# Alberta Oil & Gas Leases: Testing Competing Institutions

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**Abstract**

In Alberta, natural resource revenue averaged 26% of total revenues from 1983 to 2012. Natural resource revenues are an important component of the province's fiscal health. Currently, oil and gas leases are sold in a first price, sealed bid auction. However, there are institutional features restricting the information available to participants and the public. Often, the identity of the auction winner is unavailable and the number of bidders and the distribution of bids are never released. This has the potential to impact bids, auction revenue, and the rate of resource extraction. We use experiments to replicate the auction environment and change the amount of information available to bidders. This allows us to identify the impact current institutions have on bidding behavior and therefore auction revenue. The first treatment replicates the current bidding process; firms have the option of using a costly agent to submit their bid. The use of the agent masks the true winner of the auction. We find that bids are higher with the use of brokers in the experimental results, consistent with observed auction results. The second treatment removes the ability to use an agent from the experiment. Bids are lower in the no-broker treatment, indicating that brokers are used when bids are more valuable. The magnitude of the different coefficients indicates that there is an additional strategic effect associated with the use of brokers, increasing bids further.

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# 1 Introduction

Currently, oil and gas leases in Alberta are sold in a first-price, sealed-bid auction, where only the winner and the winning bid are revealed.[1] The government then receives additional revenues from a yearly rental fee, and royalties on production. Natural resource revenues are a relatively important part of Alberta's fiscal health; natural resource revenue has averaged 26% of total revenues from 1983 to 2012; this includes a peak of 41% (2001) and a low of 14% (1999).

While royalties account for the majority of natural resource revenue (81% on average from 1996 to 2012), revenues from sales of leases make up most of the remainder (18% on average). Total revenues from the sale of leases have averaged 5% over the same period; this is comparable to average revenues from corporate income taxes (9%).

In selling leases, the government is essentially selling the option to drill to the firms. The firms, in turn, will make their bids depending on assumptions about royalty rates, expected prices and the expected cost of development. Economic theory suggests that firms should be willing to pay the expected discounted value of a given lease in order to secure it. The current fiscal arrangement is a combination of auctions and royalties on production that balances revenues from risky development (royalties) with a certain buy-in (auctions).

A unique feature of the auctions is the ability of firms to hire what is called a "broker" to bid on their behalf, using the broker's name rather than their own to bid. Anecdotal evidence suggests firms use brokers to conceal information from their competitors, and to behave strategically in acquiring leases.[2] This ability to hide information through the use of brokers has the potential to affect bidder behaviour, and hence bids and through bids, government revenue.

Firms can choose to bid themselves, and be revealed as the winner, or to hire a broker and use that name instead of their own. In the absence of brokers, a firm would reveal their interest in a given area through the acquisition of leases. By revealing interest and/or private information in a given lease, firms also reveal information regarding the value of a lease and the surrounding leases. The implication is that brokers are used to reduce competition over leases, and hence bids. Thus, firms appear to gather information covertly.

In the auctions from 2003 to 2013, 73,834 parcels were offered up for auction. Of these, 72,829 were acquired by firms, and the average (nominal) price per hectare paid was $482. When a broker is used and wins (48% of parcels), the average price per hectare is $723, compared to an average price per hectare of $258 when firms bid under their own identity. This large price differential implies brokers are used when parcels are perceived to be more valuable. If it is the case that brokers are used to conceal information and lower competition, then bids are lower than they would otherwise be.

However, this counterfactual of what bids would be without the option to use a broker is unobservable in the current environment. With an experiment, we can observe the effect the availability of brokers has on bids by replicating the auction environment and comparing subject behaviour under both scenarios.

[1] First-price means the winner is the bidder making the highest bid. Sealed bid means participants cannot observe bids until after the auction concludes.

[2] CBC News, "Companies spend $167M in Alberta land sale," March 10, 2010, `http://www.cbc.ca/m/touch/canada/british-columbia/story/1.874537`.

# 2 Auction Environment

In Alberta, 81% of subsurface mineral rights are owned by the province. The remaining 19% is owned as freehold[3] by individuals, companies or held by the federal government. The government of Alberta holds an average of 24 auctions per year to offer firms petroleum and natural gas leases and licenses. Approximately 9,000 leases and licenses are issued each year.[4]

The maximum size of a given parcel is 15, 32 or 36 square miles, depending on the area of Alberta. The minimum size is a spacing unit.[5] In auctions between 2003 and 2013, the average size of a parcel was 412 hectares (4.12 square km, or 1.6 square miles) with a minimum of 0.8 hectares and a maximum of 8,704 hectares. In comparison, the area of Alberta is 661,848 square km; the average lease is a very small fraction of the land area. The relatively small parcels of land imply there is potential for information externalities and competition over a given lease.

The smaller the average lease size, the more likely it is that multiple leases cover an oi or gasl pool, and that multiple firms are active in the same pool. Firms bid on petroleum and natural gas leases and licenses offered by the Crown in a first-price, sealed-bid auction. The minimum bid on each parcel is currently set at $2.50 per hectare for a lease and $1.25 per hectare for a license[6]. Following the auction, a firm that holds a lease or license must pay annual rent of $3.50 per hectare or $50 (whichever is greater) as well as royalties on production. Once a firm has acquired a lease, it has five years to drill a well. The term of a license differs depending on the region of Alberta, and an additional difference is that licenses can be grouped to drill a well. It must be the true owner of the parcel that drills the well on the parce; title to the mineral rights must be transferred before a well can be drilled.

If the parcel is shown to have fluid in paying quantities, the lease is continued indefinitely.[7] The tenure ends when the lease holder can no longer show the lease is capable of producing in paying quantities, or through royalty default. If, at the end of the original five year term the lease has not been proven productive, it reverts to the province.

