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Principal-Agent Governance Mechanism in an Emerging Biofuels Supply Chain in USA

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Abstract

This article analyzes the incentives and compensation problems faced by cellulosic ethanol producer and logging firms and the consequent impact on the organization of the wood based cellulosic ethanol industry in the US. The success of this relationship is central to setting up the biofuel industry in Michigan and in the US at large. The study utilizes the theoretical framework of institutional economics and uses case methodology to discuss potential problems arising from information asymmetry. Theoretical results indicate that the specification contract under the principal-agent framework is of limited utility due to' metering' problem when the principal contracts with multiple agents for the supply of feedstock. Alternative arrangements including joint ventures have the potential to provide close to first best solutions.

Keywords: Cellulosic ethanol, Contracts, Asymmetric information, Moral hazard, Adverse selection, Supply chain

Introduction

Biofuels are being extensively promoted for their potential to contribute to energy security, stable energy prices, and mitigation of climate change in the United States (Khanna, 2008). Within the category of biofuels, corn based ethanol production has long been supported in the United States. Over 7.5 billion gallons of ethanol was produced in 2008 from corn grown over 90 million acres of farm land (Donner & Kucharik, 2008). However there has been a recent policy shift mandating increase in production of cellulosic ethanol (CE) to 21 billion gallons a year by 2022 (EISA, 2007). Currently CE is not being produced at industrial scale.

This article analyzes the incentives and compensation problems faced by a wood based

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CE producer and logging firms (they supply feedstock) and the consequent impact on the organization of the wood based CE industry in the US. We propose to study this problem under the principal-agent framework. This would allow us to introduce asymmetric information and investigate its impact on the proposed vertical coordination strategy (Macho-Stadler and Perez-Castrillo, 2001).

The US biofuel policy is comprised of tax credits for biofuel blenders and production mandates (a renewable fuel standard) authorized in the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 (EISA, 2007). The new Renewable Fuel Standard requires the use of at least 36 billion gallons of biofuels per year by 2022. The law seeks to limit the impact of corn based ethanol (defined as conventional biofuels or first generation biofuels) in the RFS by limiting its production to 15 billion gallons a year after 2015 and encouraging the use of CE which is defined as advanced or second generation biofuel. The advanced biofuels on a life cycle analysis basis must encompass 50 per cent less green house gas emissions (GHG) than the gasoline or diesel fuel that it will replace. The second generation biofuels include fuel made from cellulosic materials, hemi cellulose, lignin, sugar, starch (excluding corn), and waste, as well as biomass-based biodiesel, biogas, and other fuels from cellulosic biomass (Velasco, 2008).

First generation biofuels processes are useful but limited. There is a threshold beyond which additional production cannot take place without jeopardizing food supplies (example: corn and sugarcane) and biodiversity (Kish, 2007). They are also not cost effective when compared with fossil fuels and the green house gas emission savings are small. This had lead to increased interest in second generation cellulosic biofuels due to their enhanced potential to contribute to energy security and reduce greenhouse gas emissions by 85% while mitigating the food vs. fuel competition for land as compared to corn ethanol (Khanna, 2009).

CE production has the advantage of abundant and diverse raw material compared to sources like corn and sugar cane. Major sources for CE include switch grass, miscanthus and wood (example: aspen, poplar and willow). Cellulose is present in almost every natural free-growing plant, tree, and bush all over the world without agricultural effort or cost needed to make it grow.

Objectives

The cellulosic content in wood-logs is the major source of CE. Once the tree has been cut the cellulosic content starts declining with time. It has been estimated that an uprooted tree looses 60% of the cellulosic content if it is left unprocessed for 10 days (Maser *et al.*, 1988). Therefore the ethanol producer would prefer that landing[2] operations are completed by the loggers as soon as the tree has been cut. The problem arises during winters when snow affects logging operations. Landing becomes difficult because the same task requires more resources to be spent by the logging firm (more men, fuel and better machines for transporting wood to the landing area). This will gives rise to conflict between the objectives of the principal (CE producer) and the agent (logging firm). Opportunistic behavior on the part of the agent can adversely affect the ethanol production and hence the principal's revenue. In short, moral hazard and adverse selection problems are anticipated in the contractual relationship between the CE producer and the logging firm.

