate of 38% between 1975 and 1982, 23% from 1983 to 1991 and 18% from 1992 to 2000. Lougheed also emphasized in 1975 that Alan Blakeney's NDP government's participation in the economy made Lougheed's own government look "laissez-faire" in comparison. (Bunner, 2006).

and the effect of OPEC on the petroleum industry in Canada.

Oil production was prorationed in Alberta from 1949 until 1973 since the capacity of the province to produce exceeded the level of demand for oil (Hanson, 1958). Two federal programs were the National Oil Policy (1961 - 1972) and the National Energy Program (1980 - 1982). The National Oil Policy (NOP) guaranteed a market for western-produced oil at a price that was higher than the world price, and was guarded against competition from cheaper oil (Doern and Toner 1985, 81). The National Energy Program (NEP) kept oil prices in Western Canada below the world market price from late 1980 to 1982. The formation of OPEC (1973) was also likely to have had an effect on investment in Alberta and Saskatchewan. To reflect the structural the changes within the OPEC era, two dummy variables are used. From 1973 to 1985, the OPEC cartel's prorationing agreement increased the world price of oil. In 1985, the agreement was broken, leaving the OPEC members free to produce at capacity, driving the world price down.

For comparison purposes, columns (1) and (3) of Table 4 correspond to columns (4) and (6) from Table 2. This compares the base specifications in Table 2 to one with the included political and economic controls. Full results are available in Appendix A. The estimates of ρ are robust to the inclusion of other controls, maintaining the same sign and magnitude. Looking at the estimates of h in columns (3) and (4), we see that the estimate of h gains precision once the controls are included in the regression. However, the estimates become positive, which is inconsistent with the estimates from Table 2, as well as those reported in Table 3. Examining columns (2) and (4), we see $\hat{h} > 0$, and it is somewhat puzzling that an expropriation risk increases expenditure on land.

Columns (1) and (3) of Table 5 corresponds to columns (3) and (4) of Table 3. In column (2), the estimate of h is robust to the inclusion of additional control variables, though some precision is lost. However, comparing columns (2) and (4), we see the estimate of the h is not robust to the inclusion of a dummy for Saskatchewan, despite the dummy not affecting results in columns (1) and (2). One possibility is the expropriation risk had fallen to a low level after 1952, making it difficult to identify h from 1955 onwards.

Table 4: Effect of the CCF on Expenditures on Land (II)

Dependent Variable: Expenditures on Land (million 1947 $)	(1)	(2)	(3)	(4)
Constant	35.382***	30.921***	35.390***	30.128***
	(10.676)	(10.284)	(10.668)	(9.977)
$1+\rho$ (million 1947 dollars)	0.664***	0.678***	0.664***	0.668***
	(0.083)	(0.153)	(0.128)	(0.157)
h (million 1947 dollars)	-0.040	1.037	0.213	0.893†
	(0.399)	(0.944)	(0.243)	(0.596)
Profits (million 1947 dollars)	0.015	0.019	0.015	0.020
	(0.019)	(0.020)	(0.019)	(0.021)
Changes in Reserves (million m^3)	-0.189**	-0.171**	0.190**	-0.165**
	(0.088)	(0.083)	(0.088)	(0.082)
Saskatchewan (0,1)	-32.021***	-33.109***	-32.380***	-35.323***
	(9.446)	(11.309)	(9.532)	(12.375)
Controls	N	Y	N	Y
R^2	0.7160	0.7650	0.6441	0.7658
F-stat	56.05	40.26	60.28	38.03

Notes: $N = 124$. Columns (1) and (2) have $CCF = 1$ for 1947 - 1952; Columns (3) and (4) have $CCF = 1$ for 1947 - 1964. Columns (2) and (4) have additional control variables. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, † $p < 0.2$.

4.4 Other CCF Effects on Natural Resource Development

The results discussed above suggest the presence of a credible threat of expropriation by the CCF, captured by changes in expenditures on land acquisition. It is possible, however, that the CCF had other economic effects on the development of the oil and gas resources in the province, and on the wealth of the province. Following Bohn and Deacon (2000), we attempt to explain exploration and development activity measured by wells drilled per year and annual oil production as a function of the CCF. Variable definitions and summary statistics are presented in Table 6 and the estimated coefficients for the models specified in (25) and (26) below are presented in Table 7. In this case, the time period of the data is 1947 to 2004.

