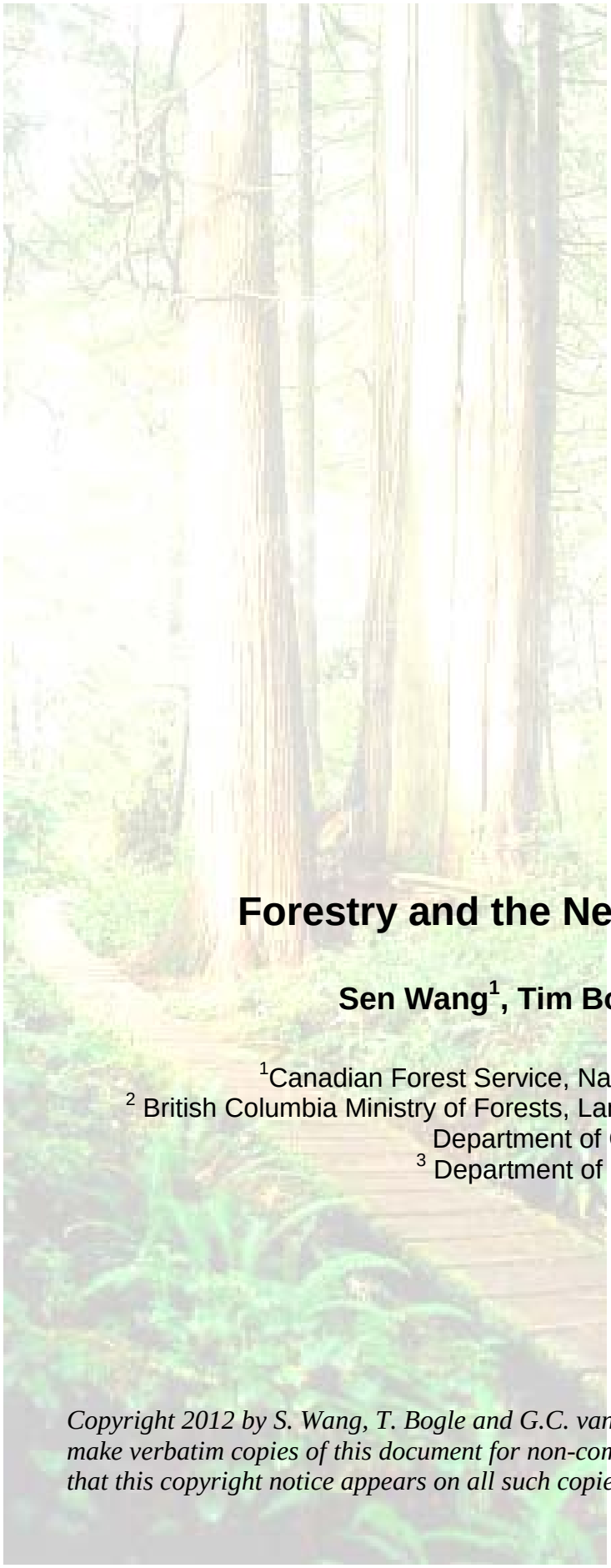

WORKING PAPER
2012-05

REPA

Resource Economics
& Policy Analysis
Research Group

Department of Economics
University of Victoria

Forestry and the New Institutional Economics

Sen Wang[1], Tim Bogle[2] and G. Cornelis van Kooten[3]

[1]Canadian Forest Service, Natural Resources Canada, Ottawa, Canada
[2] British Columbia Ministry of Forests, Lands and Natural Resource Operations and Department of Geography, University of Victoria, Canada
[3] Department of Economics, University of Victoria, Canada

July 2012

REPA Working Papers:

2003-01 – Compensation for Wildlife Damage: Habitat Conversion, Species Preservation and Local Welfare (Rondeau and Bulte)
2003-02 – Demand for Wildlife Hunting in British Columbia (Sun, van Kooten and Voss)
2003-03 – Does Inclusion of Landowners' Non-Market Values Lower Costs of Creating Carbon Forest Sinks? (Shaikh, Suchánek, Sun and van Kooten)
2003-04 – Smoke and Mirrors: The Kyoto Protocol and Beyond (van Kooten)
2003-05 – Creating Carbon Offsets in Agriculture through No-Till Cultivation: A Meta-Analysis of Costs and Carbon Benefits (Manley, van Kooten, Moeltne, and Johnson)
2003-06 – Climate Change and Forest Ecosystem Sinks: Economic Analysis (van Kooten and Eagle)
2003-07 – Resolving Range Conflict in Nevada? The Potential for Compensation via Monetary Payouts and Grazing Alternatives (Hobby and van Kooten)
2003-08 – Social Dilemmas and Public Range Management: Results from the Nevada Ranch Survey (van Kooten, Thomsen, Hobby and Eagle)
2004-01 – How Costly are Carbon Offsets? A Meta-Analysis of Forest Carbon Sinks (van Kooten, Eagle, Manley and Smolak)
2004-02 – Managing Forests for Multiple Tradeoffs: Compromising on Timber, Carbon and Biodiversity Objectives (Krcmar, van Kooten and Vertinsky)
2004-03 – Tests of the EKC Hypothesis using CO2 Panel Data (Shi)
2004-04 – Are Log Markets Competitive? Empirical Evidence and Implications for Canada-U.S. Trade in Softwood Lumber (Niquidet and van Kooten)
2004-05 – Conservation Payments under Risk: A Stochastic Dominance Approach (Benítez, Kuosmanen, Olschewski and van Kooten)
2004-06 – Modeling Alternative Zoning Strategies in Forest Management (Krcmar, Vertinsky and van Kooten)
2004-07 – Another Look at the Income Elasticity of Non-Point Source Air Pollutants: A Semiparametric Approach (Roy and van Kooten)
2004-08 – Anthropogenic and Natural Determinants of the Population of a Sensitive Species: Sage Grouse in Nevada (van Kooten, Eagle and Eiswerth)
2004-09 – Demand for Wildlife Hunting in British Columbia (Sun, van Kooten and Voss)
2004-10 – Viability of Carbon Offset Generating Projects in Boreal Ontario (Biggs and Laaksonen-Craig)
2004-11 – Economics of Forest and Agricultural Carbon Sinks (van Kooten)
2004-12 – Economic Dynamics of Tree Planting for Carbon Uptake on Marginal Agricultural Lands (van Kooten) (Copy of paper published in the Canadian Journal of Agricultural Economics 48(March): 51-65.)
2004-13 – Decoupling Farm Payments: Experience in the US, Canada, and Europe (Ogg and van Kooten)
2004–14– Afforestation Generated Kyoto Compliant Carbon Offsets: A Case Study in Northeastern Ontario (Biggs)
2005–01– Utility-scale Wind Power: Impacts of Increased Penetration (Pitt, van Kooten, Love and Djilali)
2005–02 –Integrating Wind Power in Electricity Grids: An Economic Analysis (Liu, van Kooten and Pitt)
2005–03 –Resolving Canada-U.S. Trade Disputes in Agriculture and Forestry: Lessons from Lumber (Biggs, Laaksonen-Craig, Niquidet and van Kooten)

2005–04–Can Forest Management Strategies Sustain the Development Needs of the Little Red River Cree First Nation? (Krcmar, Nelson, van Kooten, Vertinsky and Webb)
2005–05–Economics of Forest and Agricultural Carbon Sinks (van Kooten)
2005–06– Divergence Between WTA & WTP Revisited: Livestock Grazing on Public Range (Sun, van Kooten and Voss)
2005–07 –Dynamic Programming and Learning Models for Management of a Nonnative Species (Eiswerth, van Kooten, Lines and Eagle)
2005–08 –Canada-US Softwood Lumber Trade Revisited: Examining the Role of Substitution Bias in the Context of a Spatial Price Equilibrium Framework (Mogus, Stennes and van Kooten)
2005–09 –Are Agricultural Values a Reliable Guide in Determining Landowners' Decisions to Create Carbon Forest Sinks?* (Shaikh, Sun and van Kooten) *Updated version of Working Paper 2003-03
2005–10 –Carbon Sinks and Reservoirs: The Value of Permanence and Role of Discounting (Benitez and van Kooten)
2005–11 –Fuzzy Logic and Preference Uncertainty in Non-Market Valuation (Sun and van Kooten)
2005–12 –Forest Management Zone Design with a Tabu Search Algorithm (Krcmar, Mitrovic-Minic, van Kooten and Vertinsky)
2005–13 –Resolving Range Conflict in Nevada? Buyouts and Other Compensation Alternatives (van Kooten, Thomsen and Hobby) *Updated version of Working Paper 2003-07
2005–14 –Conservation Payments Under Risk: A Stochastic Dominance Approach (Benítez, Kuosmanen, Olschewski and van Kooten) *Updated version of Working Paper 2004-05
2005–15 –The Effect of Uncertainty on Contingent Valuation Estimates: A Comparison (Shaikh, Sun and van Kooten**)**
2005–16 –Land Degradation in Ethiopia: What do Stoves Have to do with it? (Gebreegziabher, van Kooten and.van Soest)
2005–17 –The Optimal Length of an Agricultural Carbon Contract (Gulati and Vercammen)
2006–01 –Economic Impacts of Yellow Starthistle on California (Eagle, Eiswerth, Johnson, Schoenig and van Kooten)
2006–02 -The Economics of Wind Power with Energy Storage (Benitez, Dragulescu and van Kooten)
2006–03 –A Dynamic Bioeconomic Model of Ivory Trade: Details and Extended Results (van Kooten)
2006–04 –The Potential for Wind Energy Meeting Electricity Needs on Vancouver Island (Prescott, van Kooten and Zhu)
2006–05 –Network Constrained Wind Integration: An Optimal Cost Approach (Maddaloni, Rowe and van Kooten)
2006–06 –Deforestation (Folmer and van Kooten)
2007–01 –Linking Forests and Economic Well-being: A Four-Quadrant Approach (Wang, DesRoches, Sun, Stennes, Wilson and van Kooten)
2007–02 –Economics of Forest Ecosystem Forest Sinks: A Review (van Kooten and Sohngen)
2007–03 –Costs of Creating Carbon Offset Credits via Forestry Activities: A Meta-Regression Analysis (van Kooten, Laaksonen-Craig and Wang)
2007–04 –The Economics of Wind Power: Destabilizing an Electricity Grid with Renewable Power (Prescott and van Kooten)
2007–05 –Wind Integration into Various Generation Mixtures (Maddaloni, Rowe and van Kooten)
2007–06 –Farmland Conservation in The Netherlands and British Columbia, Canada: A Comparative Analysis Using GIS-based Hedonic Pricing Models (Cotteleer, Stobbe and van Kooten)