The moral-hazard problem is usually formulated in terms of a contract between the principal and the agent(s). The principal and the agent can be people or institutions. With regard to agricultural sharecropping, landowner is the principal and tenant is the agent. In the moral-hazard problem, the agent works on a project for the principal. The amount of work the agent performs affects the probability distribution of the project's return. The problem is that the principal cannot monitor the agent's work, therefore agent's effort is private information, that is, it is observed by only the agent (Prescott, 1999). In some models, the agent's amount of effort is not observed. In other models, precisely how the task is performed is not observed. Adverse selection is present when agent has informational advantage concerning his own personal characteristics and will only be

[2] Landing is defined as transportation of logs of wood from the logging site to a storage site

revealed if it is in the interest of the agent to do so.

The wood based CE industry has to yet take off on a commercial scale. In that respect, we would consider our study to be futuristic. It is strongly anticipated that theoretical findings of the study would be particularly utility to firms operating at various stages in the supply chain and also to venture capitalists that have plans to invest in CE production facilities and emerging technologies in CE production. The theoretical results indicate that specification contract under the principal-agent framework is of limited utility due to' metering' problem when the principal contracts with multiple agents for the supply of feedstock.. Alternative arrangements including JVs have the potential to provide close to first best solutions.

The article is organized as follows. Section 2 presents the methodology and theoretical framework used in the research work while section 3 contains a brief literature review on supply chain contracting. The discussion section 4 is presented in the background of moral hazard and adverse selection problems. We also develop the conceptual framework which includes the base model and asymmetric information models. In section 5 we discuss various optimal contracting schemes under asymmetric information where some options are proposed and analyzed. We conclude our analysis in section 6.

Methodology

Theory of contracts and the new institutional economics provided relevant theoretical framework to conduct this case study. The case study is based on the state of Michigan in the US which is used to analyze governance issues arising from principal-agent relationship based on specification contracts. Michigan has 5th largest timberland in the US and it grows 2.5 times more wood fiber annually than it harvests (Pedersen, 2005). Michigan has enough resources to support 6 commercial facilities each producing 50 million gallons of ethanol per year. As result Michigan was able to attract investments from prospective CE producers.
One of the renewable fuels company is planning to build the first CE production facility in Michigan. The plant will be located in the Chippewa province, Upper Peninsula (Egan, 2009). The ethanol facility will use 375 thousand cords[3] of wood every year to manufacture 40 million gallons of biofuel. Wood will come mainly from areas within 150 miles radius from the plant's site. This largely rural area includes both state and federal forests, Interstate 75 and access to the Mackinac Bridge, which puts forests in the northern Lower Peninsula within reach. So too are the forests of northern Ontario, via Sault Ste. Marie's international crossing with Canada.

Michigan wood harvesting industry has about 800 logging firms. Most loggers are independent contractors and run their family businesses. Loggers are supposed to possess variety of skills which include logging, maintaining their equipments, forestry know-how, accounting, and be able to work with private forest owners. It is a hard job with many risks. While there are many combinations of equipments, a common set-up includes a feller-buncher and skidder. A feller-buncher is a large machine that has big cutter on the end of a mechanical arm. The cutter holds the trees at once and places it in small piles, where they are cut into logs by people with chainsaws. Skidder is used to pull whole trees to a collecting point called landings.

There are two primary actors in CE production- CE producer (principal) and the logging firm (agent). The CE producer processes the wood logs into ethanol by using an enzymatic process. The producer designs a contract for procuring wood from the logging firms in Upper Peninsula. The contract would typically carry quality and compensation details. The loggers generally don't own the timberland and the trees. They buy the trees from the forest land owners by paying the stumpage[4].

