1.1 DETAILED DESCRIPTION OF PROPOSED RESEARCH

Objectives

The main objective of our research is to demonstrate in the context of a single environmental management system that the laws and regulations governing a resource co-evolve and that this co-evolution follows not simply a path of increasing complexity, but a path that punctuated by rule extinction and substitution, with some positive consequences for the allocation of the resource and the yields for that allocation. We will use three organizational theories--institutional, learning, and ecological theory--in order to show how this evolution of water laws and regulation has directly affected the partitioning and allocation of water resources. Institutional theory helps us describe the regulatory system and its details; learning theory helps us build models of the dynamics within this system; and ecological theory helps us understand the impact on resource allocation and competition for water. To describe and assess the evolution of laws and regulation for water allocation with these theories requires longitudinal data and analysis. We propose to collect data on the Water and Water Protection Acts and their amendments (including case law) and on all water regulation in the Province of British Columbia, as well as the number of licences and their overall yield by time period and industry. Event history analysis will allow us to analyze the co-evolution of the water laws and regulations; time series analysis (including pooled time series analysis) will allow us to analyze some impact on licence number and yield across sectors. Ultimately, we think that this project will add to both learning and institutional theory and have practical outcomes for the formation of water management policy.

The more specific objectives of our proposed research activities are:

1. To show that different regimes and changes in industrial characteristic affect the creation and amendment of the water acts in British Columbia from 1880-2001.
2. To analyze how the evolution of the water acts affects the evolution of water regulations and their amendments, sometimes increasing and sometimes decreasing the overall complexity of the regulatory system.
3. To describe the allocation of water resources in terms of volume, number of permits, and permit yields over time.
4. To tie the co-evolution of water laws and regulation to water allocation and demonstrate the impact of changes in laws and regulations on allocation.
5. To show that some changes in legal and administrative complexity actually enhance the efficiency of the overall water management system, not simply undermine it.

Pursuing these objectives will help us to combine two distinct, powerful concepts from organization theory—the evolution of regulatory rules and the ecology of organizational resources--into what we call “an institutional ecology of regulatory rules.” Both co-principals are working currently in this rich theoretical area (Jennings and Zandbergen, 1995; Jennings, Zandbergen and Martins, 2001; Schulz, 1998; Schulz, 2001). Similarly, pursing these objectives will help us to combine practical elements of organizational design with water management and allocation principles. Both co-principal investigators have worked on environmental issues, one with the Ministry of Environment in B.C. on water-related issues (Jennings, Zandbergen and Clark, 1999; Schulz and Schilling, 1998).

Context

Current Theory and Research on The Evolution of Regulatory Rules

We intend to draw on institutional, learning and ecological theory to develop our hypotheses and models, and we think that our work will extend current thinking in both institutional and learning theory, but perhaps, to a lesser degree, ecology. Institutional theorists have focused on how to conceptualize institutional environments and how these environments shape bureaucratic organizations and their actions. Institutionalists such as Powell and DiMaggio (1991) and Scott (1995) maintain that institutional environments become typified in cognitive, normative, and regulative frames of understanding in firms, and each of these frames has a corresponding impact on the interpretation and application of rules and policies by organizations within them (e.g., Fuller, Edelman, and Matusik, 2000). Because these environments shift, the same organization can have fundamentally different ways of forming and interpreting its administrative rules when they come to be embedded within different institutional frames (Dobbin and colleagues 1994; 1997; 1998; Edelman, 1991; 1992; Ruef and Scott, 1998). Recently, Hoffman has demonstrated that these frames are reflected in "regimes" of policy and that regime changes shape whether environmental management relies primarily upon common understanding of how to manage it, implicit norms, or explicit rules. Jennings et al., (1999; 2001) have extended this work by showing that regulatory enforcement of water laws is affected by such regimes. Nevertheless, how laws and rules shift over time with these regimes and how organizations respond to these shifts has not been modeled in as much detail.