2007–07 –Bayesian Model Averaging in the Context of Spatial Hedonic Pricing: An Application to Farmland Values (Cotteleer, Stobbe and van Kooten)
2007–08 –Challenges for Less Developed Countries: Agricultural Policies in the EU and the US (Schure, van Kooten and Wang)
2008–01 –Hobby Farms and Protection of Farmland in British Columbia (Stobbe, Eagle and van Kooten)
2008-01A-Hobby Farm's and British Columbia's Agricultural Land Reserve (Stobbe, Eagle, Cotteleer and van Kooten)
2008–02 –An Economic Analysis of Mountain Pine Beetle Impacts in a Global Context (Abbott, Stennes and van Kooten)
2008–03 –Regional Log Market Integration in New Zealand (Niquidet and Manley)
2008–04 –Biological Carbon Sequestration and Carbon Trading Re-Visited (van Kooten)
2008–05 –On Optimal British Columbia Log Export Policy: An Application of Trade theory (Abbott)
2008–06 –Expert Opinion versus Transaction Evidence: Using the Reilly Index to Measure Open Space premiums in the Urban-Rural Fringe (Cotteleer, Stobbe and van Kooten)
2008–07 –Forest-mill Integration: a Transaction Costs Perspective (Niquidet and O'Kelly)
2008–08 –The Economics of Endangered Species Poaching (Abbott)
2008–09 –The Ghost of Extinction: Preservation Values and Minimum Viable Population in Wildlife Models (van Kooten and Eiswerth)
2008–10 –Corruption, Development and the Curse of Natural Resources (Pendergast, Clarke and van Kooten)
2008–11 –Bio-energy from Mountain Pine Beetle Timber and Forest Residuals: The Economics Story (Niquidet, Stennes and van Kooten)
2008-12 –Biological Carbon Sinks: Transaction Costs and Governance (van Kooten)
2008-13 –Wind Power Development: Opportunities and Challenges (van Kooten and Timilsina)
2009-01 –Can Domestication of Wildlife Lead to Conservation? The Economics of Tiger Farming in China (Abbott and van Kooten)
2009-02 – Implications of Expanding Bioenergy Production from Wood in British Columbia: An Application of a Regional Wood Fibre Allocation Model (Stennes, Niquidet and van Kooten)
2009-03 – Linking Matlab and GAMS: A Supplement (Wong)
2009-04 – Wind Power: The Economic Impact of Intermittency (van Kooten)
2009-05 – Economic Aspects of Wind Power Generation in Developing Countries (van Kooten and Wong)
2009-06 – Niche and Direct Marketing in the Rural-Urban Fringe: A Study of the Agricultural Economy in the Shadow of a Large City (Stobbe, Eagle and van Kooten)
2009-07 – The Economics and Policy of Global Warming (van Kooten, Beisner and Geddes)
2010-01 – The Resource Curse: A State and Provincial Analysis (Olayele)
2010-02 – Elephants and the Ivory Trade Ban: Summary of Research Results (van Kooten)
2010-03 – Managing Water Shortages in the Western Electricity Grids **(**Scorah, Sopinka and van Kooten)
2010-04 - Bioeconomic modeling of wetlands and waterfowl in Western Canada: Accounting for amenity values (van Kooten, Withey and Wong)
2010-05 – Waterfowl Harvest Benefits in Northern Aboriginal Communities and Potential Climate Change Impacts (Krcmar**,** van Kooten and Chan-McLeod)
2011-01 – The Impact of Agriculture on Waterfowl Abundance: Evidence from Panel Data (Wong**,** van Kooten and Clarke)

2011-02 – Economic Analysis of Feed-in Tariffs for Generating Electricity from Renewable Energy Sources (van Kooten)
2011-03 – Climate Change Impacts on Waterfowl Habitat in Western Canada (van Kooten, Withey and Wong)
2011-04 – The Effect of Climate Change on Land Use and Wetlands Conservation in Western Canada: An Application of Positive Mathematical Programming (Withey and van Kooten)
2011-05 – Biotechnology in Agriculture and Forestry: Economic Perspectives (van Kooten)
2011-06 – The Effect of Climate Change on Wetlands and Waterfowl in Western Canada: Incorporating Cropping Decisions into a Bioeconomic Model (Withey and van Kooten)
2011-07 – What Makes Mountain Pine Beetle a Tricky Pest? Difficult Decisions when Facing Beetle Attack in a Mixed Species Forest (Bogle and van Kooten)
2012-01 – Natural Gas, Wind and Nuclear Options for Generating Electricity in a Carbon Constrained World (van Kooten)
2012-02 – Climate Impacts on Chinese Corn Yields: A Fractional Polynomial Regression Model (Sun and van Kooten)
2012-03 – Estimation of Forest Fire-fighting Budgets Using Climate Indexes (Xu and van Kooten)
2012-04 – Economics of Forest Carbon Sequestration (van Kooten, Johnston and Xu)
2012-05 – Forestry and the New Institutional Economics (Wang, Bogle and van Kooten)

For copies of this or other REPA working papers contact:
REPA Research Group
Department of Economics
University of Victoria PO Box 1700 STN CSC Victoria, BC V8W 2Y2 CANADA
Ph: 250.472.4415
Fax: 250.721.6214
http://web.uvic.ca/~repa/

Forestry and New Institutional Economics

1. Introduction

A forest is much more than a bunch of trees. Scratch the surface of the vast forest landscape, and one will see a myriad of biota and a complex and interesting biophysical world. But when forests are viewed from the perspectives of society, economy and human wellbeing, a complex network of institutions comes onto the scene. It is this dynamic network of institutional arrangements that provide necessary governance structures for an array of activities related to the management and use of forest resources.

A variety of economic approaches have been utilized in the analysis of forestry problems (see van Kooten 1993; van Kooten and Bulte 2000; Hyde 2012). The focus of this chapter is on a particular approach, known as the new institutional economics (NIE), and how it may be applied to forestry. NIE builds upon and extends neoclassical economic theory by incorporating into main stream economics a body of theory pertaining to institutions (Coase 1998, 1984). Since the 1970s, NIE has made a large impact on the social sciences, especially economics and political science. Uniting theoretical and empirical research to examine the role of institutions in economic activities, NIE comprises work regarding transaction costs, property rights, hierarchy and organization, public choice and so on. In recent years, NIE has increasingly provided fresh insights into various aspects of social organization and sectors of the economy, including forestry (Wang and van Kooten 2001). The objective of this chapter is to provide an overview of what NIE contributes to economic practice and, more importantly, the insights it offers regarding forestry. We illustrate the potential contribution of NIE in terms of forest policy using a Canadian case study.

In the next section, we provide an overview of NIE in terms of its origin, scope and main developments. Then, in section 3, we offer a synthesis of the major applications of NIE to

important fields of economic analyses, and, in section 4, we present a case study of NIE applied to forest management and policy in the context of British Columbia (BC), Canada. The chapter ends with a few concluding remarks.

2. New Institutional Economics: genesis, scope, and developments

As a distinct field of economics, the New Institutional Economics traces its origins to the earlier or 'old' institutional economics found in the writings, for example, of Thorstein Veblen, John Commons, Wesley Mitchell and Clarence Ayres. These writers were discouraged by what they perceived to be the lack of explanatory power in neoclassical economics, and its failure to take account of institutions. However, the old form of institutional economics sought to jettison much of neoclassical theory but offered little in its place except descriptive analyses that took each situation as somehow unique – it lacked a solid theoretical foundation that might be applicable more broadly, say outside the particular culture or organization of economic affairs.

The term, 'New Institutional Economics,' was coined by Oliver Williamson to distinguish it from the 'old' institutional economics (Coase 1998). There is now a consensus among scholars that Ronald Coase's 1937 paper, 'The Nature of the Firm,' provided the original and enduring inspiration for the development of NIE. With a focus centering around the theory of the firm and transaction costs, NIE benefitted from the ideas of the Austrian school of economics (Hayek 1937, 1945), the economics of information (Stigler 1961, 1975), human behavior and cognitive science (Simon 1957, 1962), organizations and markets (Williamson 1975, 1985; Simon 1991), the theory of property rights (Alchian and Demsetz 1972; Demsetz 1967; Barzel 1989; Pejovich 1995), institutions (North 1990, 1991), the history of industrial enterprise (Chandler 1992), and, lastly, transaction cost economics (Williamson 1979, 1998; Groenewegen 1996).

NIE is concerned with the role of governance structures in terms of institutional environment and institutional arrangements. As far as the institutional environment is concerned, important aspects include the legal environment, property rights, norms and social conventions. From the standpoint of the theory of the firm, institutional arrangements explain why production is often internalized within an industrial organization as a result of economizing on transaction costs. Although markets act as necessary institutional mechanisms for many productive activities, vertically integrated governance structures will exist for reasons that are best explained by NIE.

2.1 Institutions, property rights, and contractual arrangements

Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights) (North 1991). Specifically, institutions are defined as the legal, administrative and customary arrangements for repeated human interactions. Their major function is to enhance the predictability of human behavior (Pejovich 1995). The growing literature around institutions point to a distinction between the institutional environment and institutional arrangements. Collectively, the institutional environment and institutional arrangements constitute governance structures. Broadly speaking, institutions provide a system of rules plus the instruments that serve to enforce the rules. In daily life, we observe explicit and implicit contractual frameworks, which include markets, firms and mixed modes within which transactions occur.

The notion of property rights is central to institutions. Property rights refer to the socially sanctioned and enforceable claims that an individual or a group has to the benefits associated with certain physical assets or services subject to the conditions that society places on the use of the assets or services in question. Property rights have a number of dimensions, including

comprehensiveness, duration, transferability, benefits, exclusiveness and security. In economic activities, the property rights over an asset indicate the individual's (group's) ability to consume the good or receive the services of the asset directly, or to consume it indirectly through exchange. Property rights include: (1) the right to use an asset, (2) the right to earn income from an asset and contract over terms of use with other individuals, and (3) the right to transfer ownership permanently to another party (Demsetz 1967; Barzel 1989). It is important to note that property rights are claims that are recognized and enforced by authorities, most notably the government (Furubotn and Pejovich 1972, 1974).