The price paid for a specific stand of timber will vary considerably due to such factors as size, species, and quality, logging conditions, distance to the mill, end product, demand and competition. Timber markets often change rapidly. The timberland owners generally obtain

[3] Volume of one cord of wood is 128 cubic feet
[4] Stumpage is the price of a standing timber before it is harvested

assistance from professional foresters and use the competitive bidding process as the ultimate determinant of fair market value for any specific tract of timber (Michigan DNRE, 2010). In the case of procuring wood for ethanol, logging conditions and distance to the processing facility would be the key factor for stumpage price determination.

The next task of the loggers is to ship the wood to a landing area. A landing area is a small clearing where loggers gather the logs. The landing area is owned and operated by the logging companies. At the landings area truckers hired by the CE producer pick up the logs and transport it to the CE mill. Operators can load an entire truck with about 15 to 20 cords in less than an hour.

Literature Review

Several supply chain coordination and collaboration mechanisms such as virtual integration, VMI, contracts and inter-firm collaboration have been researched in considerable detail. These mechanisms are designed with the common purpose of alleviating the problems caused due to information asymmetry and its impact on negotiated relationship. The prominent assumption in all such studies is that one of the transacting parties has more information either about themselves (adverse selection) or about the course of action that they would take in response to a particular situation (moral hazard). The more informed party can use this informational advantage to minimize its disutility function. While doing so the utility function of the less informed agent is adversely affected. This study focuses on similar information asymmetry problem in the forest based biofuels industry.

Contracts as governance mechanism have been studied in appreciable detail in the supply chain and economics literature. Gopal & Koka (2010) have studied the role of contracts on quality and returns to quality in offshore software development outsourcing. Various incentive structures inherent in the time and materials and fixed priced contract are found to influence the quality provided by offshore vendors. The analytical results hold that fixed price (FP) contracts ensure greater vendor quality. The incentive compatibility constraint is designed under the FP contracts in such a manner that incentivizes the vendor to recruit most skilled workers for fulfilling the contract. From cost side also, the FP contract has higher expectancy of inducing the vendor to strive for efficiency because compensation has been fixed by the principal.

Risk associated with demand forecasting (glut vs. stock outs) leads to trade-off between flexible quantity (FQ) and low-price (LP) contracts. Chung et.al. (2010) have studied FQ and LP contracts in the case of a decentralized supply chain in which there are two suppliers and a single buyer. Under the FQ contract, the buyer does not assume full responsibility for the forecast, yet the supplier guarantees the availability of the forecasted quantity with additional buffer inventory. On the other hand LP contracts places full inventory burden on the buyer, but with a cheaper price. Theoretical results show that buyers would benefit significantly from having multiple sources of supply.

One of the major contributions of this work is the application of principal-agent contracting framework to an emerging supply chain. Sebastiao and Golicic (2008) study supply chain strategy for nascent firms in emerging markets. They claim that the strategic role of supply chain management has typically been examined in mature market driven firms. However there has been relatively little research on supply chain development in terms of vertical coordination in an early stage technology driven firms. The present study is a step towards filling this research gap.

Discussion

Moral hazard

Delay in landing operation is very common during winter season due to heavy snowfall conditions in Michigan. Both harvesting and transportation to the landing site becomes difficult and costly. Additional equipments such as snow removers are required to clear the road for transportation (very few logging firms have their own snow removal vehicles). Logging firms must also hire more number of loggers to perform the same task. Usually fuel and labor costs are higher during winters. In short, logging firms are expected to invest higher levels of effort during winter operations. Higher effort implies higher disutility for the logger. However the effort of the agent is not entirely verifiable. A number of factors contribute to non-verifiability of the effort of the logging firm such as spatial nature of operations, catering to multiple buyers, complex logging and landing procedures and prohibitive monitoring cost.