## 2.1 Selection of Leases

The entire selection and auction process occurs through the province's Electronic Transfer System (ETS). Firms can search for mineral rights at any time, and can request leases they are interested in be posted for an auction, up to nine weeks before the auction date. The identity of firms requesting leases is private information known only by the government and requesting firms. Only requested parcels are posted for sale in a given auction. The Department of Energy limits the number of leases requested by a given firm to 20% of the total parcels in a sale.[8]

A sale is closed to requests a week before the available parcels are revealed. The parcels are revealed eight weeks before the auction date. At any point in time, firms observe leases available at three or four upcoming auction dates. Prior to a sale, firms have information on the surface location and size of each parcel, any surface access restrictions, the type of mineral rights included in the lease,[9]

[3] Property owned outright with the largest bundle of rights included with ownership.
[4] Licenses differ from leases in time horizon, and minimum and maximum sizes but in general, the process is the same.
[5] A spacing unit is one quarter section for an oil well and one section for a gas well. A section is a square mile.
[6] Alberta Department of Energy, "Petroleum & Natural Gas Sales Frequently Asked Questions,' 'http://www.energy.alberta.ca/Tenure/1096.asp.
[7] A lease is proven productive by drilling, producing, mapping, being part of a unit agreement or by paying offset compensation.
[8] Alberta Department of Energy, "Petroleum & Natural Gas Sales Frequently Asked Questions," `http://www.energy.alberta.ca/Tenure/1096.asp.`
[9] Petroleum, natural gas or both.

and the formation to which the mineral rights pertain.

Results are posted the day of the auction. The total bid includes the bonus offer, the annual rent and a processing fee. A firm which requests a lease and fails to bid is fined and does not win the lease, unless another firm bids. The fine is equivalent to the minimum revenue the government would have received had a bid been made. Failing to request parcels does not exclude a firm from participating in an auction. Sale results include the winning bid, and the identity of the winning bidder. No other information is revealed. The parcels available for a given sale and the auction results are posted on the Alberta Department of Energy website.

## 2.2 Use of Brokers

A unique feature of the auctions for petroleum and natural gas leases in Western Canada is the ability of firms to hire brokers, and use the broker's name instead of their own for the bid. Brokers provide many services involving the acquisition of surface access and mineral rights for freehold[10] and Crown lands. They are also a way for exploration and production firms to outsource the administration of their land and mineral rights holdings. Brokers can also represent smaller firms that do not have access to the ETS database, and hence are unable to submit their own bid; however, it is not necessarily the case that the firm uses the broker's name. The service of interest for our purposes is the use of the name in the auctions.

The exploration and development firms choose which parcels to bid on, and the amount of the bid. Firms choose whether to bid under their own name, or hire the broker. In Alberta, all bids are submitted electronically, and payment is made through a pre-authorized debit system;[11] Firms must have access to ETS to bid.[12] A broker "name" must be hired separately for each lease. The cost per lease to use a broker is approximately $100, and the fee includes the transfer of title from the broker to the hiring firm.

A concern may be that brokers are also bidding under their own authority, in competition with the exploration and development firms. If this were the case, then bids made by brokers may not accurately measure the willingness to pay of exploration and development firms, as it would not be their bidding decision. It would also be impossible to identify who is making the bidding decision, brokers or the firm that hires the broker. Both brokers and the exploration and development firms are required to use licensed land agents to negotiate for and acquire surface and subsurface rights.[13] The licensing of land agents is regulated by the Land Agents Licensing Act and the Land Agents Licensing Regulation in Alberta. A land agent is defined as "a person who negotiates for or acquires an interest in land (i) on behalf of the person's employer, (ii) as an agent on behalf of another person, or (iii) on the person's own behalf."[14]

Standards of conduct enforced by the government of Alberta and Registrar of Land Agents include a requirement to act in the client's best interest, keep confidential information acquired in the course of a professional relationship, and not enter into a situation with a conflict of interest.[15]

[10] Privately owned lands and mineral rights.

[11] In British Columbia and Saskatchewan, paper bids are accepted and so another service provided by a broker is carrying the bid for firms, though this service is separate from the use of the name.

[12] Alberta Department of Energy, "Petroleum & Natural Gas Sales Frequently Asked Questions," `http://www.energy.alberta.ca/Tenure/1096.asp`.

[13] Alberta Department of Jobs, Skills, Training and Labour, "Land Agents Licensing," `http://work.alberta.ca/labour/land-agents-licensing.html`.

[14] Province of Alberta, "Land Agents Licensing Act," 2010. Chapter/Regulation L-2 RSA 2000.

[15] Alberta Department of Jobs, Skills, Training and Labour, "Land Agent Standards of Conduct," `http://work.alberta.ca/labour/standards-of-conduct.html`.

The professional conduct of land agents in Alberta is also regulated by the Canadian Association of Petroleum Landmen (CAPL). The ethical standards are in the same vein as those enforced by the government of Alberta. Members of CAPL are prohibited from undertaking activities creating a conflict of interest with their employer or client, or from disclosing confidential information.[16] The regulations on land agents and their employers, the brokers, prevents the brokers from using information gained in the provision of services to acquire leases on their own. Anyone found in violation of the ethical standards risks losing their license. These standards ensure brokers are not competing with the firms hiring them, and means the only strategic effect of brokers is through the use of the name.

# 3 Observations from Auction Results

Data for leases sold in auctions from January 1996 to December 1999 have been collected from the Government of Alberta's auction results website. Information provided to firms by the government includes the surface location of the lease, the size of the lease, the pertinent mineral rights, and any surface access restrictions. A lease can include multiple tracts, which can differ by physical location or by mineral rights. Mineral rights can be natural gas, petroleum or both. The description of mineral rights also includes the depth of any relevant formations, or restrictions on drilling depth and formations attached to the lease. An unrestricted lease would be petroleum and natural gas from the surface to basement (bedrock). A restricted lease could be restricted to a certain type of fluid, include only fluid above or below a certain formation/depth, or exclude a certain formation or interval.

A weakness of the data is only the identity of the winning bidder is revealed, necessitating a secondary source to determine the hiring firm in the case of a broker winning. A dataset of well information acquired from a private exploration and development firm allows identification of the true winner. As with the bidders, a unique code was assigned to each firm observed to be operating a well. In order to do this accurately, the chain of title for each firm was tracked so there was accurate contemporaneous ownership in each year an auction occurred.[17] Wells drilled after the auction date were matched to each lease by specific geographic location. These matches provide a basis for computing the *ex post* value of a lease. Wells drilled prior to the auction date were matched to lands adjacent to each lease. These wells provide an indication of *ex ante* information held by firms. Finally, leases sold in each month were matched to subsequent leases sold to uncover the dynamics of firm behaviour. For more details on the data, see Winter (2012).

## 3.1 Initial Data Analysis

Removing leases that were withdrawn, had no offers or where all offers were rejected leaves 24,761 observations. Of these, 49.6% of the leases were allowed to lapse: no well was drilled on these leases between the auction date and July 2007. The unconditional average price per hectare is $251.81, is $301.97 for non lapsed leases, and $200.85 for lapsed leases. When a broker wins, the average price per hectare is $374.96, and when a broker is not used the average price per hectare is $197.38. The simple conditional averages suggest there is a difference in willingness to pay associated with hiring a broker. The average lease size is 234.73 hectares. Summary statistics are presented in Table 1.