Production and exchange involve contractual arrangements. As a legally enforceable agreement between two parties, a contract is a legal commitment to which each party gives express approval (either in written or less often verbal form) and to which a particular body of law applies. Contractual activities take place, not only for the purpose of accomplishing the exchange of goods and services but also to permit the exchange of bundles of property rights (Furubotn and Pejovich 1972). From the point of view of markets and organizations, contract terms are influenced by a number of factors including the access that contractual parties have to information, the costs of negotiating, and the opportunities for cheating (Simon 1991). While it is of great importance to examine the institutional environment and property rights structure surrounding an economic activity, it would be a mistake to neglect contractual arrangements. In fact, analysis at the level of contractual terms will often yield deep insights regarding economic incentives and transaction costs.

2.2 Transaction cost economics

In spite of the fundamental role of markets in coordinating economic activities, the firm has been recognized as a primary coordination mechanism. According to Coase (1937), the nature of the firm is to reduce the number of transactions for the purpose of producing a more

efficient outcome. As long as the firm can coordinate a transaction at a lower cost than the market, it pays to internalize the function. Once coordination becomes onerous, a firm may need to allocate the function to the market.

The theory of the firm is viewed as the core of NIE, and transaction cost economics (TCE) is at the heart of that theory and at the centre of the economics of organization. The term, 'transaction costs,' has many definitions. Generally speaking, transaction costs refer to costs incurred for the creation, maintenance, use, and change of institutions and organizations. They include the costs of defining rights, the costs of utilizing and enforcing the rights specified, and the costs of information, negotiation and enforcement.

Humans are assumed to be rational economic agents to a certain degree and people are opportunistic. Bounded rationality and opportunism are two key assumptions underlying the TCE theory. While the opporunistic aspect of human nature is easy to imagine, the concept of bounded rationality needs elaboration (see Simon 1957). It is costly for individuals to contemplate and contract for every contingency that might arise over the course of the transaction; this adds to the ex ante cost of drafting a contract. These costs may be so high that the individuals fail to provide for the contingency in the contract or fail to undertake the contemplation necessary to foresee the contingency. According to Williamson (1975, 1971), the central concern for economic organizations is to devise contracts and governance structures that have the purpose and effect of economizing on bounded rationality, while simultaneously safeguarding transactions against the hazard of opportunism.

TCE places an emphasis on the firm. In other words, the firm acts as an institution within which transactions take place – as an alternative to transactions that take place in a market. From the point of view of TCE, firms and markets are alternative means of economic organization. Whether transactions are organized within a firm (hierarchically) or across a

market between autonomous firms is a decision variable. Which mode is adopted depends on the transaction costs that attend each. The basic premise of TCE is that transactions tend to be organized in ways that maximize the net benefits they provide, where the cost of the transaction is taken into account. Transactions differ in their attributes and are thus aligned with governance structures that differ in their costs and competence in a transaction-cost economizing way. Differential transaction costs give rise to discriminating institutional alignment according to which some transactions will align with one set of governance structures and other transactions will align with others. Each mode of governance is defined by a series of attributes, whereupon each displays discrete structural differences with respect to both cost and competence.

Williamson extends the scope of TCE to emphasis to all economic organizations. More recently, scholars tend to think of TCE in the context of all economic institutions and institutional arrangements. Hence, it is valid to examine contracts by looking at the transaction costs ex ante and ex post. Ex ante transaction costs include the costs of negotiating a contract, searching and information gathering; ex post costs include the costs of safeguarding the deal that was originally struck, namely, the monitoring and enforcement costs.

Transaction costs are difficult to quantify, but this difficulty is mitigated by the fact that transaction costs are always assessed in a comparative way, in which one mode of contracting is compared with another. Accordingly, it is the difference between rather than the absolute magnitude of transaction costs that matters (Williamson 1985, pp.21-22). Empirical research on transaction costs focuses on the question of whether contracting practices and governance structures line up with the attributes of transactions as predicted (Williamson 1985).

The key technical, human and behavioural dimensions of transactions correspond to asset

specificity, bounded rationality, and opportunism, respectively (see Table 1). Generally speaking, the more specific or specialized an asset (or activity), the higher is the possibility of appropriating the benefits arising from its designated and intended uses, but the less adaptable is the asset (or skill) to employment in an alternative use.

Table 1: Important Parameters of Transaction Cost Economics

Dimension	Atrributes
Specificity	**Physical asset specificity** is a measure of asset redeployability arising from the special and general purpose of investments. Special purpose investments may be risky because specialized assets cannot be redeployed if contracts are interrupted or prematurely terminated. General purpose investments do not pose the same difficulties. Hence, the more specific a physical asset or skill, the lower is its opportunity cost in its best alternative use; hence, the cost of transacting to re-employ or re-deploy the asset is higher. **Human asset specificity** is a measure of relation-specific investments, such as bilateral dependency.
Uncertainty	The capacity of the governance structure in adapting to disturbances is measured by the probability of continuation (durability of firm-specific assets). Also, contract length is important because long-term contracts mitigate inefficiencies associated with ex ante underinvestment and ex post opportunism.
Frequency	The degree to which transactions recur is positively related with the specialization of governance structures. For idiosyncratic investment, when frequency reaches a certain point, unified governance comes into being.

Unlike the standard economic approach that is preoccupied with technology and production expenses, TCE examines comparative costs of planning, adapting and monitoring task completion under alternative governance structures. For this purpose, there is a need to identify different types of transactions and how they vary under different circumstances. Specifically, the factors responsible for transaction cost differences need to be identified in order to understand why some transactions are organized one way and other transactions another. Asset specificity is positively correlated with firm size, with small companies more likely to have general purpose plant and equipment. The market is the main governance structure for nonspecific transactions in the case of both occasional and recurrent contracting.

In terms of the advantages that TCE offers, Williamson (1985, pp.17-18) considers the

economic importance of asset specificity, the business firm as a governance structure rather than a production function, and the means for comparing the transaction cost implications of alternative contractual arrangements. Williamson notes that any issue that can be formulated as a contracting problem can be investigated in the transaction costs economizing framework.

2.3 Moral hazard, agency, and information problems

Contracts are important because of their indispensable role in coordinating the exchange of products and services (Hart 1995). In analyzing contracts, the issue of moral hazard needs to be taken into account and the problem of agency should be dealt with by means of appropriate contractual terms. The incidence and effect of moral hazard were analyzed extensively in the literature concerning businesses and other organizations (Holmström 1979; Jensen and Meckling 1976). The notion of moral hazard may best be understood from the perspective of human behaviour, using a principal-agent (PA) setting. The agent has an incentive to hide crucial information from the principal in order to exploit opportunities for gain by pursuing one's own self-interest. It is entirely possible that the agent possesses hidden information or goals that are detrimental to the principal (Holmström 1979). Williamson (1985, p.51) defined this behavior as the 'propensity of human agents to behave opportunistically.' Ross (1973) was one of the first to model formally PA relationships, while Fama (1980) elaborated the agency problem using the theory of the firm.

Economic activities are associated with various types of information. Often the available information is limited, incomplete or irrelevant. Strictly speaking, there are two aspects to the information problem, namely, information deficiency and information asymmetry (Ross 1973; Stiglitz 1974, 1975). The recognition that the transfer of information between principal and agent is a key element to their effective relationship has led to significant theoretical research into the economics of information (Stigler 1961; Campbell 2006).

Two crucial elements that characterize principal-agent problems arise from the asymmetry of information between the two parties. The agent may choose actions that are not in the interest of the principal, termed *adverse selection* (Salanie 1997). Consider as an example a forest landowner (principal) who hires a logging firm (agent) to harvest timber. Suppose the issue pertains to salvage harvesting of wind, pest or fire damaged timber. In some cases the logging firm has the ability to select which timber is to be harvested; thus, the firm will harvest damaged timber with the most suitable properties desired for further processing, leaving more questionable timber standing. By removing more valuable trees and not addressing proximate areas, the agent reduces the value of the principal's resource base. Likewise, if damaged trees could be assigned to a specialty mill with optical scanners (to extract the greatest value from the timber) but the principal chooses a logger associated with a mill owner who has opted not to invest in the necessary technology, the value of the forest resource is reduced by what amounts to a wasteful practice of which the principal may not be aware.

Given the moral hazard problem, the principal must carefully consider the costs and tradeoffs of alternative actions in order to strike as efficient a contract as possible in a world of informational deficiency. To do so, the principal may use signalling or screening ex ante (Slangen et al. 2008), although signalling may also occur ex post. A proper design of contractual terms with careful consideration of potential agency problems will help diminish transaction costs and achieve efficient outcomes from an economic standpoint.

2.4 Economic development and natural resources in an NIE context

The problems of economic development, natural resources and social dilemmas (viz., externalities, open access) (Ostrom 2000) are not that neoclassical economic explanations are inappropriate, but rather that they are incomplete. Other than markets and private property, three additional factors have been addressed by NIE – economic institutions, the role of the

state and social capital (Fukuyama 2002).

As noted above, a country or state must have a set of institutions within which policy change can occur. Institutions consist of formal rules (constitutions, laws and property rights) that constrain political, economic and social interactions, and include such things as commercial and criminal courts. Unlike cultural constraints, they are more amenable to change, although certain inertia may be required to overcome vested interests. Economists have often ignored institutions, even though existing institutions may not always be the 'right ones' (Bromley 1999). Research in economic development now stresses the need for good institutions, as some institutions retard rather than promote growth (La Porta et al. 1999), or become an obstacle to resolving social dilemmas in resource management (Ostrom 2000). In order to remain effective, institutions need to evolve over time in response to changing circumstances, and the rate at which they evolve must not slow the progress of policy change.

Economic policies can only be carried out by the state, but the state must be limited in scope and yet able to enforce the rule of law. The state must be competent and sufficiently transparent in formulating policy, and have enough legitimacy to be able to make painful decisions. The role and performance of government is essential to economic development and the resolution of social dilemmas (La Porat et al. 1999). Good governments protect property rights and individual freedom, keep regulations on businesses to a minimum, provide an adequate (efficient) level of public goods (e.g., infrastructure, schools, health care, police protection, court system), and are run by bureaucrats who are generally competent and not corrupt. Unfortunately, regulatory agencies often prevent entry, courts resolve disputes arbitrarily and sometimes dishonestly, and politicians use government property to benefit their supporters rather than the population at large.