Since the agent's effort cannot be observed therefore it cannot be included in the contract. Output is an observed variable when CE producer contracts with only one logging firm for all its feedstock needs. However in case of multiple agents, the principal can only observe the group output due to the lumpy nature of the production process. In absence of the information related to marginal output, the CE producer will find it practically very difficult to incentivize agents to provide high effort. This will adversely affect CE production and revenue for the principal.

Presence of moral hazard problem would not allow the principal to distinguish between those agents who exert high effort from low effort agents. As a result high effort agents will self-select themselves to those buyers whose production process allows them to make such distinction.

Adverse selection

Michigan logging industry is highly fragmented, diverse and has many small and medium sized logging firms. Therefore CE producer is expected to contract with multiple loggers. Logging firms differ from each other in terms of expertise (unobserved), number of co-workers (varies from season to season), access to machines, and degree of mechanization. Based on these criterions we can broadly categorize agents into two types: high type and low type agents.

Lack of homogeneity in the logging industry can give rise to adverse selection problem due to inability of the CE producer to observe the agent type. On heavy snowfall days, agents are supposed to exert high effort in order to avoid decay of cellulosic content. This implies greater disutility for the agent.

Agents are aware of the fact that it is not possible for the principal to make an approximation of their effort by visualizing the logs of wood supplied by them because principal observes only total output. Hence they have incentives to delay the landing operations and instead supply the fresher logs to nearby factories for example-paper and pulp industry, furniture firms etc. because in these industries, the agent's effort can be ascertained by visualizing and touching the wood (Green and Ross, 1997).

In the background of this information, the low-type ability loggers (defined as those with lower logging skills and lesser equipments and employees) would self-select themselves in the CE industry. On the other hand high type agents will not be interested in working with CE producers because they can maximize their objective function by working in those markets which can verify their high effort and type based on output produced. We would formally show that how this would adversely affect the principal's utility function.

Conceptual framework

This section presents the analysis of various contractual schemes between the CE producer and the logging firm(s) in the principal-agent framework. We begin by explaining the source of tension between the principal and agent followed by a discussion of the model under symmetric information. Thereafter we examine the case of asymmetric information, the incentive mechanism under the first best solution, and the optimal contract design in the presence of moral hazard and adverse selection problems.

CE producer is the principal who contracts with the agent to supply wood. The prime objective of the principal and the agent is to maximize their respective utility functions. Their utility function can be expressed as follows:

(1) Principal's utility function: $B[R(c(t)) - w]$

(2) Agent's utility function: $U(w, e) = u(w) - v(e)$

R(c (t)): denotes the revenue from the sale of ethanol is function of the cellulosic content in the wood which in turn is dependent on time

taken t taken in landing operations after the tree has been cut.
w: compensation received by the agent.
e: agent's effort exerted during logging and landing.
v (.): disutility from a particular level of effort.

For sake of simplicity, we assume a single-shot game and just two effort levels: high effort and low effort. Hence e ε (e^H , e^L) and that disutility from higher effort is more than disutility from lower effort level, i.e. $v(e^H) > v(e^L)$

The agent is interested to have higher w which is cost to the principal, whereas the principal is interested in higher levels of e, because high e implies higher cellulose content and hence higher R, but high e translates into higher disutility for the agent. This explains the source of conflict in the relationship.

Outcome does not only depend entirely on logger's effort but also on random factors which are beyond the control of the logger. A partial list of such factors includes forestry practices of the landowner, specie harvested, weather, technological constraints, ethanol demand etc. Hence, we can attach probability values to each type of effort that can result into various levels of revenue for the principal. This is formally expressed as:

$$\Pr[R=R_i \mid e] = p_i(e) \text{ for } i\ \varepsilon\ (1, 2, 3, \ldots, n)$$

Base model

The base model is the perfect or symmetric information model. The principal and the agent share the same level of information with respect to variables and functions determining the relationship (such as production function, or the distribution of random variables such as principal's revenue) and with respect to identities (both know the utility function of the other) and behavior relevant to the relationship. Therefore principal can observe agent's effort without any monitoring cost. Whatever informational asymmetries exist, they are common for both the players.