Discussion with industry experts has indicated firms are strategic in their bidding decisions. The decision to bid on a specific lease and the decision to use a broker in acquiring the lease are related. We begin with a simple regression of the winning bid on lease characteristics. The dependent variable is the price per hectare paid by the winning bidder. The explanatory variables are lease size,

[16] Canadian Association of Petroleum Landmen, "Canadian Association of Petroleum Landmen By-Laws," April 2009, `http://www.landman.ca/pdf/constitution.pdf`.

[17] Chain of title includes mergers, name changes, and amalgamations, etc.

Table 1: Lease Summary Statistics

| | mean | standard deviation | min | max |
|---|---|---|---|---|
| Lease Size (hectares) | 234.731 | 194.107 | 0.02 | 6400 |
| Auction Bid (dollars) | 52,135.43 | 93,010.20 | 2.2 | 3,248,654.00 |
| Bid per Hectare | 251.81 | 704.03 | 2.5 | 75,280.50 |
| Broker Wins (0,1) | 0.294 | 0.456 | 0 | 1 |
| Lease Lapses (0,1) | 0.496 | 0.500 | 0 | 1 |
| Joint Venture Wins (0,1) | 0.090 | 0.287 | 0 | 1 |
| Number of Adjacent Wells (pre-auction) | 20.032 | 24.983 | 0 | 261 |
| Number of Wells Drilled on Lease (post-auction) | 1.523 | 3.100 | 0 | 143 |
| Number of Firms Operating Adjacent Wells | 6.882 | 4.829 | 0 | 46 |
| Number of Adjacent Leases Sold | 2.861 | 2.874 | 0 | 44 |
| Number of Adjacent Lapsed Leases | 1.457 | 1.991 | 0 | 18 |
| Revenues (millions) | 1.603 | 6.508 | 0.00 | 282.926 |
| Drilling Costs (millions) | 0.776 | 1.603 | 0.00 | 43.768 |
| Operating Costs (millions) | 0.178 | 0.483 | 0.00 | 15.846 |

N: 24,761

whether a broker wins, whether the lease subsequently lapses, revenue, drilling costs, the number of firms operating adjacent wells, as well as the number of adjacent wells. Other variables of interest are the number of adjacent leases sold in the same year, and the number of adjacent leases sold in a previous year. These variables provide an indication of the overall activity in the area surrounding each lease. The number of firms operating adjacent wells is a simple proxy for the number of bidders. Other lease characteristics included are dummies for location and mineral rights, whether a joint venture won the lease, and the number of firms in the joint venture. Auction-specific characteristics controlled for are the month and year, and the number of other leases available at the auction date, as well as the total area of leases available at the auction. Results are reported in Table 2.

The average bid per hectare is well over the reservation price of $2.50 per hectare, indicating firms consider the leases to be fairly valuable, or there is substantial competition for each lease. The number of firms operating adjacent wells is a proxy for both the number of potential bidders and activity in an area; the positive sign indicates as the number of firms increases, competition increases, driving the bids up. The number of adjacent leases sold in the same year has a negative effect on the winning bid, whereas the number sold in a previous year is positively correlated with bids. Both are measures of interest in an area, though the negative coefficient on the same year variable is somewhat puzzling. The number of adjacent wells drilled is positively correlated with bids, as expected. Drilling a well is correlated with positive expectations of finding oil or natural gas, which would in turn influence willingness to pay.

Table 2 suggests that a firm winning a lease while using a broker has a substantial effect on the winning bid relative to the average. As a rough calculation, ignoring all other marginal effects, a broker winning increases the winning bid (measured per hectare) by $148. Using a log-linear regression allows us to determines the percentage change in bids as a result of using a broker. A broker is associated with a 75% increase in the bid per hectare, and a 78% increase in the overall bid. However, there is likely endogeneity in a broker being used and winning, and the winning bid.

Table 2: Regression of Winning Bid on Lease Characteristics

| | Dependent Variable: | | | |
|---|---|---|---|---|
| | Bid per Hectare | ln(Bid per Hectare) | Total Bid | ln(Total Bid) |
| Constant | 437.522*** | 4.925** | 55,803.300*** | 10.137*** |
| | (42.561) | (0.113) | (17,515.150) | (0.116) |
| Size (Hectares) | -0.245*** | -6.023e-4*** | 99.459*** | 0.002*** |
| | (0.034) | (6.570e-5) | (7.080) | (1.067e-4) |
| Broker Wins (0,1) | 148.221*** | 0.747*** | 32,597.800*** | 0.784*** |
| | (9.664) | (0.017) | (1362.826) | (0.018) |
| Number of firms operating | 4.963*** | 0.026*** | 747.652*** | 0.011*** |
| adjacent wells | (1.412) | (0.003) | (151.238) | (0.003) |
| Lease Subsequently Lapses (0,1) | -72.580*** | -0.418*** | -17,321.560*** | -0.536*** |
| | (9.135) | (0.020) | (1,499.273) | (0.020) |
| Revenue (million $) | 5.645*** | 0.009*** | 1,567.745*** | 0.010*** |
| | (1.043) | (0.002) | (280.325) | (0.002) |
| Drilling Costs (million $) | 11.693*** | 0.034*** | 5,118.017*** | 0.025*** |
| | (3.737) | (0.009) | (1,076.148) | (0.009) |
| Operating Costs (million $) | -12.096 | -0.045* | -10,675.740*** | -0.066*** |
| | (11.431) | (0.025) | (2,680.323) | (0.024) |
| Number of Adjacent Leases Sold | -3.511** | -0.035*** | -1,136.236*** | -0.078*** |
| in the Same Year | (1.507) | (0.004) | (250.063) | (0.004) |
| Number of Adjacent Leases Sold | 5.324* | 0.017*** | 707.526** | -0.008 |
| in a Previous Year | (2.803) | (0.006) | (334.380) | (0.006) |
| Number of Adjacent Wells | 1.297*** | 0.001** | 38.127 | -0.002*** |
| Drilled (pre-auction) | (0.205) | (5.264e-4) | (27.894) | (5.329e-4) |
| $R^2$ | 0.0428 | 0.1930 | 0.1798 | 0.2605 |
| F-stat | 53.87 | 179.68 | 69.38 | 228.53 |

*Notes*: $N = 24,761$. Robust standard errors in parentheses. Other controls: auction month and year; lease location by area (plains and northern); dummies for mineral rights; number of leases and licenses sold on the auction date; total area of leases and licenses sold on the auction date; joint venture wins; number of firms in winning joint venture. Statistical significance: $^{***}$ $p < 0.01$, $^{**}$ $p < 0.05$, $^{*}$ $p < 0.10$.