Learning theory enters precisely at this point. Organizational learning theorists are interested in how problems are identified and solutions (sets of rules) are formed and applied—and with what result (March and Olson, 1989; Schulz, 2001). March, Schulz and Zhou (2000) have recently argued that bureaucracies form ecologies of rules that are structured by the ways in which individual rules are connected to each other and by the ways in which rule regimes are constructed to regulate the flow of attention to problems. They observed that rule changes would destabilize rules and would spread to related rules in their neighbourhood. At the same time, they observed that rates of rule birth and rule change would decrease over time and with the number of rules in the system. Together, these findings suggest to us that rule evolution might follow a path of stabilization that is punctuated by waves of rule substitution and extinction. Perhaps it is possible for complex bureaucracies to slow the expansion of their complexity, even in complex environments. Such a bureaucratic stabilization could have significant outcomes for organizational outcomes, e.g., resulting in more stable or more efficient allocation of resources. However, learning theorists so far have not examined the impact of the bureaucracy and its environment(s) on the bureaucracy's clients or other important organizational outcomes, like allocation of a natural resource. Also, those studying the ecology of rules have studied mostly not-for-profit or for-profit organizations and not examined government bureaucracies.

Both institutional and learning theorists draw on ecological approaches to organizations, hence ecological theory needs to be explicitly addressed in our theory of regulatory rules. Institutional theorists studying regime development and the development or changes in rules have acknowledged that there is competition for legitimacy and organizational resources by new regimes and resources. Some studies have directly drawn on both institutional conceptions of environments and ecological conceptions of competition to model this creation and replacement process, such as Dacin (1997), who has shown that that founding of Finnish newspapers includes regime changes, partitioning of resource niches, and changes in legitimacy of organizations filling these niches. Learning theorists have also explicitly drawn on ecological theory (e.g., Schulz, 1998; March, Schulz and Zhou, 2000) to explore competition among different organizational rules and the carrying capacity of rule making systems over time. Some current work by ecologists also addresses how communities create and support and sustain organizational structures over time (Aldrich, 1999), suggesting that interorganizational cooperation might play as much a part as competition in these rules. Modeling this simultaneous presence of cooperation and competition among organizations in different geographic locales is one of the goals of current quantitative studies (Haveman, 1992; 1995;; Wade et al., 1998). Nevertheless, ecologists have not examined competition among regulatory rules or conceptualized such competition in abstract terms of a "space" or "domain" for laws and regulations, something we intend to do.

An Institutional Ecology of Regulatory Rules for Water Management

The main argument in the institutional ecology approach to regulatory rules is simple: *laws and regulations co-evolve and this co-evolution follows a path punctuated by rule extinction and substitution, with consequences for resource allocation and efficiency.* The first point is that there is a set of laws and regulations (i.e., "rules") that exist in a "domain space" of rules. The dimensions of this domain space consist of issues or interests (Knocke and Laumann, 1987). Furthermore, this domain space of rules is nested in a larger regulatory system -- a "regime," defined as the interpretation or approach taken by legitimate governing actors to create and carry out policy within their mandate (Friedland and Alford, 1991; Hoffman and Vantresca, 1998). Regimes enact laws about an issue, such as water management, these laws compete or combine with existing laws in the domain space (Jennings et al., 1999; 2001). Together regimes and laws create opportunities for regulations, which exist in a separate but overlapping domain space for regulations. Over time, the domain of laws and the domain of regulations co-evolve in the regulatory system, shaped by their competition, the issue area, and the regime.

The co-evolution of laws and regulations involves the top-down influence of regulators (regime effects), changes in issue definition (interpretive effects), competition among older and newer rules (competitive effects), and combinations of rules (cooperative effects). Institutional theory emphasizes the importance of regime effects and some issue interpretation; while learning and ecological theory emphasize the importance of competition and cooperation for the production, substitution, and extinction of rules. We argue that *both regime changes and the internal dynamics of competition and cooperation* influence what new laws and rules will be seen in a regulatory system over time. For this reason, it might be called an "institutional ecology" that affects "regulatory rules."

The dynamics of this ecology can be modeled using the basic format below, which we put in textual terms:

Model 1: The hazard rate of rule change from time 1 to 2 = exp function of [regime indicator + regime age + birth rate of new laws + time varying, competing rules density + time variant resource demand effects]

As the model shows, we expect that the likelihood of a rule change to be increased by particular shifts in regimes, the enactment of new laws, the enactment of competing rules, and changes in demand for the resource. These likelihoods or "hazard rates" allow us to model the stability and instability of rule changes over time. In general, we know that early institutional history is characterized by instability due to high rates of formation for new laws and regulation; then by periods of relative stability, except where regimes change. We also suspect that increasing rule density might lead to reduced rates of rule production and change, thereby producing more stable and perhaps more efficient resource allocations and outcomes.