The bargaining relationship between the ethanol producer and the logging firm under symmetric information is presented graphically in the figure 1

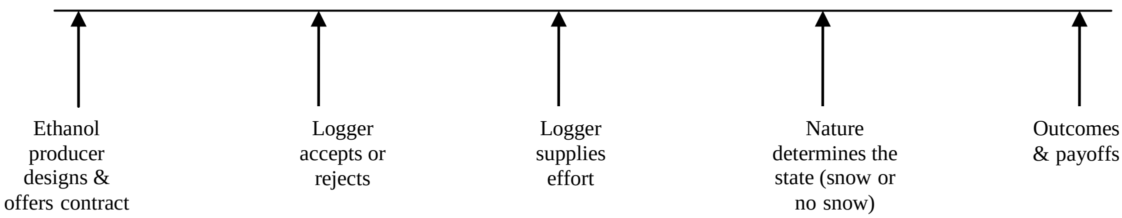

Figure 1: Order of moves under symmetric information

When the logging and landing effort is verifiable and the output is observable, the ethanol producer's decision process can be modeled as the following maximization problem:

$$\text{Max} \quad P_H^H B[R_H - w(R_H)] + P_L^H B[R_L - w(R_L)]$$

$$\left[e\,,\, \{w(R_i)\}_{i=1,2,\ldots,n}\right]$$

s.t.

PC: $P_H^H u(w_H) + P_L^H u(w_L) - v(e_H) \geq \overline{U}$

$\overline{U}$ is the logger's reservation utility and equals the utility from the compensation he receives in the other wood based industry like paper and pulp producing firms or the furniture industry. The optimal contract under the symmetric information would be fixed payments (FP) depending on the effort level observed by the ethanol producer. We derive the following solution after having set up the Lagrangian function of the above maximization problems and then finding the first order conditions with respect to effort e and compensation w:

$$w^H = u^{-1}\left[\bar{U} + v(e_H)\right]$$

The producer would offer w^H for high effort and $w^L = 0$ for low effort in order to incentivize the agent to provide higher effort.

Model under asymmetric information (contracting with only one agent)

Informational asymmetries can arise due to agent's behavior during the relationship. We have already discussed such a scenario in section 3 where the ethanol producer cannot observe the effort of the logging firm to ensure timely logging and landing operations. As a result the principal cannot distinguish between suboptimal outputs caused due to factors beyond the control of the agent or due to agent's opportunistic behavior i.e. lower effort is exerted on a snowy day in order to bring down operations cost. Relationship between the logging firm and the ethanol producer under asymmetric information is graphically presented in figure 2.

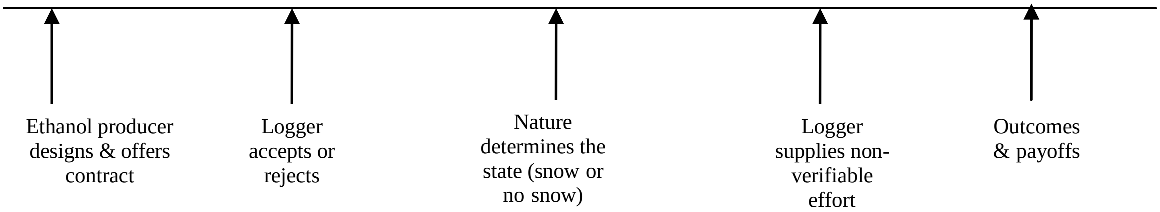

Figure 2: The order of moves under asymmetric information (contracting with one agent)

The extent to which the agent deviates from the principal's desired level of effort can be captured by the variable L, which is defined as the portion of cellulose lost due to delay in landings. If agent puts high effort then L=0 with probability $P(R_H \mid e_H)$, and if agent exerts low effort, then 0<L<1.