Presumably, a lease that has a higher value to a firm is associated with a willingness to hide interest from competitors, suggesting a broker is more likely to be used when a firm is willing to bid high, or when the firm has some private information regarding the value of the lease. Unfortunately, the firm that hires a broker can only be determined when a lease does not lapse, and so identifying the determinants of a broker winning necessitates restricting the data to non-lapsed leases.

## 3.2 Data Limitations

There are several econometric issues with an attempt to estimate the effect of using brokers on bids. These are:

(i) Only the winning bid is observed.

(ii) The number of bidders participating in each auction is unknown.

(iii) Private signals are known only to the firms and are unobserved by the econometrician.

(iv) The choice of hiring a broker and a broker winning is correlated with the unobserved private signal.

(v) Only leases requested by firms are offered in the auctions, resulting in sample selection.

An unavoidable limitation of the data is that because the government only reveals the winning bidder, the number of bidders and number of potential bidders is unknown. Furthermore, in the case where a broker wins, the wells drilled on the lease subsequent to the auction is the only method of uncovering the firm that hired the broker, and the true winner of the lease. Another issue is that use of a broker is only observed when a broker wins a lease. It is possible in the case of a non-broker win that at least one firm hired a broker and failed to win. When a broker wins, the decision of other firms to use a broker or not is unobserved. As well, the decision by a firm to use a broker is based on private information held by the firm that is unobserved by the firm's competitors.

The set of potential bidders can be proxied by the number of firms observed to be active in bidding over the sample period. An additional measure is the number of firms operating adjacent wells, as these can be expected to be the firms with the most interest in a given area. Without knowledge of the number of bidders or the number of potential bidders, analysis of bidder strategy in the traditional sense is impossible. The private information influencing a firm's decision to bid and hire a broker is also unobservable. The general idea is that adjacent wells and leases owned by the winning firm prior to the auction date provides additional information about the expected value of the lease, and affects the decision to hire a broker as well as the bid.

Under the assumption that the choice to use a broker is positively correlated with the value of a lease, omission of the private signals will bias the coefficient on broker upwards. One method of correcting for the omitted variable bias is the use of instrumental variable methods. A valid instrument in this case is one that is correlated with the decision to hire a broker but does not affect the bid itself. However, any variable that is correlated with the private signal would affect the bid, and hence is not a valid instrument. A supply side variable, such as one that affects the fee paid to a broker, would be a valid instrument. Unfortunately, such information is not available.

An alternative way to correct for the omitted variable bias is by including variables that are correlated with the private information held by firms. Constructed measures of firm behaviour, and potentially private information that influences the decision to hire a broker can be used as proxies for the unobserved signals. Proxies considered are adjacent lease acquired by the winner, total adjacent leases sold, the number of adjacent wells, the number of adjacent wells operated by the winner, the

total number of firms operating adjacent wells, firm-specific characteristics, and average price in the area surrounding the lease from previous auctions.

The consequence of the data limitations discussed here is that we cannot conclude there is clear, causal relationship between the decision to use a broker and the effect on all bids, as well as winning bids. While we can conclude it certainly appears brokers are associated with higher bids, we cannot discount the possibility that there are other, unknown explanatory factors as well as endogeneity between the choice to use a broker and a bid. This makes an experiment ideal for the question we wish to address: how does the use of brokers influence bidder behaviour and bids?

### 3.3 Why an Experiment

Experimental methodology is ideal for exploring the efficiency of resource auctions. In the outside world, it is expensive and time consuming to alter regulations and policies governing the institutional framework for these auctions. It is difficult to argue it is efficient to undertake significant alterations to the bidding process for exploratory research. Unsuccessful alterations may not only have a dramatic negative impact on government revenues but may also lead to suboptimal extraction. In the lab, these potentially negative consequences are eliminated while also suggesting policy changes that may be efficiency-enhancing relative to the current status quo.

Second, there are significant data quality issues. As described above, the current data available to researchers only contains information regarding the winning bid and under the current system, the *winning bidder* is not always revealed. Arguably, researchers could survey employees of competing firms to better understand how they form their bids on various parcels and then impose a functional form determining the bidding decision. Such models could then be used to predict the fluctuations in government revenues and parcel sales under competing institutions. Unfortunately, even if the functional form of the decision process is correctly defined, the parameterization is, at best, dubious. First, surveys are notorious for their lack of incentive compatibility. That is, the participant has no incentive to truthfully reveal their preferences. Second, we find it unlikely employees would voluntarily surrender accurate bidding rules as this information, if revealed to competitors, could negatively impact firm revenues. Moreover, with accurate bidding information, governments may be able to devise bidding institutions that reduce the firm's revenue. As such, we find it unlikely we would gain informative data by surveying these types of firms.

### 3.4 Experiment Limitations

Obviously there are different variables and structures in the lab and the field so it is important we consider the limits of the study. Because we are using a simulated environment to model a marketplace in the real world, it is not possible for us to introduce every possible interaction, cost, or benefit. What is important is that our laboratory environment shares key characteristics with the auctions currently ongoing in Alberta. While our experiment will not (nor is it designed to) provide dollar estimates of changes in government revenues under competing policies, it will shed light on previously unknown bidding behavior, provide support for directional hypotheses, and suggest the changes in the magnitude of government revenues accompanying changes in the bidding institution.

## 4 Experiment Design and Procedures

The experiment is structured to replicate the current bidding institutions as a base case. The experiment consist of three stages, with multiple rounds in each stage. Subjects in the experiment play the role of a firm in a resource extraction industry. There are four firms in each industry. Industry

membership is fixed during each stage. Subjects do not know the identities of who they are playing against.