It may be the case that an expropriation risk affects reserve values, but as Bohn and Deacon (2000) argue, exploration and development of resources as well. The purpose of this specification is to isolate the political effects of changes in parties and party leaders on exploration decisions made by firms in Alberta and Saskatchewan. Exploration and development intensity is approximated by

Table 5: Effect of the CCF on Price per Hectare of Land (II)

Dependent Variable: Price per Hectare (1947 $)	(1)	(2)	(3)	(4)
Constant	4.285***	3.539	4.651*	4.359
	(1.542)	(3.977)	(2.503)	(4.439)
$1+\rho$ (million 1947 dollars)	0.849***	0.882***	0.846***	0.862***
	(0.072)	(0.106)	(0.075)	(0.116)
h (million 1947 dollars)	-0.871***	-0.838†	-0.814***	-0.391
	(0.347)	(0.650)	(0.406)	(0.656)
Profits (million 1947 dollars)	-0.004	-0.004	-0.004	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Change in Reserves (million m^3)	-0.067*	-0.069*	-0.067*	-0.070**
	(0.037)	(0.036)	(0.038)	(0.036)
Saskatchewan (0,1)			-0.595	-2.907
			(2.630)	(3.409)
Controls	N	Y		
R^2	0.7989	0.8415	0.7990	0.8433
F-stat	76.44	68.56	62.03	74.40

Notes: $N = 104$. $CCF = 1$ for 1955 - 1964. Column (2) has additional control variables. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, † $p < 0.2$.

the number of wells drilled. The empirical specification is:

$$\begin{aligned}\log\left(wells\ drilled\right)_{it} &= \alpha_i + \beta_0 CCF_{it} + \beta_1 NDP_{it} + \beta_2 SC_{it} + \beta_3 Liberal_{it} \\ &+ \gamma_0 \log\left(price\right)_t + \gamma_1 \log\left(avgDepth\right)_{it} + \gamma_2 t \\ &+ \delta_0 Lougheed_{it} + \delta_1 Blakeney_{it} + \delta_2 OPEC1_t \\ &+ \delta_3 OPEC2_t + \delta_4 Proration_{it} + \delta_5 NEP_t + \delta_6 NOP_t + \epsilon_t\end{aligned} \tag{25}$$

Here, we regress the logarithm of number of wells drilled per year on ownership instability (the presence of the CCF), the logarithm of price, the logarithm of average well depth, a time trend, and dummy variables for OPEC. In addition, dummy variables for the presence of prorationing, the NEP and NOP were included as these are expected to have an effect on exploration decisions. Dummy variables for when the other political parties in Alberta and Saskatchewan were in power are also included (New Democratic Party, Social Credit Party and Liberal Party). The Progressive Conservative Party is the omitted category, as it was the only political party that has been in power in both provinces.

A similar specification to (25) for production intensity is approximated using the ratio of pro-

Table 6: Summary Statistics for Exploration and Production Models

	Mean	Standard Deviation	Min	Max
log (*wells drilled*)	7.493	1.148	4.127	9.871
log (*production/reserves*)	-2.471	0.768	-3.702	0.002
CCF (1944 - 1964)	0.155	0.364	0	1
log (*crude oil price*) (1972 $)	3.517	0.467	2.675	4.426
log(*average well depth*)	6.999	0.240	6.341	7.570
Year	1975.5	16.813	1947	2004
Year squared	3.903e+06	6.64e+04	3.791e+06	4.016e+06
OPEC1 (1973 - 1985)	0.224	0.419	0	1
OPEC2 (1986 - 2004)	0.345	0.477	0	1
Prorationing in Alberta (1949 - 1973)	0.466	0.501	0	1
National Oil Policy (1961 - 1972)	0.224	0.419	0	1
National Energy Program (1981 - 1982)	0.017	0.131	0	1
Liberal party in power	0.069	0.254	0	1
Social Credit party in power	0.207	0.407	0	1
New Democratic Party in power	0.224	0.419	0	1

N = 116

duction to reserves as the dependent variable.