The third factor needed to resolve social dilemmas is social capital (Putnam 2000), or "the

proper cultural predispositions on the part of economic and political actors" (Fukuyama 2002, p.24). The 'cultural factor' constitutes informal constraints (sanctions, taboos, customs, traditions, and norms or codes of conduct) that structure political, economic and social interactions. Social capital has both individual and aggregate components (Gelauff 2003). Individual social capital consists of intrinsic aspects (charisma, values) and aspects in which one can invest (trustworthiness, personal networks), although these two aspects are difficult to separate. Aggregate social capital, on the other hand, constitutes the total of the social capital of the individuals in society, varying by form (trust in people, trust in government, level of participation in society), place (firm, region in a city or country, neighbourhood), and group (ethnic and religious groups, service organizations, sport associations, gangs). It is difficult for society to invest in aggregate social capital because the manner in which the social capital of individuals is aggregated is not clear. A society can only invest in culture by somehow affecting individuals who do the investing. For example, society can encourage couples to stay together longer by making divorce more difficult, or encourage church attendance by providing tax incentives for charitable giving, but both actions fail to address culture directly.

Trust is perhaps the most important component of social capital: "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time" (Dasgupta 2000). Trust is not social capital, but a manifestation of it; trust is related to institutions and affects the costs of transacting. If confidence in an enforcement agency falters, one may not trust others to fulfil their agreements and thus enter into fewer agreements. There is an element of trust in any transaction where one has to decide (make a choice) before being able to observe the action of the other party to the transaction. One has to assume that the other person is not acting with guile, keeping information hidden that could be used to their advantage at the expense of the other party to the transaction. Like

other components of social capital, trust makes an economy function more efficiently (Fukuyama 1999).

In addition to trust, other elements of social capital include social norms, or behavioural strategies (e.g., always do *p* if *q* occurs) subscribed to by all in society, and networks of civic engagement (membership in swim clubs, church organizations, etc.) that enhance cooperation. Ostrom (2000) shows how social norms of reciprocity and trust, combined with local enforcement and graduated sanctions, result in effective resource management regimes.

As noted, one important aspect of trust relates to hidden information – the asymmetry of information that exists between two parties to a transaction or contract. This evolved into principal-agent (PA) theory, with studies of PA problems paralleling developments in transaction cost studies. Significant progress has recently been made into the PA problem and the role of property rights in resource exploitation and environmental protection. The latter line of inquiry evolved into new thinking about collective action, led by the late Nobel laureate Elinor Ostrom (1990, 2005). Her 1990 book, entitled *Governing the Commons: The Evolution of Institutions for Collective Action*, quickly became a classic as it showed that economic governance structures are multi-faceted and complex, making analysis trickier. Ostrom (2005) subsequently demonstrated that common property could be successfully managed by the users of a resource, given a set of conditions that includes trust and carefully designed cooperation-enhancing incentives. Her work in the area of collective action and political economy provides a link between the fields of organizational theory and political science via a separate body of literature known as public choice. These writings have made significant contributions to advancing our understanding of how the institutions governing natural resources evolved and how they can be efficiently managed.

In the context of forest ecosystems, Ostrom (1998) rejected simple, large-scale, centralized

governance units, arguing that forest biodiversity needs to be matched by institutional diversity. In the next section, we examine the role of institutions and insights that NIE thinking has on forest policies and management.

3. Applications of the new institutional economics framework to forestry

Economists having an interest in forests are keenly aware that the institutional framework will significantly influence both the policy choices available to the public landowner and the responses of the forest firms (Nelson 2007). Where past approaches tended to focus on the economic response to rules, Luckert (2005) indicates that economists are now beginning to examine alternate arrangements, where economic behaviour influences the development of the institutions or rules.

3.1 Relevance of new institutional economics to forestry

In the context of the institutional reforms made to British Columbia's forestry sector at the end of the last century, Wang and van Kooten (2001) applied NIE to investigate forest companies' decisions to contract out silvicultural activities or to perform them in-house. A model was developed to test the relationship between a firm's choice of contractual forms and (a) the attributes of the activity (e.g., specificity of technical skills and physical assets, frequency of operations, and uncertainty in controlling performance quality), and (b) the characteristics of the firm (e.g., company size). Data from a survey of forest companies in BC were used to test several hypotheses arising from the NIE approach. The empirical results confirmed the transaction cost logic that silvicultural activities performed in-house are likely those that are complex to manage, have a low degree of seasonality, require high levels of human skills, and involve highly specialized physical assets. As asset specificity or specialized skill increased and the duration of the activity decreased, contracting an activity became more attractive to the firm.

Recently, the application of NIE approaches has increased in intensity. For example, van Kooten et al. (2002) examined the institutional arrangements and economic incentives needed to encourage landowners in Canada to plant trees on a large scale. They concluded that the transaction costs of getting landowners to convert agricultural land to forest plantations were a major roadblock to their adoption. The analytics of transaction costs has been used in the examination of biological carbon sinks (van Kooten 2009), and the institutional context of forest management systems in China has been examined from the perspective of NIE (Zhang 2001).

One important concept, as noted above, deals with asymmetry in contracting, which has led the adoption of principal-agent (PA) theory to the issue of forest tenures. In its simplest form, the PA relationship is one of delegated choice where the principal (public landowner) delegates management to another party (forest company), called the agent (Rees 1985). Delegation arises when tasks are "… too complicated or costly to carry out oneself" (Sappington 1991). In the next section, we adapt the principal-agent framework to contemporary forestry issues in Canada's province of British Columbia.

3.2 The principal-agent problem in the forestry context

With specialized assets, the agent may wish to keep the proprietary interests that may be created hidden for competitive advantage in the marketplace. A forestry example of this is provided by Nelson et al. (2009), who examined whether the managers of BC forest companies (mill managers) were maximizing their economic options. They found that managers (the agents) were readily willing to discuss general questions about perception in the forestry business, but were highly wary about discussing specific financial issues related to their firm.

On the surface, the PA relationship developed because it is mutually beneficial to both

parties. If the parties share a common objective and management understanding then the agent's choices (actions) will bring about outcomes desired by the principal. Stiglitz (1974) produced one of the earliest examples of a unified description of the PA problem in natural resources; he explored the landlord-labour relationship in agriculture. He concluded that, when direct supervision is either costly or ineffective, the use of sharecropping has an incentive and risk-sharing effect, making the principal-agent relationship more efficient than internalizing the activity. Sterner (2003) notes that information asymmetry in natural resources between the principal and agent can be so severe that simple rental agreements may be the only appropriate policy instrument.

The principal-agent theory has often been used to describe differentiated contractual services in forestry. Wang and van Kooten (2001) used the PA theory to explain the emergence of silvicultural contractors when the BC government chose to shift responsibility for regeneration (and hiring of individual tree planters) to the forest companies. Vedel et al. (2006) provide an elegant theoretical principal-agent explanation for why private forest companies initially switched to differentiated contracts for forest advisory services, while Paarsch and Shearer (2009) recently examined the effectiveness of incentives offered to tree planters in determining the optimal piece-rate contract. The piece-work context has been suggested as the sole application of the PA theory, but this assertion has been challenged because the paradigm has such broad applicability (van Ackere 1993). In fact, Miller (2005) points out that there is no single solution to the principal-agent problem, as it is the juxtaposition of the two party's beliefs, goals, and willingness to deal with risk that produces the necessary blend of actions between the two parties.

For this reason, many qualitative forestry examples use PA theory's explanatory power. Kufuor (2004) uses the PA theory to describe the policy failure that plagued attempts to

create sustainable forestry conditions in Ghana. Gray (2002) uses it to describe forestry concession policies with respect to government revenue systems, while Karsenty et al. (2008) apply the theory to forestry concessions in Central Africa and South America, stating that the economic value of the forest to the principal is contingent on the efficiency of the forest company. A number of qualitative studies have used the framework to describe forestry certification systems (Cousins 2006; Rametsteiner 2002; Kiker and Putz 1997). And Bowers (2005) applies the theory to examine incentive instruments that could be used to motivate private forestry firms to carry out sustainable forestry activities as defined by the principal or regulator.

Quantitative examples of the use of the PA theory in a forestry context are more difficult to find. Krepps and Caves (1994) use the theory to explain why the value obtained from tribal forest land was dependent on whether tribal lands were managed internally (by the principal) or externally under contract with the United States Bureau of Indian Affairs. It was found that both the quantity and quality of timber increased when the tribal leaders retained services in house rather than contracting to agents with a lower stake in the financial outcomes for the tribe.

Laffont and Martimort (2002) have pointed out that the principal uses the tactic of *screening* to obtain a certain type of agent. For example, until recently, provincial governments in Canada regularly required appurtenancy in forest tenures – the forest company (agent) had to operate a mill as a condition for obtaining access to large timber quota. Appurtenancy introduced an explicit commitment level for a company and served many purposes, including investment in infrastructure, the employment of local people and the increased likelihood that the company would take a longer rather than shorter term view of the forest resource. This screening mechanism was seen as an impediment to a competitive forest industry and was

eliminated under the BC government's 2003 Forestry Revitalization Plan (British Columbia Ministry of Forests and Range 2003; Niquidet 2008). Agents are then able to *self-select*, not taking contracts that are outside their specialization or beyond their capacity (Slangen et al. 2008).

3.3 Mountain pine beetle and forest policy in British Columbia

Government news releases can be seen as a *signalling* mechanism used to provide insights into how government views a certain situation. British Columbia's provincial government sent a strong signal concerning the catastrophic nature of the mountain pine beetle (MPB) epidemic by creating a geographic salvage area defined in Order-In-Council 661-08. This provided forest companies with some valuable funding from the federal government, but also put existing tenure holders (agents) on notice that pine salvage was a key priority. Multiple reports released by the BC government showed that the signal was picked up by the agents, with most responding by increasing the proportion of pine in harvests above the proportion of pine on the land base (Forest Analysis and Inventory Branch 2007). However, signals can only be effective if the agents' response has a limited impact on their economic well-being.