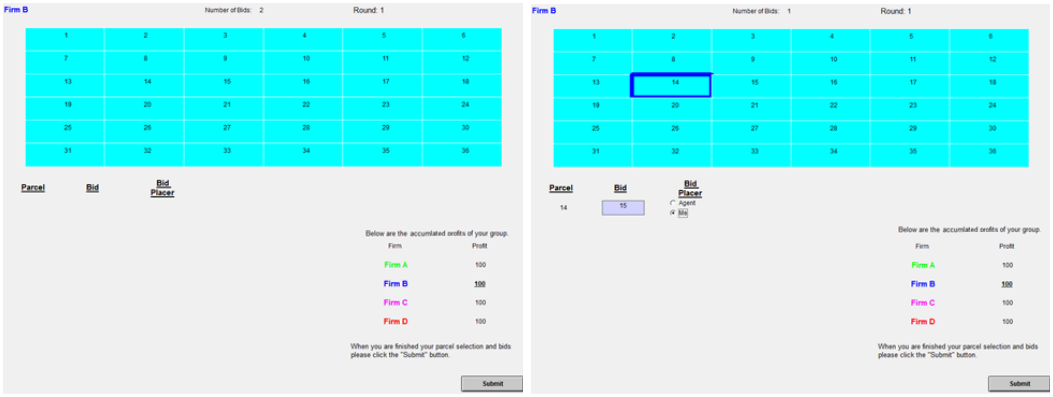
The industry firms operate in is a resource extraction industry (e.g. oil). Firms increase their earnings by extracting resources from parcels of land that are under their control. To gain control of a parcel, firms participate in a first-price sealed-bid auction where only the winning bid and winner is announced after the auction. The parcels firms bid on have common (to all firms) values that are assigned prior to the start of the experiment. All bids must be greater than zero. The algorithm determining the value of each parcel is written such that parcels that share a border are more likely to have similar values. Subjects know this rule. The value of parcels is fixed across all experiments.

The winner of each auction pays their bid and earns the initial value of the parcel minus their winning bid. Each round thereafter, the firm earns the value of the parcel multiplied a discount factor. The discount factor decreases the value of the parcel by 80 percent each round.[18] Once a firm gains control of a parcel, it remains under their control for the remainder of the the stage.

Prior to the start of a stage, values are randomly assigned to each parcel. The minimum value a parcel can take is 13 experimental currency units (ECUs) while the maximum is 100 ECUs.[19] In the first period of a stage subjects have no information regarding the value of any parcel. However, if they win a parcel, subjects are given information about the value of the parcel they won and the values of all the parcels sharing a border with a parcel they won. This information is private; no other firms in the subject's industry will know these values, unless they also own a neighboring parcel.

To make their bidding decisions, firms use a map like the one seen in Figure 1. Firms bid on parcels by clicking on a rectangle on the map. Once they do so, an input box will appear where they input their bid and whether or not they want to use a computer agent (see the right panel of Figure 1). If a firm wins a parcel, they are given information about the values of all the parcels that share a border with the parcel they won. All bids must be in one ECU increments.

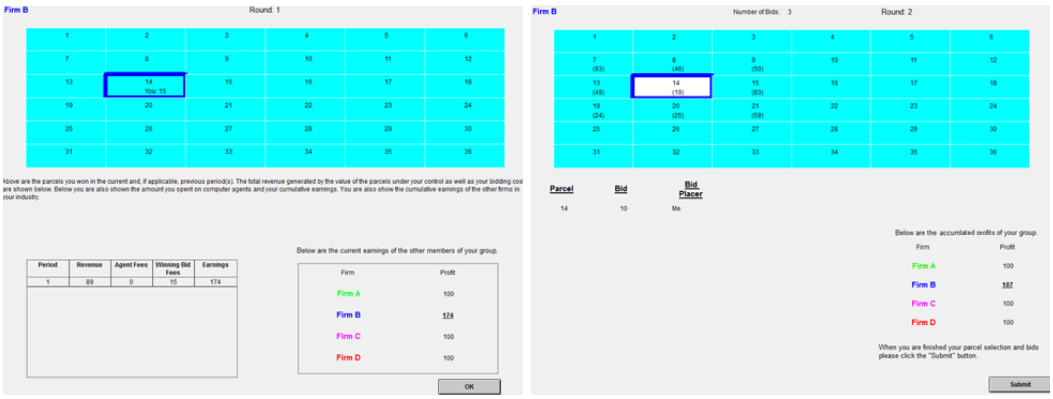
Figure 1: Decision Screens I




[18] This is a simplifying assumption based on the fact that well production rates decline over time, abstracting from changes in price. The National Energy Board reports wells decline rates in Appendix 6 of the Energy Briefing Note "Natural Gas Supply Costs in Western Canada in 2009." The average initial decline rate for wells in Alberta, BC and Saskatchewan is 0.94, which means production declines 94 percent relative to initial production, with a minimum initial decline rate of one percent and a maximum of 200 percent.

[19] The exchange rate is 1 ECU for 75 Canadian cents.

Figure 2: Decision Screens II




Firms can bid on any parcel not under the control of another firm in their industry. Subjects can tell what parcels are available for auction by the color of the outline of the parcel. Parcels with a thin white outline can be bid on while parcels with a heavy outline are under control of a firm in their industry. The color of the outline corresponds to the firm owning a parcel. If the color of the outline is green, then other firms in the industry know that Firm A (Green) owns that parcel. However, if a firm that won a parcel used an agent to bid for them, then the outline of the parcel is black. Additionally, subjects are given information regarding the cumulative profits of each firm in their industry.

After the round ends, subjects are given the results of the round. On the map, subjects can observe the winning bid for each of the parcels that were bid on and whether or not they won. Subjects given a summary of their earnings. This includes their period revenue, bid fees, and agent fees (see Figure 2).

Subjects have a scarce number of bids and can only own at most 8 parcels. At the start of the first period in each stage they are given two bids. Each period thereafter they are given two more bids. Bids are cumulative so if a subject does not win a parcel in period 1, they have four bids in period 2. Likewise, if a firm wins two parcels in period 1, they will only be able to make two bids in period 2.

Subjects can bid any amount less than their current earnings for parcel; subjects are informed that the initial value of a parcel is capped at 100 ECUs. In the event of a tie, the computer adds a random number to each subject's bid; the subject with the greater randomly selected number added to their bid therefore wins the parcel. Subjects start the beginning of each stage with 100 ECUs and are not able to transfer their earnings from one stage to the other. Subjects are not told the number of stages there will be nor are they told the number of periods there will be in each stage.

The treatment in this experiment is to eliminate the option to use a broker. Subjects play the exact same game, but are not given the ability to hide their bids. As such, subjects always know who has won a given parcel.