$$\begin{aligned}\log\left(\frac{production}{reserves}\right) &= \alpha_i + \beta_0 CCF_{it} + \beta_1 NDP_{it} + \beta_2 SC_{it} + \beta_3 Liberal_{it} \\ &+\gamma_0 \log\left(price\right)_t + \gamma_1 \log\left(avgDepth\right)_{it} + \gamma_2 t + \gamma_3 t^2 \\ &+\delta_0 Lougheed_{it} + \delta_1 Blakeney_{it} + \delta_2 OPEC1_t \\ &+\delta_3 OPEC2_t + \delta_4 Proration_{it} + \delta_5 NEP_t + \delta_6 NOP_t + \epsilon_t\end{aligned} \tag{26}$$

The logarithm of production is regressed on ownership instability, the logarithm of price, the logarithm of average well depth, a time trend, and dummy variables for OPEC. We define production as yearly output per reserve levels. The same dummy variables for political controls are included in this specification. The year-squared term is included because production may be characterized by "Hubbert's peak", where production in Canada peaked in the early 1970s. Results with all controls are reported in Table 10 in Appendix A.

In explaining wells drilled, the coefficient for the CCF dummy is positive. This is not unexpected, given the results of the previous models estimated. In addition, in order to attract firms, the CCF government offered concessions and stated it would not expropriate. The coefficient is

Table 7: Exploration and Production Model Results

	Dependent variable:	
	log(*wells drilled*)	$\log\left(\frac{production}{reserves}\right)$
Constant	-188.966	3416.659**
	(16.533)	(1357.485)
$\log(P)_t$	0.044	0.050
	(0.187)	(0.210)
$\log(avgDepth)_{it}$	1.400***	-1.843***
	(0.305)	(0.360)
CCF (0,1)	0.325*	0.354*
	(0.189)	(0.212)
Liberal (0,1)	0.599***	0.162
	(0.166)	(0.166)
Social Credit (0,1)	0.005	-0.582***
	(0.208)	(0.206)
NDP (0,1)	-0.548***	0.145
	(0.140)	(0.128)
Lougheed (0,1)	-0.016	-0.250
	(0.167)	(0.200)
Blakeney (0,1)	-0.201	-0.352***
	(0.253)	(0.127)
R^2	0.9038	0.7296

Notes: $N = 116$. Robust standard errors in parentheses.
Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

likely capturing these positive effects. The CCF government was also aggressively pursuing resource development along with its socialist policies, which can partly explain the positive effect on exploration and development levels. The coefficient for the Liberal government is positive and significant. The coefficient for the NDP government is negative and significant. Both the NDP and the Liberals had never been governing parties in Alberta, and so the effects are purely from Saskatchewan. These effects are interesting, as the NDP was the successor party to the CCF and formed crown corporations in the petroleum industry, so a negative effect on exploration is not unexpected. However, the absence of a significant positive influence of the Social Credit Party in Alberta is surprising. The populist party sought to attract external capital to develop Alberta's oil resources and was in power in Alberta from 1935 to 1971. It is possible that the coefficient could be capturing other effects, such as collinearity with the pro-rationing regime variable.

In the production model, the estimated coefficients for the political parties are not significant, with the exception of the Social Credit party. These results indicate the CCF did not have a major effect on exploration or production intensity. Activity in the resource sector did not fall due to a perceived expropriation threat, and that production and exploration decisions were positively affected. This suggests that the effect of the CCF was only on the value of the fixed factor, land. Given the positive risk premium found, this implies that only when the value of the fixed factor is driven to zero is will exploration and production be affected.

5 Conclusions

Government policy can have a significant effect on economic outcomes, as well as investment decisions by firms. The most important way a government can affect positive economic outcomes is by ensuring secure property rights. We developed a model of the value of land with an extractable natural resource, with uncertainty in the form of an expropriation threat by the government. We find the change in the value of land to a firm is a linear function of current profits, the current value of land, and the change in the resource stock. This simple specification allows identification of the probability of expropriation, as perceived by the firm. A key feature of this model is it's simplicity and the linearity of the expropriation probability parameter, making it attractive for empirical work.