Once the principal becomes convinced that agent activities could impact the value of the future forest, something beyond monitoring simple harvest content is required. In response to concerns that agents had begun to include more non-pine in the harvest mix in regions affected by the MPB epidemic, the BC government implemented something called 'partitioning,' whereby the harvest level determined in a management unit was distributed between stand types or species mixes in an attempt to regulate or constrain the harvest activities of the agents. This increased the principal's monitoring requirements. As the difficulty of monitoring increases, the principal may find it is better to incentivize truth telling.

An interesting forestry example meant to facilitate truth telling is the historic use in BC of a dead timber grade (Grade 3), which was charged a nominal fee of C$0.25 (pre-2006). Although the principal lost some resource rent if the value of a dead tree was nonetheless significant, the principal used Grade 3 to encourage the use of deteriorating logs thereby leading to greater lumber recovery while obtaining a clear signal of the agent's activity. When the BC government altered its timber grading system to capture additional rent, representing a more differentiated stumpage, dead timber could be assigned a sawlog Grade 1 or Grade 2, with stumpage rates in excess of $\$10/m^3$. Companies responded by kiln drying entire logs before grading occurred, because logs could erroneously be assigned Grade 1 or 2 when in fact they were eligible as Grade 4 (called ironically a lumber reject), as kiln drying of logs exposes the cracks that might be completely hidden due to the length of time the logs are exposed to elements such as rain or snow. Exposure to moisture causes the wood to expand and seal up the previously visible checks (Oliveira and Kostiuk 2008). Although an extreme process, companies could realize substantial savings by kiln drying low-grade, beetle-damaged logs. With stumpage accounting for 25% of log cost and reforestation costs also born by the forest company, the management of these costs can play a significant role in defining the economic land base (van Kooten and Folmer 2004, pp.48-53; Luckert 2007). This is an example of the *time inconsistency* problem, whereby the principal may change its policy and thereby weaken an agent's sense of certainty with respect to planning for the future (Slangen et al. 2008).

To engage an agent to provide a service or product, the principal must be fully aware of the minimum *participation condition* required to entice the agent to agree to a relationship or sign a contract. Once a contract is in place there is 'institutional lock-in' so that the principal may be able to use 'coercion-focused' constraints to affect the agent's behaviour (Stanbury and Vertinsky 1998). However, if the effort required by the agent or the asymmetry of

information is above some threshold, the principal must include an *incentive condition* if it hopes to manage the agent's behaviour by relying on the agent's self-interest.

In the case of forestry, the most common PA relationship likely pertains to the timber disposition on public forestland. The principal must decide on the tenure arrangement and the bundle of property rights and responsibilities to allocate to a forest firm, which, in turn, influences the complexity of the PA relationship. Public forestland can be managed in various ways, but the common ones include standing timber sales, volume-based tenures and area-based tenures. At 95%, BC has one of the highest proportions of public forestland ownership in the world, making it an ideal location for exploring the principal-agent relationship (Niquidet 2008). Gray (2002) points out that government typically lacks the internal capacity, capital and industry experience to operate logging operations, and chooses instead to contract this out to specialized forestry firms. This leads to a PA relationship.

To manage this relationship, the BC government uses standing timber sale licenses administered through BC Timber Sales (TSL), two types of volume-based tenures – non-replaceable (NR) and replaceable (R) – and an area-based tenure. The latter tenure consists primarily of tree farm licenses (TFL) operated by a forest company, although there are smaller area-based tenures such as woodlots managed by individuals and community forests managed by community groups. In Figure 1, we provide an indication of the control over management that the principal grants the agent. Three management characteristics are displayed in the figure: (1) the exclusivity of property rights enjoyed by the license holder (vertical axis), (2) the term of the license agreement (horizontal axis), and (3) the size of the extent to which an agent can impact the forest footprint (with a larger font indicative of a greater footprint).

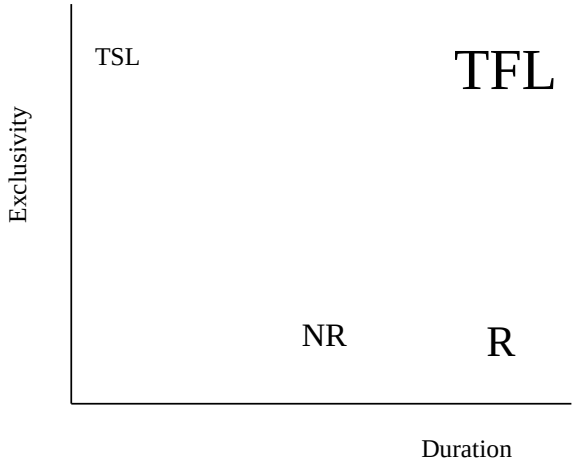

Figure 1: Tenures compared by exclusivity, duration and influence on the forest estate: timber supply license (TSL), non-replaceable license (NR), replaceable license (R), and tree farm license (TFL).

A timber sales license provides complete exclusive rights within the physical boundaries of the timber sale area developed for harvest by the principal, but rights are short-lived. This tenure maximizes control that the principal can exert over the management of harvests. With standing timber sales, the principal develops the forestlands for harvest and limits the influence that the agent has on the forest, but it needs to retain a highly specialized work force to develop these sales. The agent is provided exclusive rights to the area defined by the TSL, but the principal must still be aware of incentive constraints to ensure the best possible outcome from its perspective. Given the repeatability of these transactions and their short duration, the principal gains knowledge of the various agents so as to modify quite easily future contracts and even refuse certain bidders (Leffler and Rucker 1991). While providing the highest level of control, in managing TSLs for multiple values the public landowner may be criticized for failing to achieve the best financial benefit and may even result in a burden on the public purse because administrative cost may be incurred when the agent decides not to harvest a site (Rucker and Leffler 1988). To address concerns raised by U.S. softwood lumber producers concerning lack of transparency (market forces) in setting stumpage fees, the provincial government shifted 20% of the volume allocated under long-term R and TFL

tenure forms to TSLs sold at auction, thereby also creating a government timber development agency, BC Timber Sales (Niquidet 2008).

At the other extreme, forest management activities on a particular forest may be completely delegated to the holder of a Tree Farm License; a TFL grants exclusive timber rights over a much larger area and for a long duration than a TSL, which implies that the license holder is able to plan not only short-term harvest decisions but also longer term management without interference from another licensees. In this case, however, the principal must consider how the agent will behave. Using appropriate differentiated stumpage mechanisms, the principal can ensure that the forest is not high-graded during the term of the license agreement (Amacher et al. 2001).

Mathey and Nelson (2010) considered optimal decision-making within an area-based tenure when mountain pine beetle struck, concluding that the tenure-holder's most profitable strategy would actually achieve the government's risk reduction strategy on public land, a key consideration in the principal-agent relationship. However, it is the exclusivity of operations that is assumed to protect the value of the forest and, indeed, evidence indicates that area-based TFL holders spend more on silviculture than volume-based TSL holders, but not as much as private landowners (Zhang and Pearse 1996). The harvesting rights for this tenure type currently constitute 17% of the provincial annual allowable cut (AAC), with the distribution skewed geographically towards the BC coast (where 47% of the public forestland in under area-based tenure) and much lower in the BC interior (only 8%) (Ministry of Forests, Lands and Natural Resource Operations 2012).

A replaceable (R) tenure holder may experience the same duration of access to timber as a TFL, but the holder may share the area with other tenure holders and thus lacks exclusive rights. The main reason why the license is replaceable is because the tenure holder owns a

sawmill or other manufacturing facility that creates employment for a local community, and the government is committed to maintain community and employment stability. Arguably, the asymmetry of information, whereby the agent is more knowledgeable than the principal may be the most extreme in the volume-based tenure. Gray (2002) warns that the use of volume-based tenures, also known as timber quotas, can overlap and create significant complexity in monitoring the activities of the firms. The principal needs to create the most effective performance measures in delegating work through agents to ensure that the outcome meets the principal's desires as closely as possible. BC currently manages 35% of its AAC using this tenure.

Similarly, the non-replaceable (NR) tenure holder may have harvesting rights in the same general area as the replaceable holder, but such rights have a fixed duration. The NR tenure holder generally does not own a sawmill or other manufacturing facility. It turns out that these two tenure types actually encourage different types of agent behaviour because the objectives of the agents differ. BC has often used the NR license for salvage harvesting as its fixed duration implies that the license is not meant to be sustainable in perpetuity and conditions can be tailored to describe the timber types eligible for harvest, allowing the principal more discretion in influencing the harvest choices of the licensee and the state of the forest. However, the discretion does not allow the principal the ability to change the contractual relationship at a later date. Currently 26% of BC's AAC is allocated to this form of tenure, primarily in response to the damage caused by the mountain pine beetle.

If we consider how well designed this continuum of timber tenures is to changing forest conditions and catastrophic natural disturbance, several recent studies provide insight into the PA dilemma faced in BC and other jurisdictions. Bogle and van Kooten (2012c) use the PA theory to derive a simple monitoring rule for the principal to use in determining the efficacy

of the agent's actions towards achieving the principal's post-salvage forest objectives. They highlight the very real risk to the principal's objective (assumed to be the maximum future value of the timber portfolio) when the agent can privately survey and select the most profitable stands to harvest (hidden information). In an area-based tenure, the agent can confidently manage the entire forest to the company's strategic advantage, an incentive not enjoyed by the agent with quota-based tenure. Lack of coordination between quota-based tenure holders can be expected to not only affect the principal's objective, but the outcome will also be adversely impacted by the multiplicity of agents operating in the region, especially when natural disturbance is considered (Cumming and Armstrong 2001, 2004).

Stumpage allowances are the predominant means used to fund silviculture in BC – that is, silvicultural costs are recognized as a claim against stumpage fees. These benefits are estimated to provide $200 million annually to silvicultural operations (Ministry of Forests, Lands and Natural Resource Operations 2011). Bogle and van Kooten (2012a) use the PA theory to describe the influence of agent responses to stumpage allowances on silvicultural outcomes. They find that allowing agents to manage silvicultural budgets to attain the future timberland productivity outcomes, rather than simply enforcing regeneration standards of harvested stands, could lead to improvements in the future productivity of the forest as it incentivizes agents to include silviculture decisions as part of their harvesting decision. The obstacles to improving forest productivity through silvicultural techniques have long been known (Pearse 1985), but, under the quota-based tenure arrangement, incentivizing agents to manage the silvicultural outcomes in the forest in addition to their regeneration obligations creates an even more complex PA relationship.