Experiments are run at the University of Calgarys Behavioral and Experimental Economics Laboratory (CBEEL). Subjects are recruited with the ORSEE recruitment system Greiner (2004) and are students at a large Canadian university. The experiment is run using zTree Fischbacher (2007) in lab detected for social science experiments. After the main experiment ends, subjects complete a series of surveys. Experiments last approximately one hour and 30 minutes. In addition to their experimental earnings, subjects earn a $7 (Canadian) show-up fee.

# 5 Preliminary Results

As of September 2014, 44 subjects have participated in six sessions. Three sessions, with 32 subjects, were the baseline scenario, where subjects had the option to use a computer agent for their bids. Two sessions, with 12 subjects, were the treatment, with no ability to use the computer agent. The average age of participants is roughly 20 years. Each subject participates for 13 periods. There were 3 stages in all sessions. The first stage has five periods and the second and third stages had four periods each. Including their show-up fee, subjects made on average XXX.

Table 3 presents summary statistics for the six sessions. Thus far, there are 1041 total bids between the 44 subjects, meaning on average subjects submitted 24 bids each. The total number of parcels available to bid on was 1088 (36 parcels by 3 stages by 11 groups). The average bid is 15.5 ECUs which is well below than the average (initial) value of a parcel (64.5 ECUs). This results in large profits for each individual parcel that are almost three times the amount of the bid submitted. Figure 3 demonstrates this relationship. Note that the majority of bids are below the 45 degree line, implying that subjects are gaining rather large profits should they win a given parcel.

Table 3: Summary Statistics

| | OBS | MEAN | ST. DEV. | MIN | MAX |
|---|---|---|---|---|---|
| Bid | 1041 | 15.550 | 15.274 | 1 .000 | 150.0299 |
| Bid (agent used) | 107 | 27.655 | 18.680 | 1.028 | 120.093 |
| Bid (agent available, not used) | 670 | 15.638 | 15.377 | 1.000 | 150.030 |
| Bid (agent not available) | 264 | 10.418 | 9.713 | 1.002 | 51.017 |
| Agent (0, 1) | 777 | 0.138 | 0.345 | 0 | 1 |
| No Agent Treatment (0, 1) | 1041 | 0.254 | 0.435 | 0 | 1 |
| Number of bidders | 1041 | 1.264 | 0.509 | 1 | 3 |
| Period in a stage | 1041 | 2.644 | 1.183 | 1 | 5 |
| Total periods played | 1041 | 7.150 | 3.778 | 1 | 13 |
| Profit | 1041 | 48.974 | 25.866 | -95.093 | 98.957 |
| Initial parcel value | 1041 | 64.524 | 21.955 | 13 | 100 |
| Expected parcel value (first period) | 1041 | 80.562 | 27.408 | 16.224 | 124.800 |
| Observe value of bordering parcels (0,1) | 1041 | 0.609 | 0.488 | 0 | 1 |
| Value of bordering parcels | 1041 | 40.964 | 36.777 | 0 | 100 |

Subjects do not often use agents, as only slightly more than 13 percent of the bids are made using computer agents (conditional on an agent being avilable). When subjects do use agents, the subjects bid significantly higher amounts. This is consistent with the observed behavior of firms; as noted in Section 3.1, when an agent was used and won, the (nominal) average price per hectare was 75% higher than when a firm bid under its own name.

Figure 3: Initial Parcel Value vs. Bid

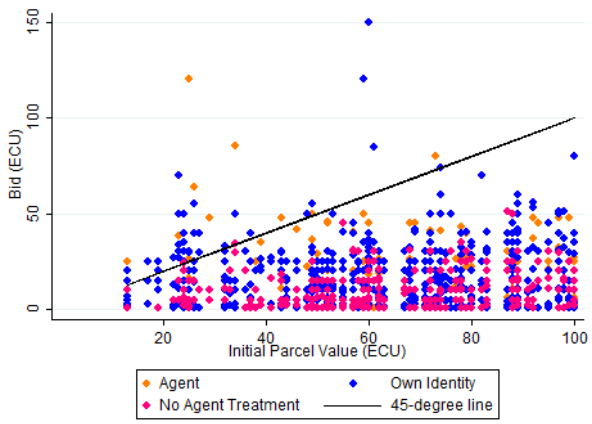



Figure 4: Average Bids

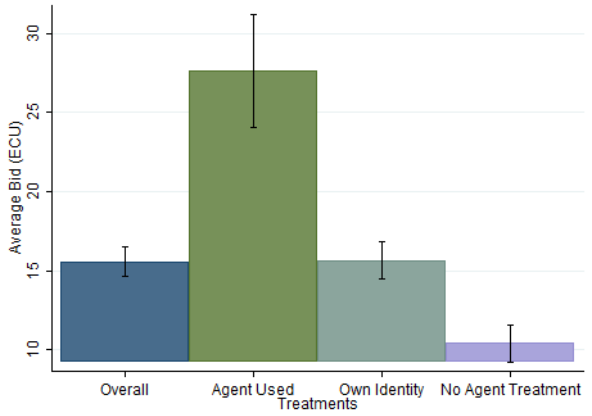



Figure 4 presents the average bid overall, bids made by subjects without agents, bids when subjects used the computer agents, and bids made by subjects in the no-agent treatment. Bids using by agents are significantly different than bids submitted by firms using their own identity (t=-7.27) and have greater values (z = -7.382). Comparing the treatment with agents and the treatment without, bids are higher when agents are present (z=-5.335). The distribution of bids by treatment can be seen in Figure 5.There is a clear difference in the distribution of bids when an agent is used; the difference between the no-agent treatment and when subjects opted to not use an agent is less clear. Figure 6 shows the frequency of bids by bid amount across the two three bid types. The histogram shows low bids are much more frequent with the no-agent treatment and when subjects choose to not use an agent.