A significant portion of Western Canada's wealth is generated by the oil industry, and this source of wealth was thought to have been under the threat of expropriation in Saskatchewan during the governance of the CCF. We estimate the perceived probability of expropriation occurring in Saskatchewan in the 1940s and 1950s, and the effect of the expropriation threat on the oil industry in both Alberta and Saskatchewan. The results presented in Section 4 suggest there was an effect from CCF policies, both during the risk period and the tenure of the party. Due to limited data, no conclusions can be made about an expropriation probability during the threat period. However, use of price per hectare as a proxy for land value in the latter period of the CCF regime suggests a positive risk premium existed in Saskatchewan.

Further analysis shows that the CCF government had a significant positive effect on exploration and development and oil production in Saskatchewan. This is likely due to increased interest in developing Western Canada, despite potential expropriation risk. These conflicting results suggest that the CCF did not have a significant negative effect on investment in capital and output in the Saskatchewan oil industry compared to Alberta, but did increase the required rate of return for operating in Saskatchewan. This indicates that the effect of the threat from CCF policies was to lower land values, the fixed factor in production, rather than to decrease development and production. Future work will involve extending the price per hectare data to examine the effect of the CCF in the early part of the regime.

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A Detailed Results

Table 8: Effect of the CCF on Expenditures on Land (II)

Dependent Variable: Expenditures on Land (million 1947 \$)

	(1)	(2)	(3)	(4)
Constant	35.382***	30.921***	35.390***	30.128***
	(10.676)	(10.284)	(10.668)	(9.977)
$1+\rho$ (million 1947 dollars)	0.664***	0.678***	0.664***	0.668***
	(0.083)	(0.153)	(0.128)	(0.157)
h (million 1947 dollars)	-0.040	1.037	0.213	0.893†
	(0.399)	(0.944)	(0.243)	(0.596)
Profits (million 1947 dollars)	0.015	0.019	0.015	0.020
	(0.019)	(0.020)	(0.019)	(0.021)
Changes in Reserves (million m^3)	-0.189**	-0.171**	0.190**	-0.165**
	(0.088)	(0.083)	(0.088)	(0.082)
Saskatchewan (0,1)	-32.021***	-33.109***	-32.380***	-35.323***
	(9.446)	(11.309)	(9.532)	(12.375)
OPEC1		9.932		12.113
		(9.892)		(10.299)
OPEC2		-8.054		-5.848
		(14.310)		(15.029)
NEP		-28.130		-27.396
		(22.035)		(22.146)
NOP		1.445		2.622
		(4.844)		(5.319)
Lougheed		-22.501**		-22.417**
		(11.081)		(10.971)
Blakeney		1.931		2.446
		(12.473)		(12.467)
TSX Index		0.007		0.007
		(0.006)		(0.006)
R^2	0.7160	0.7650	0.6441	0.7658
F-stat	56.05	40.26	60.28	38.03

Notes: $N = 124$. Columns (1) and (2) have $CCF = 1$ for 1947 - 1952; Columns (3) and (4) have $CCF = 1$ for 1947 - 1964. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, † $p < 0.2$.

Table 9: Effect of the CCF on Price per Hectare of Land (II)

Dependent Variable: Price per Hectare (1947 $)

	(1)	(2)	(3)	(4)
Constant	4.285***	3.539	4.651*	4.359
	(1.542)	(3.977)	(2.503)	(4.439)
$1+\rho$ (million 1947 dollars)	0.849***	0.882***	0.846***	0.862***
	(0.072)	(0.106)	(0.075)	(0.116)
h (million 1947 dollars)	-0.871***	-0.838†	-0.814***	-0.391
	(0.347)	(0.650)	(0.406)	(0.656)
Profits (million 1947 dollars)	-0.004	-0.004	-0.004	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Change in Reserves (million m^3)	-0.067*	-0.069*	-0.067*	-0.070**
	(0.037)	(0.036)	(0.038)	(0.036)
Saskatchewan (0,1)			-0.595	-2.907
			(2.630)	(3.409)
OPEC1		2.674		2.903
		(4.905)		(4.763)
OPEC2		-10.522**		-10.320**
		(4.717)		(4.779)
NEP		-20.051**		-19.280**
		(7.978)		(8.372)
NOP		-1.151		-0.719
		(3.249)		(3.296)
Lougheed		-4.091*		-5.817
		(2.177)		(3.593)
Blakeney		9.392		11.217*
		(5.972)		(6.636)
TSX Index		0.004***		0.004***
		(0.001)		(0.001)
R^2	0.7989	0.8415	0.7990	0.8433
F-stat	76.44	68.56	62.03	74.40

Notes: $N = 104$. $CCF = 1$ for 1955 - 1964. Robust standard errors in parentheses. Arrelano-Bond test for serial correlation fails to reject the null hypothesis of no serial correlation. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, † $p < 0.2$.