The co-evolution of laws and regulations has a direct effect on how the resources of the regulatory domain are allocated. The resources in this case are water resources and allocation refers to how water is allocated across parties over time and with what result. Water laws specify how to allocate water and to whom. Water is allocated via application to private and public individuals and organizations, who are then granted licences to use certain volumes of water in particular locales. In return the licensees pay fees and are required to live up to the specifications of the permit. Over time the allocation principles change, as the laws and regulations change. We anticipate that allocation rules that are added to or compete with existing allocation rules will lead to less efficient allocation outcomes, compared to allocation rules that stand alone or are explicitly combined with or replace existing rules.

The models for examining this impact of co-evolving laws and regulations on allocation of water via permits and revenue yields follows more of a linear, time-series format, where the average yields over the years are modelled. Given that we will have more data for recent years, particularly by sector, we will probably think about pooling such data, lagging the variables, and controlling for time periods. In textual terms, the model can be expressed as:

Model 2: The revenue/permit at time 2 (in a sector) = [constant + yield of permit at time 1 (per sector) + regime indicator + # of allocation rules time 1 (per sector) + type of allocation rules time 1 (sector) + density of rules time 1 (sector) + industrial demographics time 1 (sector) + region controls]

Methodology

Data Sources

Our models require data from 1880-2001 on the Water and Water Protection Acts, their amendments, important cases in case law, and all related water regulation in BC; data on licences and their yields over much of that period; and data on some important external factors, such as over time industry profiles. We have confirmed that the data on water laws and regulations is available from the UBC Law Library, with some back up data in Victoria, BC at the Legislative Libraries. All laws and regulations have been entered into public record, with time codes. In addition, there is a file of case law, for major cases, that discusses how these laws have been applied and interpreted. The main issue then is copying and collating and entering all of these data into an over time data base. That is not a small task, but a surmountable one.

The data on licences and their yields over time is available in a more limited form from the Ministry of Sustainable Resources, where the water allocation and licensing branch are currently located, and the Ministry of Water, Land, and Air Protection, where water quality and water management are currently located. The head of permit allocations has said that number of permits is available in electronic and hard copy form, including recent detailed information on holdings. The Deputy Controller of Water Management has said that revenue data for a number of years are available, but how far back is uncertain. The Head of Water Management and the main person in Government Publications has said that much of this information is public record, with the proper documentation and a Freedom of Information Application. We anticipate that we can gather at least enough permit numbers data for the whole time period and enough yield information to do more detailed tests on the model for later time periods. The addition of this information to the large file of data on laws and regulations over time will not be a difficult task, particularly since the information will be merged primarily by time code (year).

The data on industry profiles in BC over time is kept in the UBC Koerner library and in the Vancouver Public Library. One of the co-principals worked with researchers at UBC who used these data in another study (Shearer and Sproul, 1999) and one more studies with recent panels of such industry data (Jennings et al., 1999; 2001), which makes him confident it will be available. The data on regime changes over time at the government level are available in standard government and history textbooks, and the data on bureaucratic interpretations over time of these laws are available, in part, from the case law discussed above, and, in part, from discussion with ministry and former ministry officials. The addition of this information to the large file of data on law, regulations, and allocation outcomes will not be difficult in the case of regime changes, because the regime changes will be coded based on time periods. The addition of the industry data will be a bit more difficult, since we hope to do some subpopulation/domain analysis by types of water use regulations, allocation, and industries affected.

Measurement

Three variables function as dependent variables, if in different models: 1) water laws and their amendments; 2) water regulations and their amendments; and 3) water allocation. In keeping with prior work on the topic of coding the first two variables, laws and regulations as institutional rules (North, 1990; Dobbin et al., 199x; Schulz, 1998), we are interested only in broad codes for the rules on two dimensions; first, what is the specific issue area (water licence, water arbitration, water rights, and so forth) and second, what is the time code of when it was created (exact month, year). In addition, we will add a third and fourth dimension that links that specific law or regulation with others that overlap it in the issue area; that is, a unique code for each law and regulation (rule) and a link code with other laws and rules. Finally, a fifth code will be added, which categorizes the law, according to whether it competes, combines, replaces existing laws with which it is linked.