Regression results (Table 4) support our preliminary eyeball econometrics but also add some context. Column (1) presents the basic results, with controls for stage of the experiment and number of periods played. Column (2) presents results with a control for when a subject knows the value of the parcel with a dummy variable; column (3) controls for the subjects' knowledge with the value of the parcel. Columns (4), (5) and (6) repeat the same regressions, but with observations from the first period in each stage removed. We do this because the first period is the only one in which subjects

Figure 5: Bid Distribution

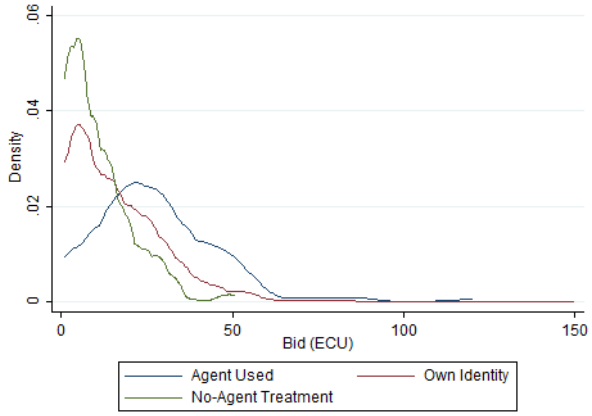
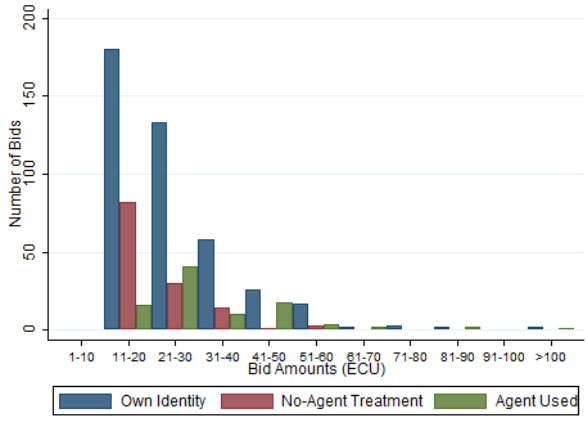



Figure 6: Bid Distribution (by Bid Amount)



have no knowledge of parcel values. Knowledge gained through acquiring parcels appears to affect bids, as exhibited in the positive coefficients on the control variables for this knowledge. Learning also appears to matter, as bids increase within a given stage as time goes on. This indicates subjects are becoming more competitive as a given stage progresses and fewer parcels are available. However, bids are declining as the total number of periods played increases.

As seen in previous tables and figures, subjects bid significantly larger amounts when they choose to use agents. Bids are also lower in the no-agent treatment; these two results are consistent, even when the first period played is removed from the data set (columns 4, 5, and 6). The positive coefficient on agent use and the negative coefficient for the non-agent treatment suggests two effects are present. First, agents are used on more valuable parcels. Second, the existence (and use) of agents appears to create a strategic response, where subjects bid higher in response to the use of agents. We can conclude this strategic interaction is at play, because if agents were only used on more valuable parcels, the agent-use coefficient would be equal to the no-agent coefficient.

Table 4: Basic OLS Regression Results

| | Dependent Variable: Bid | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Agent Used (0,1) | 11.50*** | 11.56*** | 11.62*** | 10.20** | 10.29** | 10.34** |
| | (4.011) | (4.140) | (4.127) | (4.123) | (4.217) | (4.205) |
| No Agent Treatment (0,1) | -5.114** | -5.289** | -5.241** | -4.395* | -4.652* | -4.582* |
| | (2.007) | (2.041) | (2.036) | (2.282) | (2.326) | (2.323) |
| Initial Parcel Value | 0.0412 | 0.0331 | 0.00960 | 0.0771* | 0.0665* | 0.0423 |
| | (0.0287) | (0.0272) | (0.0265) | (0.0406) | (0.0394) | (0.0393) |
| Number of periods played | -5.040*** | -5.311*** | -5.048*** | -5.604*** | -5.604*** | -5.305** |
| | (1.591) | (1.653) | (1.594) | (2.062) | (2.062) | (2.026) |
| Stage | 19.96*** | 20.95*** | 19.72*** | 22.83** | 22.74** | 21.35** |
| | (6.944) | (7.159) | (6.910) | (9.046) | (9.031) | (8.878) |
| Period in stage | 5.914*** | 6.047*** | 5.790*** | 6.606*** | 6.517*** | 6.252*** |
| | (1.787) | (1.819) | (1.784) | (2.206) | (2.197) | (2.183) |
| Parcel Value Known (0,1) | | 2.295* | | | 2.898** | |
| | | (1.176) | | | (1.326) | |
| Parcel Value if Known | | | 0.0384** | | | 0.0417** |
| | | | (0.0175) | | | (0.0189) |
| Constant | -5.827 | -7.023 | -4.492 | -11.70 | -12.37 | -9.494 |
| | (7.482) | (7.748) | (7.419) | (9.789) | (9.872) | (9.743) |
| Observations | 1,041 | 1,041 | 1,041 | 812 | 812 | 812 |
| R-squared | 0.131 | 0.136 | 0.137 | 0.106 | 0.113 | 0.113 |
| Subject clusters | 44 | 44 | 44 | 44 | 44 | 44 |
| First period dropped | N | N | N | Y | Y | Y |

Clustered standard errors in parentheses. ***: $p < .01$, **: $p < .05$, and *: $p < .1$

Table 5 displays more conservative results, with subject clusters and parcel fixed effects. The basic results from Table 4 are repeated for comparison, and the results are reported in levels as well as log-linear (to evaluate percentage changes). Adding parcel fixed effects does not substantively change the results, though the coefficient on both effects of interest – use of an agent and the no-agent treatment – do decrease slightly in magnitude. The biggest difference is that with the log-linear

regressions, the coefficient on the no-agent treatment is no longer statistically significant, a curious result.

Table 5: Regression Results: Parcel Fixed Effects

| | Dep. Var.: Bid | | Dep. Var.: ln(Bid) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Agent Used (0,1) | 10.29** | 8.784* | 0.731*** | 0.617** |
| | (4.217) | (4.401) | (0.247) | (0.259) |
| No Agent Treatment (0,1) | -4.652* | -4.397** | -0.249 | -0.249 |
| | (2.326) | (2.162) | (0.258) | (0.257) |
| Initial Parcel Value | 0.0665* | | 0.00735** | |
| | (0.0394) | | (0.00309) | |
| Number of periods played | -5.604*** | 0.535 | -0.373** | 0.0572 |
| | (2.062) | (0.659) | (0.164) | (0.0489) |
| Stage | 22.74** | | 1.555** | |
| | (9.031) | | (0.733) | |
| Period in stage | 6.517*** | 0.745 | 0.468*** | 0.0615 |
| | (2.197) | (1.127) | (0.171) | (0.0870) |
| Parcel Value Known (0,1) | 2.898** | -0.537 | 0.188 | -0.0796 |
| | (1.326) | (2.055) | (0.123) | (0.154) |
| Constant | -12.37 | 15.47*** | -0.0943 | 2.252*** |
| | (9.872) | (4.018) | (0.846) | (0.403) |
| Observations | 812 | 812 | 812 | 812 |
| R-squared | 0.123 | 0.242 | 0.097 | 0.189 |
| Subject clusters | 44 | 44 | 44 | 44 |
| First period dropped | Y | Y | Y | Y |
| Parcel FE | N | Y | N | Y |