Table 10: Exploration and Production Model Results

	Dependent variable:	
	log(*wells drilled*)	$\log\left(\frac{production}{reserves}\right)$
Constant	-188.966	3416.659**
	(16.533)	(1357.485)
$\log(P)_t$	0.044	0.050
	(0.187)	(0.210)
$\log(avgDepth)_{it}$	1.400***	-1.843***
	(0.305)	(0.360)
t	0.094***	-3.425**
	(0.008)	(1.370)
t^2		8.61e-04**
		(3.45e-04)
OPEC 1973 - 1985 (0,1)	0.700***	-0.151
	(0.212)	(0.148)
OPEC 1985 - 2006 (0,1)	-0.284	0.441***
	(0.230)	(0.130)
Proration (0,1)	1.252***	-0.586*
	(0.294)	(0.330)
NOP (0,1)	-0.664***	0.390*
	(0.154)	(0.223)
NEP (0,1)	-0.124	0.063
	(0.145)	(0.124)
CCF (0,1)	0.325*	0.354*
	(0.189)	(0.212)
Liberal (0,1)	0.599***	0.162
	(0.166)	(0.166)
Social Credit (0,1)	0.005	-0.582***
	(0.208)	(0.206)
NDP (0,1)	-0.548***	0.145
	(0.140)	(0.128)
Lougheed (0,1)	-0.016	-0.250
	(0.167)	(0.200)
Blakeney (0,1)	-0.201	-0.352***
	(0.253)	(0.127)
R^2	0.9038	0.7296

Notes: $N = 116$. Robust standard errors in parentheses.
Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

B Data Appendix

B.1 Main Data

The market value of land purchased by a firm for the purpose of natural resource production would ideally be observed from actual market transactions by firms. Market values of oil firms in Alberta and Saskatchewan would be difficult to use for this sort of exercise as many large firms have investments and interests in other nations. In addition, any between-firm sales of land may involve different geographical areas, making the value of a specific tract of land difficult to determine. To compound these difficulties, firm-specific data is unavailable for the time period in question. In this data set, the value of a unit of land is proxied by yearly expenditures in a province by the petroleum industry on land. Land leases and the petroleum and natural gas rights associated with the leases are auctioned by the provincial governments in a first-price, sealed bid auction. In Alberta, the auctions occur, on average, 24 times per year. In Saskatchewan, the auctions occur six times per year.

The data used is yearly observations by province, from 1947 to 2006. The Canadian Association of Petroleum Producers (CAPP) publishes detailed information on the Canadian petroleum industry in its *Statistical Handbook*. For most variables of interest in our study there are annual data for 1947 to 2006, including prices of crude oil per cubic metre; expenditures on exploration, development, operations, land and royalty payments; volume of production; and several measures of reserves. The data set consists of observations for Alberta and Saskatchewan from 1947 to 2006 giving a total of 120 annual observations.

The variable V_{it} is the value of a unit of land in province i at time t. It is approximated by the value of annual expenditures on land to acquire mineral rights by the petroleum industry. The second measure used is the average price per hectare for mineral rights, which is available from 1955 onwards. This necessitates the use of the extended threat period. The term $(p_{it} - c_{it}) \cdot q_{it}$ is aggregate profits for the oil industry in province i at time t, where p_{it} is the province-specific[9] price of crude oil, c_{it} is the average cost of production, and q_{it} is aggregate production. The dummy variable for the threat period, D_{it} , is interacted with V_{it} in order to determine the perceived expropriation probability.