Bogle and van Kooten (2012b) employ a bilevel mathematical programming approach to the PA problem in the context of catastrophic disaster caused by the MPB. The bilevel

formulation separates the policy variables controlled by the principal from the behavioural variables controlled by the agents, and both from impact variables such as beetle damage and lumber markets that are uncontrollable. Using stumpage fees and harvest rates as policy variables, they examined outcomes under two agent types – vertically integrated R license holders and NR license holders, who are primarily market loggers. The authors surmise that R types will generally have built a mill (as historically they were required to under appurtenancy) and thus minimize the costs of harvesting their quota, while NR license holders are considered to be market loggers that maximize net income, or difference between log value and log cost, for the short duration of their license. They find that the cost minimization behaviour of the R tenure holder can lead to an outcome that is better aligned with the principal's objectives than the actions of non-replaceable tenure holder. They also show that if the principal does not take into account these behavioural differences, policy failure is assured.

Salvage operations create a very real challenge to the public landowner already using quota-based or area-based tenures, because the harvest of dead timber poses a financial risk to the agents. As noted by Nelson (2007), the government has little recourse but to alter the existing property rights of license holders. This was strongly highlighted in the 1980s' mountain pine beetle infestation on the Chilcotin Plateau in BC's central interior. At the time, the government was unable through the regular bidding process to find a company interested in harvesting timber under an NR license. The timber was marginal in quality and located over 200 kilometres from the nearest mills in the town of Williams Lake. The government received a single detailed proposal by Carrier Lumber Ltd. that included stumpage provisions before it would undertake harvesting. The company had developed an innovative approach that altered the economics of the poor quality timber by on-site milling using portable mills. However, it was the total package submitted by the company that altered the economics to

make the license viable.

In subsequent years, the Ministry of Forests changed a number of forest policies, both in terms of timber pricing and silvicultural obligations. Carrier attempted to operate under the original agreement but the government revoked those timber cutting rights for failing to supply silviculture performance bonds, which were a new obligation under the revised policies. However, in 1999, the BC Supreme Court upheld Carrier Lumber's view on the contract (Byl et al. 1999) and a $72 million compensation package was awarded in 2002 (Meissner 2002). This outcome reinforces the idea that, while the government owns the forest resource in BC, property rights and responsibilities are contractual. There is a financial risk within this institutional structure if costs and benefits for the two parties are not kept in balance.

It has long been held that the BC volume-based tenure system is a deterrent to efficient timber management as there are no territorial rights, which frequently leads to the idea that privatization of the forest resource is the most efficient means of ensuring good forest management (Haley 1985). From a timber production and efficiency perspective, this is likely true because the roles of the agent and the principal become one so that all of the effects of harvesting decisions are internalized. However, it is unlikely that privatization will be "environmentally, socially or politically" acceptable and may not even be economically viable (Kant 2009), although the government can regulate activities on private forestlands so that environmental outcomes are realized as they would if the forestland remained in public ownership. Research suggests that areas with long rotations are not likely candidates for industrial privatization as the subsequent future harvest of forested stands is too distant to truly influence firm behaviour (Gray 2002), although sustainable forestry operations do occur on private forest lands. And privatization does not eliminate the principal-agent relationship

as the regulator must choose wisely the instruments that can bring about sustainable forest management outcomes when society values forest land for other purposes (Zhang and Flick 2001).

While unwilling to go so far as to privatize public forestlands in BC, the government made a failed attempt to eliminate volume-based tenures by converting them to TFLs in 1988 (Cashore 2000). Part of the justification for such a move was to provide security of tenure and exclusivity of management, key drivers meant to encourage the internalization of harvesting actions and decisions concerning investment in the forest resource. Tenure reform with increasing the use of area-based tenure is a key element in the discussions of a legislative committee struck in 2012 to discuss options for mitigating the looming mid-term timber supply shortage as a result of damage from mountain pine beetle, because this tenure type is seen as providing the greatest incentive for more intensive forest management practices (Special Committee on Timber Supply 2012).

The tenure relations used in the management of public forestlands in BC leads to an interesting array of principal-agent concerns. Under a timber supply license (TSL), the principal is clearly in charge when it comes to forest management, deciding on which areas to harvest and managing the actions of the agent with straight-forward timber auctions and short-term contracts. However, this requires the principal to be continually active in preparing forestlands for potential timber sales. At the other extreme, by shifting forest management to the exclusive purview of a single tenure holder, as in the case of a tree farm license (TFL), many of the transactions that occur are eliminated and takes advantage of the specialist knowledge of the tenure holder from a silvicultural perspective. But the principal has less knowledge about the forest and logging operations than the agent, potentially causing the private company to benefit from informational asymmetries, such as those that are the object

of complaints by U.S. lumber producers. Other tenure arrangements also have their benefits and drawbacks. The government must act wisely in how it chooses institutions and tenure arrangements in managing public forestlands if it is to efficiently and effectively extract the greatest benefits for citizens.

4. Conclusion

The new institutional economics complements standard neoclassical economics by drawing attention to the importance of institutions and emphasizing organizational modes and contractual relations. It also emphasizes the role of social capital and the rule of law in facilitating transactions and resolving social dilemmas. NIE provides a framework for analysing problems in forestry, in particular providing insights into the relationship between forestland owners (or even managers) and on-the-ground operators – logging companies and silvicultural contractors. As illustrated here, the principal-agent theory has a particular application to problems of forest tenure, especially in cases where public ownership is the dominant characteristic of the forest sector, as is the case in Canada.

Over the past two decades, the NIE analytical framework has fruitfully been applied by forest economists to real-world problems. Studies in the context of British Columbia, Canada suggest that the choice of contractual forms has implications for opportunities to economize on transaction costs. Appropriate governance structures tend to align with transaction attributes and firm characteristics so that some costs of transacting can be minimized. In essence, the choice of governance mode should be dictated by the nature of the activities and transactions involved.

Principal-agent analysis has been applied to investigate responses to the mountain pine beetle catastrophe in British Columbia. Researchers and policymakers have come to recognize that desired outcomes in responding to the MPB epidemic depend not only on the structure of the

incentives (mainly differentiated stumpage fees) that forest companies face, but also on the tenure arrangements in which the forest company finds itself. Using the PA theory, it is possible to target incentives at specific forest companies rather than attempt to regulate outcomes after setting incentives. Public landowners need to recognize that firms will not respond as desired, and especially when they are asked to undertake tasks that lead to negative returns. It is important to recognize information asymmetries.

Finally, we find that in forestry there are too few studies that employ the methods of the new institutional economics to examine important problems related to forest tenures, trade in forest products (e.g., many issues in the on-going Canada-U.S. softwood lumber dispute might best be addressed within an NIE framework of analysis), carbon sequestration in forest ecosystems and the creation of suspect carbon offset credits (van Kooten and de Vries 2012), urban forestry, and forestry's role in economic development. As institutions and governance structures change over time (e.g., Clean Development Mechanism, REDD+), transaction attributes as well as the characteristics of economic agents are also subject to change. In this changing institutional environment, forest economists are unlikely to ever run out of problems to investigate.

References

Acheson, J.A. 1985. The Maine Lobster Market: Between Market and Hierarchy. *Journal of Law, Economics, and Organization* 1: 385-398.

Alchian, A.A. and Demsetz, H. 1972. Production, Information Costs, and Economic Organization. *American Economic Review* 62: 777-795.

Allen, D.W. and Lueck, D. 1993. Transaction Costs and the Design of Cropshare Contracts. *Rand Journal of Economics* 24: 78-100.

Alston, L.J., Datta, S. and Nugent, J.B. 1984. Tenancy Choice in a Competitive Framework with Transaction Costs. *Journal of Political Economy* 92: 1121-1133.

Amacher, G.S., Brazee, R.J. and Witvliet, M. 2001. Royalty Systems, Government Revenues, and Forest Condition: An Application from Malaysia. *Land Economics* 77: 300-313.

Bardhan, P.K. 1989. The New Institutional Economics and Development Theory: A Brief Critical Assessment. *World Development* 17(9): 1389-1395.

Barzel, Y. 1989. *Economic Analysis of Property Rights*. Cambridge, UK: Cambridge University Press.

Bogle, T.N. and van Kooten, G.C. 2012a. Options for Maintaining Forest Productivity after Natural Disturbance: A Principal-Agent Approach. *Forest Policy & Economics* Forthcoming.

Bogle, T.N. and van Kooten, G.C. 2012b. Protecting timber supply on public land in response to catastrophic natural disturbance: A Principal-Agent Problem. J. Environ. Econ. Manage. Under Review.

Bogle, T.N. and van Kooten, G.C. 2012c. Why Mountain Pine Beetle Exacerbates a Principal-agent Relationship: Exploring strategic policy responses to beetle attack in a mixed species forest. *Canadian Journal of Forest Research* 42: 621-630.

Bowers, J. 2005. Instrument choice for sustainable development: an application to the forestry sector. *Forest Policy & Economics* 7: 97-107.

British Columbia Ministry of Forests and Range. 2003. Forestry revitalization plan [online]. Available from http://www.for.gov.bc.ca/mof/plan/frp/pdf.htm [accessed 14 July 2012].

Bromley, D.W., 1999. *Sustaining Development: Environmental Resources in Developing Countries*. Cheltenham, UK: Edward Elgar.

Buckley, P.J. and Michie, J. 1996. *Firms, Organizations, and Contracts: A Reader in Industrial Organization*. Oxford, UK: Oxford University Press.

Byl, D., MacLeod, R., Pearlman, P. and House, D. 1999. Carrier Lumber Ltd (Plaintiff) versus Her Majesty the Queen in Right of the Province of British Columbia (Defendant): Reasons for judgement of the Honourable Mr. Justice W.G. Parrett. 30093.

Campbell, D.E. 2006. *Incentives: Motivation and the Economics of Information*. 2nd edition. Cambridge, UK: Cambridge University Press.

Cashore, B.W., Hoberg, G., Howlett, M., Rayner, J. and Wilson, J. 2000. *In Search of Sustainability: British Columbia Forest Policy in the 1990s*. Vancouver: UBC Press.