Water allocation will be considered as three separate sets of outcome variables: 1) number of permits in a year (average and variation by size); 2) the volume of water in those permits (average and variation by size); and 3) the revenue yield in a year (all permits and the average yield per permit). Brander (1995), Day and Geogeson (1991), Dorsey (1991a; 1991b) and others who have studied resource allocation in BC, particularly water, focus on permits and volume and revenue. In addition, we will examine the subcategories of permits by industry, such as agriculture and mining and heavy manufacturing, and look in our more detailed models at location by region in BC as a subcategory, such as Lower Mainland, Vancouver Island, and so forth (Jennings et al., 1999; 2001; Schearer and Sproul, 1999).

As our discussion of Model 1 and Model 2 in the theory section should have made clear, the independent variables for Model 2, include the above dependent variables for Model 1. For instance, in the second set of models, we intend to examine the impact of this dynamic system among laws and regulations over time on allocation in terms of number of permits and revenue yield for these permits, controlling for geographic variation. In this case, laws and regulations and their amendments become independent variables. Nevertheless, there are some independent variables that are exogenous (outside) the main effects and outcomes of the model, and there are also some independent variables that are controls. One truly exogenous variable will be regimes. Regimes will be coded using the political history of BC, especially changes in government parties controlling parliament, along with information on changes in ministry policy (whenever policy). This is in keeping with recent work in institutional theory (Scott, 1995; Hoffman, 1999; Jennings et al., 2001). Industry will be categorized by type of industry and also number of organizations (or total value) in that industry over time. Population demographics will be coded by region using census data. Geographic region will be categorized by region of BC using census definitions. We will have to combine some of these geographic categories in our final model if we wish to examine allocation across regions that that ministry defines for administration.

Methods of Analysis

Institutional (Dobbin and Sutton, 1998; Edelman, 1991; Greve, 1998; Greve and Taylor, 2000) and learning theorists (Mezias, 1991; Schulz, 1998; 2001) have employed event history models to determine whether variation in laws and rules are strongly associated with regimes, organizational covariates, and time periods. We will follow a similar strategy. Like these other authors, we intend to use piecewise, exponential hazard rate models (Allison, 1984; Cox, 1972; Blossfeld and Rohwer, 1995; Tuma and Hannan,1984) to estimates effects of the determinants on charges. In the piecewise exponential model, the hazard rate is a function of time periods and proportional covariates:

$$r_{jk}(t) = \exp[a_l^{(jk)} + A^{(jk)}a^{(jk)}], \text{ if } t \text{ E } I(l), \qquad \text{(Eq. 1)},$$

where $r_{(j\,k)}(t)$ is the transition rate, and for each transition (j,k), $a_l^{(jk)}$ is the constant coefficient associated with the lth time period; and $A^{(jk)}$ is the row covariates, and $a^{(jk)}$ is an associated vector of coefficients assumed not to vary across the periods (Blossfeld and Rohwer, 1995: 111-117). We also employ exponential models with period-specific effects to capture the impact of constant covariates within each of the four time periods in question. This model is a slightly more general model than the one in Equation 1, where t varies only within each time period and not for all (l). Finally, we will explore more complex models using spell splitting, particularly for the co-evolution of laws and regulations, where we have fine-grain temporal data. Maximum likelihood techniques will be used to assess the overall fit of the model and the significance of specific coefficients.

Institutional researchers (e.g., Deephouse, 1999; Cliff, Jennings, and Greenwood, 2001) and strategists (Baum et al., 2001; Bromiley, 19991) have examined the impact of organizational changes on resource allocation and other strategic outcomes using dynamic linear models, often version of the general linear model estimated with generalized least squares (Greene, 1993). We anticipate using a similar method of analysis, where we will pool data in the most recent time periods, across sectors, and run models GLS with lag variables:

$$Y_{(ti)} = \alpha\, Y_{(t-1)} + \gamma\, X_{(t-1)} + \beta\, C_{(jt-1)} + \varepsilon_{(it)} \qquad \text{(Eq. 2)}$$

where $y_{(ti)}$ represent yield in current year for an industry and is a function of yield in the prior year, $Y_{(t-1)}$, prior laws and regulations affecting allocation in the sector, $\gamma\, X_{(t-1)}$, the control variables for the regime, the sector, and the region in the prior period, $\beta\, C_{(jt-1)}$, as well as an error term for the current period that requires explicit modeling, $\varepsilon_{(it)}$. If there are sufficient data over time on yield, we will also explore some simple time-series models of yields per sector. These models relax the assumptions of stability in the underlying causal structure of covariates. As in the event history models, maximum likelihood estimation will normally be used, and the resulting loglikelihood and t-statistics for testing our expectations.