The data on reserves usable for the purpose of this paper are the remaining established reserves at year end. The data on reserves includes initial volume in place by year of discovery (1947 - 2006) and geological age (as of December 31 2005), yearly production (1947 - 2006), initial established reserves by year of discovery (1947 - 2006), and remaining established reserves at year-end (1962 - 2006), and reserve additions. CAPP defines "initial established reserves" as established reserves before production; "remaining established reserves" as initial established reserves minus cumulative production; and "cumulative production" as production of oil/gas to date. Initial established reserves by year of discovery credits additional discoveries or reserve additions in a given oil pool in subsequent years back to the year of the initial discovery. As such, the data would not reflect the actual knowledge of the oil industry at the time of the land sales and could not be used to determine its investment decisions. Government reports from the provinces of Alberta and Saskatchewan were used to determine reserves from 1945 to 1961. Data on Alberta's reserves (1948 - 1967) are from the Oil and Gas Conservation Board Report 68-18. The reserve observations for 1945 - 1947 are from Hanson (1958). His source for reserves information was the Petroleum and Natural Gas Conservation Board, the previous incarnation of the Oil and Gas Conservation

[9]Provincial prices differ because of differences in quality, transportation costs, and distances from markets.

Board. For Saskatchewan, reserves data (1953 - 1963) are from the Saskatchewan Petroleum and Natural Gas Statistical Yearbooks 1900 - 1959, 1960, 1961, 1962 and 1963. The first official report of Saskatchewan's reserves was in the 1952 Annual Report of the Department of Natural Resources. Prior to that, Saskatchewan had relatively few producing wells and fields, making reserves difficult to estimate. Reserves for the period 1945 - 1952 in Saskatchewan were approximated by letting reserves equal production.

Average wellhead price in each province is available from CAPP from 1951 to 2006. Prior to 1951, we use the Edmonton par price in current dollars per barrel from the Historical Statistics of Canada.[10] We convert price per barrel to price per cubic metre with the conversion factor being 6.292 barrels per cubic metre. Data for the Toronto Stock Exchange 300 Composite Index are from the Historical Statistics of Canada (1956 - 1977), Series J4819 through J494 and CANSIM II, series V122620 (1977 - 2006).[11] All current dollar values are deflated to constant 1947 values using the consumer price from CANSIM II, series V737344 with a base year of 2001.[12]

Production and reserve data from CAPP are reported in thousands of cubic metres, which were adjusted to cubic metres. Reserve data for both provinces prior to 1963 are reported in millions of barrels, which we convert to cubic metres. Cost data includes annual industry expenditures by province, for exploration, development, operations, and royalties in millions of current dollars, but does not include specific extraction costs. We approximate the total cost of production as operating expenditures plus royalty expenditures. Exploration and development expenditures are a fixed cost, while royalty and operational expenditures are variable. Average cost of production is calculated by dividing total cost by annual production. This can be considered the working costs for oil production, but the cost information is for the entire petroleum industry, which includes oil and natural gas. This means that the average cost calculated is higher than the actual average cost per cubic meter of oil produced.

The dummy variable for Saskatchewan, S_i, captures the average difference in the value of land sales in Saskatchewan compared to Alberta after controlling for the quantity and profitability of oil reserves. Interacting the dummy variable for Saskatchewan with land value, V_{it}, reveals the difference in the risk-free rate of return between Saskatchewan and Alberta.

B.2 Data for Supplemental Analysis

Average well depth was calculated by dividing total metres drilled by the total number of wells drilled. Data from CAPP on number of wells drilled and total meters drilled was only available from 1955 to 2004. For data from 1947 to 1954, government reports were used. For Saskatchewan, the Petroleum and Natural Gas Statistical Yearbook 1900 - 1959 was the source for total wells drilled and total footage drilled. For Alberta, (Hanson, 1958, p. 117) was the source for total footage drilled and average well depth. Number of wells drilled was found by dividing total footage by average well depth. For both provinces, depth in feet was converted to meters. Data on yearly production and reserves by province are from CAPP. As with the exploration model, dummy variables for the presence of prorationing, the NEP and the NOP were included.

[10] This comes from dividing total value produced (Series Q20) by quantity produced (Series Q19)

[11] For the years prior to 1956, an approximation of the stock index was created by averaging the stock indices for Mines, Industrials, Banks and Utilities from the Historical Statistics of Canada, Series J490 through J493. The base year used was 1947, with the index in 1947 equal to 100.

[12] The CPI was converted into a 1947 base year by dividing all values by the CPI entry for 1947 and then multiplying by 100.