Chandler, A.D., Jr. 1992. Organizational Capabilities and the Economic History of the Industrial Enterprise. *Journal of Economic Perspectives* 6: 79-100.

Coase, R.H. 1937. The nature of the firm. *Economica* 4: 386-405.

Coase, R.H. 1960. The problem of social cost. *Journal of Law and Economics* 3: 1-44.

Coase, R.H. 1972. Industrial Organization: A Proposal for Research. In *The Firm, the Market, and the Law* (pp.57-74) edited by R.H. Coase. Chicago, IL: University of Chicago Press.

Coase, R.H. 1984. The New Institutional Economics. *Journal of Institutional and Theoretical Economics* 140: 229-232.

Coase, R.H. 1988. The Firm, the Market, and the Law. In *The Firm, the Market, and the Law* (pp.1-31) edited by R.H. Coase. Chicago, IL: University of Chicago Press.

Coase, R.H. 1992. The institutional structure of production, *American Economic Review* 82: 713-719.

Coase, R.H. 1998. The new institutional economics. *American Economic Review* 88(2): 72-74.

Cousins, K. 2006. Principals, Agents, and Public Goods: Information and Structural Complexity in Policy Implementation Systems. *In* 47th Annual International Studies Association meeting, March 22-25, San Diego, California. *Edited by* International Studies Association.

Crocker, K.J. and Masten, S.E. 1988. Mitigating Contractual Hazards: Unilateral Options and Contract Length. *Rand Journal of Economics* 19: 327-343.

Crocker, K.J. and Reynolds, K.J. 1993. The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement. *Rand Journal of Economics* 24: 126-146.

Cumming, S.G. and Armstrong, G.W. 2001. Divided land base and overlapping forest tenure in Alberta, Canada: a simulation study exploring costs of forest policy. *The Forestry Chronicle* 77: 501-508.

Cumming, S.G. and Armstrong, G.W. 2004. Divided land base, overlapping forest tenure and fire risk. *The Forestry Chronicle* 80: 478-484.

Dasgupta, P. 2000. Economic Progress and the Idea of Social Capital. In *Social Capital. A Multifaceted Perspective*, edited by P. Dasgupta and I. Serageldin. Washington: The World Bank.

Datta, S.K., O'Hara, D.J. and Nugent, J.B. 1986. Choice of Agricultural Tenancy in the Presence of Transaction Costs. *Land Economics* 62: 145-158.

Demsetz, H. 1967. Toward a Theory of Property Rights. *American Economic Review* 57: 347-359.

Drobak, J.N. and Nye, J.V.C. 1997. *The Frontiers of the New Institutional Economics*. San Diego, CA: Harcourt Brace Jovanovich.

Eggertsson, T. 1990. *Economic Behavior and Institutions*, Cambridge, UK: Cambridge University Press.

Fama, E.F. 1980. Agency Problems and the Theory of the Firm. *Journal of Political Economy* 88: 288-307.

Fama, E.F. and Jensen, M.C. 1983. Separation of Ownership and Control. *Journal of Law and Economics* 26: 301-326.

Fischer, S. 1977. Long-term contracting, sticky prices, and monetary policy: comment. *Journal of Monetary Economics* 3: 317-324.

Forest Analysis and Inventory Branch. 2007. Monitoring harvest activity across 16 mountain pine beetle impacted timber supply areas. Ministry of Forests and Range, Victoria, BC. Available from http://www.for.gov.bc.ca/hts/MPB_Harvest_2007.pdf [accessed 7 July 2012].

Fukuyama, F. 1999. *The Great Disruption. Human Nature and the Reconstitution of Social Order*. New York.: The Free Press.

Fukuyama, F. 2002. Social Capital and Development: The Coming Agenda, *SAIS Review* XXII(1): 23-37.

Furubotn, E. and Pejovich, S. 1972. Property Rights and Economic Theory: A Survey of Recent Literature. *Journal of Economic Literature* 10: 1137-1162.

Furubotn, E. and Pejovich, S. 1974. *The Economics of Property Rights*. Cambridge, MA: Ballinger.

Furubotn, E. and Richter, R. 1991. *The New Institutional Economics: An Assessment*. College Station, TX: Texas A&M University Press.

Furubotn, E. and Richter, R. 1997. *Institutions and Economic Theory: The Contribution of the New Institutional Economics*. Ann Arbor, MI: University of Michigan Press.

Gallick, E.C. 1984. *Exclusive Dealing and Vertical Integration: The Efficiency of Contracts in the Tuna Industry*. Washington, DC: Bureau of Economics, Federal Trade Commission.

Gelauff, G.M.M. 2003. Sociaal Kapitaal in De Economie. Economisch Statistische Berichten 88(4398): 3-5.

Globerman, S. and Schwindt, R. 1986. The Organization of Vertically Related Transactions in the Canadian Forest Products Industries. *Journal of Economic Behavior and Organization* 7: 199-212.

Goldberg, V.P. and Erickson, J.R. 1987. Quantity and Price Adjustment in Long-Term Contracts: A Case Study of Petroleum Coke. *Journal of Law and Economics* 30: 369-398.

Gray, J.A. 2002. *Forest Concession Policies and Revenue Systems: Country Experience and Policy Changes for Sustainable Tropical Forestry*. Washington, DC: The World Bank.

Groenewegen, J. 1996. Transaction Cost Economics and Beyond. In *Transaction Cost Economics and Beyond* (pp.1-9) edited by J. Groenewegen. Dordrecht, NL: Kluwer Academic Publishers.

Grossman, S.J. and Hart, O.D. 1986. The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy* 94: 691-719.

Haley, D. 1985. The Forest Tenure System as a Constraint on Efficient Timber Management: Problems and Solutions. *Canadian Public Policy* 11: 315-320.

Hallwood, P.C. 1991. On Choosing Organizational Arrangements: The Example of Offshore Oil Gathering. *Scottish Journal of Political Economy* 38: 227-241.

Hart, O.D. 1995. *Firms, Contracts, and Financial Structure*. Oxford, UK: Oxford Clarendon Press.

Hart, O.D. and Moore, J. 1990. Property Rights and the Nature of the Firm. *Journal of Political Economy* 98: 1119-1158.

Hayek, F.A. 1937. Economics and knowledge. *Economica* 4: 33-54.

Hayek, F.A. 1945. The use of knowledge in society. *American Economic Review* 35: 519-530.

Hennart, J.-F. 1988. Upstream Vertical Integration in the Aluminum and Tin Industries. *Journal of Economic Behavior and Organization* 9: 281-299.

Holmström, B. 1979. Moral Hazard and Observability. *Bell Journal of Economics* 10: 74-91.

Holmström, B. and Milgrom, P. 1994. The Firm as an Incentive System. *American Economic Review* 84: 972-991.

Hubbard, R. G. and Weiner, R.J. 1991. Efficient Contracting and Market Power: Evidence from the U.S. Natural Gas Industry. *Journal of Law and Economics* 34: 25-67.

Hyde, W.F. 2012. *The Global Economics of Forestry*. Washington, DC: RFF Press.

Jensen, M.C. and Meckling, W. 1976. Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure. *Journal of Financial Economics* 3: 305-360.

Joskow, P.L. 1985. Vertical Integration and Long-Term Contracts: The Case of Coal-Burning Electric Generating Plants. *Journal of Law, Economics, and Organization* 1: 33-80.

Joskow, P.L. 1987. Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets. *American Economic Review* 77: 168-185.

Joskow, P.L. 1988. Price Adjustment in Long-Term Contracts: The Case of Coal. *Journal of Law and Economics* 31: 47-83.

Joskow, P.L. 1990. The Performance of Long-Term Contracts: Further Evidence from the Coal Markets. *Rand Journal of Economics* 21: 251-274.

Kant, S. 2009. Sale of Canada's public forests: Economically non-viable option. *The Forestry Chronicle* 85: 841-848.

Karsenty, A., Drigo, I.G., Piketty, M. and Singer, B. 2008. Regulating industrial forest concessions in Central Africa and South America. *Forest Ecology and Management* 256: 1498-1508.

Kiker, C.F. and Putz, F.E. 1997. Ecological certification of forest products: Economic challenges. *Ecological Economics* 20: 37-51.

Klein, B. 1988. Vertical Integration as Organized Ownership: The Fisher Body-General Motors Relationship Revisited. *Journal of Law, Economics, and Organization* 4: 199-213.

Klein, P.G. 2000. New Institutional Economics. In *Encyclopedia of Law and Economics. Volume I* (pp. 456-489) edited by B. Bouckaert and G. De Geest. Northampton, MA: Edward Elgar.

Klein, P.G. and Shelanski, H.A. 1996. Transaction Cost Economics in Practice: Applications and Evidence. *Journal of Market-Focused Management* 1: 277-296.

Krepps, M.B. and Caves, R.E. 1994. Bureaucrats and Indians: Principal-agent relations and efficient management of tribal forest resources. *Journal of Economic Behavior & Organization* 24: 133-151.

Kufuor, K.O. 2004. New Institutional Economics and the Failure of Sustainable Forestry in Ghana. *Natural Resources Journal* 44: 743-760.

Laffont, J. and Martimort, D. 2002. *The Theory of Incentives: The Principal-Agent Model*. Princeton, NJ: Princeton University Press.

Langlois, R.N. and Robertson, P.L. 1989. Explaining Vertical Integration: Lessons from the American Automobile Industry, *Journal of Economic History* 49: 361-375.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A. and Vishny, R.W. 1999. The Quality of Government, *Journal of Law, Economics and Organization* 15(1): 222 -79.

Leffler, K.B. and Rucker, R.R. 1991. Transactions Costs and the Efficient Organization of Production: A Study of Timber-Harvesting Contracts. *Journal of Political Economy* 99: 1060-1087.

Levy, D. 1985. The Transaction Cost Approach to Vertical Integration: An Empirical Examination. *Review of Economics and Statistics* 67: 438-445.

Lieberman, M.B. 1991. Determinants of Vertical Integration: An Empirical Test. *Journal of Industrial Economics* 39: 451-466.

Luckert, M.K. 2005. In Search of Optimal Institutions for Sustainable Forest Management: Lessons from Developed and Developing Countries. In *Institutions, Sustainability and Natural Resources* (pp. 21-42) edited by S. Kant and R.A. Berry. Dordrecht, NL: Springer.