Clustered standard errors in parentheses. ***: $p < .01$, **: $p < .05$, and *: $p < .1$

# 6 Conclusions

An observed trait of auctions for petroleum and natural gas leases in Alberta is that bids are higher when firms hide their identity via bidding using a broker. However, an issue with this data is that the choice to use a broker is only observed when a broker is used and won. This means that any regression looking at the relationship between winning bids and the use of brokers cannot identify the causal effect of the use of brokers on bids. To overcome this difficulty, we have designed an experiment that replicates the auction environment and allows us to observe the choice to use a broker as well as the distribution of bids and the number of bidders.

In the base treatment that replicates the status quo, we observe bids are higher when brokers are used by the subjects. In the simplest regression (column 1 in Table **??**) we find bids are 82 percent higher (ignoring other marginal effects) when a broker is used. Adding other controls lowers this "premium" to 73 percent (column 4 in Table 5). This is surpisingly close to the 75 to 78 percent premium observed in the auction data. Bids are lower in the no-agent treatment; the premium associated with brokers is greater than the negative coefficient in the no-broker treatment. This

suggests that while brokers are used when parcels are more valuable, there is an additional strategic effect from the use of brokers that also increases bids. In effect, the presence of brokers increases competition, and is beneficial to the auctioneer. However, these observations are based on an admittedly small sample size, and additional experiments are required to confirm the pattern revealed.

With future treatments, we hope to explore these relationships further and determine the effect of changing the institutional environment of the auctions. With the second treatment, subjects did not have the option to use a broker. Comparing the first and second treatments clarified how the availability of brokers affects bidding behaviour. The third treatment (planned) will provide additional information to subjects, including the identities of bidders and distribution of bids on each parcel. Additional treatments we may undertake include increasing the number of subjects playing in a "group" to determine if increased competition influences the decision to use a broker.

# References

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Greiner, Ben (2004) 'An online recruitment system for economic experiments'

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# A Appendix

## A.1 Instructions

Welcome to the experiment. I will first walk you through the experiment while giving instructions. The instructions are simple, and if you follow them carefully, you can earn a considerable amount of money. All the money you earn is yours to keep, and will be paid to you, by cash, and in private, after the experiment ends. Your confidentiality is assured.

In this experiment, you will be assigned the role of firm in a resource extraction industry (e.g. oil, natural gas, or gold). You will be assigned into industries of 4 firms for each stage. There will be multiple stages. The industry you are in will remain fixed for the given stage. You will not know the identity of the other members of your group and nor will they be told your identity.

You will participate in each stage for a randomly drawn number of periods. Each stage may have the same or a different number of periods.

The industry firms operate in is a resource extraction industry (e.g. oil). Firms increase their earnings by extracting resources from parcels of land that are under their control. For the purposes of this study assume that there are no other costs to the resource's extraction and the firm's use of the land does not harm the natural environment in any way.

To gain control of a parcel, firms participate in multiple auctions where only the winning bid and winner is announced after the auction. The parcels firms bid on have common values but these values are randomly assigned in the first period. The value of parcels will remain fixed for the entire experiment unless a firm gains control of it. All bids for parcels must be greater than zero. Firms can have up to 8 parcels under their control. You cannot bid more than your current earnings.

To bid on a specific parcel, you will click on the parcel you want. After you click on a parcel, a box will appear where you will input the amount you wish to bid for the parcel you clicked on. At that time, you will also be asked whether or not you want to use a computer agent to bid for you. We will discuss computer agents later in the instructions.

Each parcel will be assigned a value at the start of the stage. The MAXIMUM value of a parcel is 100 experimental currency units (ECUs). Each parcel's value is assigned such that neighboring parcels are MORE LIKELY to have similar values. You will not know the value of any parcels until you win at least one. If you win a parcel you will not only gain the parcel and learn its value, you will also learn the values of parcels sharing a border with the parcel(s) you win. Once you win a parcel, that parcel is yours for the remainder of the stage. While you will gain information about the parcels under your control and the parcels neighboring the ones you control, unless a competing firm controls a parcel neighboring your parcel (or one of your neighboring parcels), other players will not be told the value of the parcel under your control or the value of the parcels neighboring the ones you won.

You are allowed to bid on any parcel not currently under the control of any firm. You will be able to see what parcels are under control of specific firms by the color of the outline of the parcels. Parcels that are available for bidding have light outline while parcels that are not available for bidding have a heavy colored outline. For example, if Firm BLUE has control of a parcel, the heavy outline of the parcel in question will be blue.

The winner of each auction pays their bid and earns the value of the parcel minus their winning

bid. Each round thereafter the firm earns the value of the parcel multiplied a discount factor. The discount factor decreases the value of the parcel by 80 percent each round. This discount is applied to the parcels firms have under their control because each period the firm is extracting some of the resource from the parcel.

Each period firms will be given the option to pay a computer agent to bid on their behalf. If a bid placed by computer agent wins, the firm earns the same amount they would have if they had bid on the parcel (and won) themselves minus the small one ECU cost of using the agent. If a firm's agent wins a given parcel, other firms in the industry will not be told which firm won the parcel - only that an agent submitted the winning bid. Parcels won by a computer agent, will be indicated by having a heavy black outline.

Conversely, if a firm selects to not use an agent, and wins a parcel, other firms will be able to see who won the parcel (by the parcel's outline).

Your earnings in a round is equal to your current total earnings in the round plus the current value of the parcels under you control minus your total expenditure on computer agents.

Additionally, if you win a parcel, you will earn the value of the parcel minus the amount of your winning bid.

At the conclusion of each round, you will see a map displaying the parcels that were bid on. The winning bid for each parcel will be shown below the parcel's identification number as well as if you won a given parcel. You will also be given a summary of your previous decisions and the current value of the parcels under your control. Last you will also be told the profits of the firms in your industry.

Finally, you will be told whether or not there will be an additional period.

All currency units are valued at .75 Canadian cents. Unless there are further questions, we are ready to begin the experiment.

Please click the BEGIN button.