Luckert, M.K. 2007. Property rights, forest rents, and trade: The case of US countervailing duties on Canadian softwood lumber. *Forest Policy & Economics* 9: 581-590.

MacDonald, J.M. 1985. Market Exchange or Vertical Integration: An Empirical Analysis. *Review of Economics and Statistics* 67: 327-331.

Masten, S.E. 1984. The Organization of Production: Evidence from the Aerospace Industry. *Journal of Law and Economics* 27: 403-417.

Masten, S.E. 1996. *Case Studies in Contracting and Organization*. New York: Oxford University Press.

Masten, S.E., Meehan, J.W., Jr and Snyder, E.A. 1991. The Costs of Organization. *Journal of Law, Economics, and Organization* 7: 1-25.

Meissner, D. 2002. A family-owned logging company that a judge found was treated in an abusive manner by the former BC government has reached a settlement in the long-running dispute. Canadian Press NewsWire.

Menard, C. 1996. On clusters, hybrids, and other strange forms: The case of the French poultry industry. *Journal of Institutional and Theoretical Economics* 52: 154-183.

Miller, G.J. 2005. Solutions to Principal-Agent Problems in Firms. In *Handbook of New Institutional Economics* (pp. 349-370) edited by C. Ménard and M.M. Shirley. Dordrecht, NL: Springer.

Ministry of Forests, Lands and Natural Resource Operations. 2011. A New Silviculture Framework for British Columbia: Options and Recommendations Report. Victoria, BC: Resources Practices Branch.

Ministry of Forests, Lands and Natural Resource Operations. 2012. Current Allowable Annual Cut (AAC) for Tree Farm Licences (TFL) . Available from http://www.for.gov.bc.ca/hts/tfls.htm [accessed 7 July 2012].

Mulherin, J.H. 1986. Complexity in Long-Term Contracts: An Analysis of Natural Gas Contractual Provisions. *Journal of Law, Economics, and Organization* 2: 105-117.

Nelson, H. 2007. Does a Crisis Matter? Forest Policy Responses to the Mountain Pine Beetle Epidemic in British Columbia. *Canadian Journal of Agricultural Economics* 55: 459-470.

Nelson, H., Cohen, D. and Nikolakis, W. 2009. Are forest sector firms maximizing the economic returns from their timber? Evidence from British Columbia. *The Forestry Chronicle* 85: 361-371.

Niquidet, K. 2008. Revitalized? An event study of forest policy reform in British Columbia. *Journal of Forest Economics* 14: 227-241.

North, D.C. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge, UK: Cambridge University Press.

North, D.C. 1991. Institutions. *Journal of Economic Perspectives* 5: 97-112.

Oliveira, L. and Kostiuk, A. 2008. Follow-up on the Implementation of the 'Guidelines for heating up MPB Logs in Conventional Lumber Dry Kilns'. Ministry of Forests and Range, Victoria, BC.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press.

Ostrom, E. 1998. Scales, polycentricity, and incentives: designing complexity to govern complexity. In *Protection of Biodiversity: Converging Strategies* (pp. 149-168) edited by L.D. Guruswamy and J.A. McNeely. Durham, NC: Duke University Press.

Ostrom, E., 2000. Collective Action and the Evolution of Social Norms, *Journal of Economic Perspectives* 14(3): 137-158.

Ostrom, E. 2005. *Understanding Institutional Diversity*. Princeton, NJ: Princeton University Press.

Paarsch, H.J. and Shearer, B.S. 2009. The response to incentives and contractual efficiency: Evidence from a field experiment. *European Economic Review* 53: 481-494.

Palay, T.M. 1984. Comparative Institutional Economics: The Governance of Rail Freight Contracting. *Journal of Legal Studies* 13: 265-287.

Pearse, P.H. 1985. Obstacles to silviculture in Canada. *The Forestry Chronicle* 61: 91-96.

Pejovich, S. 1995. *Economic Analysis of Institutions and Systems*. Dordrecht, NL: Kluwer.

Poppo, L. and Zenger, T. 1997. Testing Alternative Theories of the Firm: Transaction Cost, Knowledge-Based, and Measurement Explanations for Make-or-Buy Decisions in Information Services. *Strategic Management Journal* 19: 853-877.

Posner, R.A. 1993. The New Institutional Economics Meets Law and Economics. *Journal of Institutional and Theoretical Economics* 149: 73-87.

Putnam, R.D. 2000. *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

Rametsteiner, E. 2002. The role of governments in forest certification—a normative analysis based on new institutional economics theories. *Forest Policy & Economics* 4: 163-173.

Rees, R. 1985. The theory of principal and agent: part I. *Bulletin of Economic Research* 37: 3-26.

Ross, S. 1973. The economic theory of agency: the principal's problem. *American Economic Review* 63: 134-139.

Rucker, R.R. and Leffler, K.B. 1988. To Harvest or Not to Harvest? An Analysis of Cutting Behavior on Federal Timber Sales Contracts. *Review of Economics & Statistics* 70: 207-213.

Salanie, B. 1997. *The Economics of Contracts: A Primer*. Cambridge, MA: MIT Press.

Sappington, D.E.M. 1991. Incentives in principal-agent relationships. *Journal of Economic Perspectives* 5: 45-66.

Shelanski, H.A. and Klein, P.G. 1995. Empirical Research in Transaction Cost Economics: A Review and Assessment. *Journal of Law, Economics, and Organization* 11: 335-361.

Simon, H.A. 1957. *Administrative Behavior*. New York: The Free Press.

Simon, H.A. 1962. New developments in the theory of the firm. *American Economic Review* 52(2): 1-15.

Simon, H.A. 1991. Organizations and Markets. *Journal of Economic Perspectives* 5: 25-44.

Slangen, L.H.G., Loucks, L.A. and Slangen, A.H.L. 2008. *Institutional Economics and Economic Organisation Theory: An Integrated Approach*. Wageningen, NL: Wageningen Academic Publishers.

Snetsinger, J. 2005. Guidance on landscape- and stand-level structural retention in large-scale mountain pine beetle salvage operations. Ministry of Forests and Range, Government of British Columbia, Victoria, BC. Available from http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/cf_retention_guidance_dec2005.pdf. [accessed 17 Oct 2011].

Special Committee on Timber Supply. 2012. Discussion Paper. Legislative Assembly of British Columbia, Victoria, BC. Available from http://www.leg.bc.ca/timbercommittee/docs/SC_Timber_Supply_Discussion_Paper.pdf [accessed July 5 2012].

Stanbury, W.T. and Vertinsky, I.B. 1998. Governing instruments for forest policy in British Columbia: a positive and normative analysis. In *The Wealth of Forests: Markets, Regulation and Sustainable Forestry* (pp. 42-77) edited by C. Tollefson. Vancouver: UBC Press.

Sterner, T. 2003. Policy instruments for environmental and natural resource management. Resources for the Future : World Bank ; Swedish International Development Cooperation Agency, Washington, DC : Stockholm, Sweden.

Stigler, G.J. 1961. The economics of information. *Journal of Political Economy* 69(3): 213-225.

Stiglitz, J.E. 1974. Incentives and risk sharing in sharecropping. *The Review of Economic Studies* 41: 219-255.

Stiglitz, J.E. 1975. Incentives, risk, and information: notes towards a theory of hierarchy. *Bell Journal of Economics* 6: 552-579.

Stuckey, J. 1983. *Vertical Integration and Joint Ventures in the Aluminum Industry*, Cambridge, MA, Harvard University Press.

van Ackere, A. 1993. The principal/agent paradigm: Its relevance to various functional fields. *European Journal of Operations Research* 70: 83-103.

van Kooten, G.C. 1993. *Land Resource Economics and Sustainable Development: Economic Policies and the Common Good*. Vancouver: UBC Press.

van Kooten, G.C. 2009. Biological Carbon Sinks: Transaction Costs and Governance. *The Forestry Chronicle* 85(3): 372-376.

van Kooten, G.C. and Bulte, E.H. 2000. *The Economics of Nature: Managing Biological Assets*. Oxford, UK: Blackwell.

van Kooten, G.C. and F.P. de Vries, 2012. Carbon Offsets. Chapter 165 in *Encyclopedia of Energy, Natural Resource and Environmental Economics* edited by J. Shogren. Oxford, UK: Elsevier.

van Kooten, G.C., Shaikh, S.L. and Suchánek, P. 2002. Mitigating Climate Change by Planting Trees: The Transaction Costs Trap. *Land Economics* 78(4): 559–572.

Vedel, S.E., Lund, D.H., Jacobsen, J.B. and Helles, F. 2006. Grants for advisory services in the private Danish forestry sector – A principal–agent approach. *Journal of Forest Economics* 12: 185-199.

Walker, G. and Weber, D. 1984. A Transaction Cost Approach to Make-or-Buy Decisions. *Administrative Science Quarterly* 29: 373-391.

Walker, G. and Weber, D. 1987. Supplier Competition, Uncertainty and Make-or-Buy Decisions. *Academy of Management Journal* 30: 589-596.

Wang, S., van Kooten, G.C. 2001. *Forestry and New Institutional Economics – An Application of Contract Theory to Forest Silvicultural Investment*. Aldershot, UK: Ashgate Publishing Company.

Williamson, O.E. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*, New York, NY, Free Press.

Williamson, O.E. 1979. Transaction-cost economics: the governance of contractual relations. *Journal of Economic Behavior and Organization* 1: 5-38.

Williamson, O.E. 1985. *The Economic Institutions of Capitalism*, New York, NY, Free Press.

Williamson, O.E. 1993. Transaction Cost Economics Meets Posnerian Law and Economics. *Journal of Institutional and Theoretical Economics* 149: 99-118.

Williamson, O.E. 1996. *The Mechanisms of Governance*, New York, NY, Oxford University Press.

Williamson, O.E. 1998. Transaction cost economics: how it works; where it headed. *De Economist* 146(April): 23-58.

Zhang, D. and Flick, W.A. 2001. Sticks, Carrots, and Reforestation Investment. *Land Economics* 77: 443-456.

Zhang, D. and Pearse, P.H. 1996. Differences in Silvicultural Investment under Various Types of Forest Tenure in British Columbia. *Forest Science* 42: 442-449.

Zhang, Y. 2001. Economics of transaction costs saving forestry. *Ecological Economics* 36: 197-204.