Under the present scenario if the principal gives fixed wage $\bar{w}$, to the agent, the payoff functions for the agent:

$$EU^H = u(\bar{w}) - v(e^H)$$
$$EU^L = u(\bar{w}) - v(e^L)$$

Since $v(e^H) > v(e^L)$, the agent will choose the lower level of effort. In that case, the utility of the principal is $B\left[R(c)*(1-L) - \bar{w}\right]$. Hence, we have the moral hazard problem if we impose the first best solution to the asymmetric case of non-verifiable agent's effort.

Model under asymmetric information (contracting with multiple agents)

While contracting with multiple loggers, there are three sources of information asymmetry (i) the non-verifiable agents' effort and (ii) the type of agent and (iii) the marginal output. Therefore in addition to the moral hazard problem, principal faces adverse selection problem and lack of information on marginal output when he deals with multiple agents.

Vast quantities of wood are logged by foresters to provide fibers for pulp, paper products, and boards industry, and saw timber for house building and furniture. The buyers of wood in fiber and timber industry are concerned with the tensile strength of the wood that is, lignin content. Lignin is a glue-like polymer found in the cell wall of plants that surrounds cellulose to provide strength to fibers and to resist microbial decay. The hardness of the wood can be appreciably ascertained through visual inspection. The monitoring cost in such industries is hence not very high. As a result, the low type firms would find it difficult to have contractual arrangements with the fiber and timber processors.

The CE producer is concerned with the cellulosic content in the wood. Unlike the case of lignin, the presence of higher cellulosic content cannot be based on tensile strength of wood. Inspection of cellulosic content instead requires chemical treatment of the wood (Rui *et al.*, 2010). Chemical pretreatment raises the cost for using the wood as the source of cellulose. It is not possible to examine the cellulose content outside the laboratory. Therefore the agent's output is not observed. Moreover compensation to the logger must be equal or greater than the existing levels. Hence, the low type agent has the incentive to self select himself in the contractual relationship with the CE producer whereas the high type agent will self-select himself in those industries which can verify its higher effort and ability.

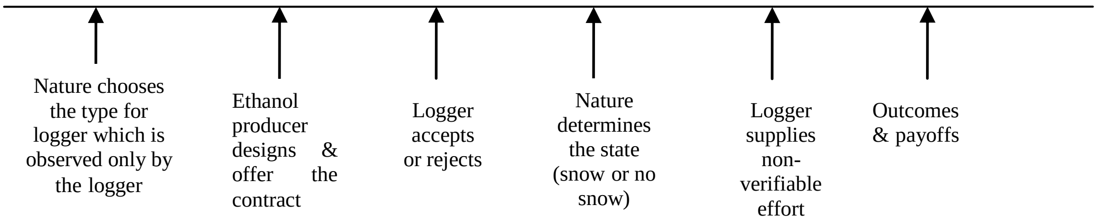

Figure 3: Order of moves under asymmetric information (contracting with multiple agents)

The application of first best or Pareto efficient solution in this case will lead to twin problems of moral hazard and adverse selection. The payoff functions of the ethanol producer and the logger under the status quo are summarized in Figure 4 EU and EB denote the expected utilities of the logging firm and the producer respectively with subscripts denoting the type of the agent (High, Low) and the superscripts denoting the effort level (High, Low).

From the figure 4, it is evident that the ethanol producer will prefer to contract with high type agent because if both types exerts high effort then $EB_H^H > EB_L^H$. This holds true because $v(e_H^H) < v(e_L^H)$, i.e. the disutility of exerting high effort to high type is less than to the low type. Moreover the low type has incentive to self-select into ethanol market under status quo because $EU_L^L > \overline{U} = u(\overline{w}) - v(e^L)$. This illustrates the presence of moral hazard (high type chooses low effort) and adverse selection (low type self-selects) under the first best case.

		Agent's effort level: High	Low
Agent's type	High	$EU_H^H = \sum_{i=1}^n P_i^H(e)\, u(\overline{w}) - v(e_H^H)$ $EB_H^H = \sum_{i=1}^n P_i^H(e)\, B(R - \overline{w})$	$EU_H^L = \sum_{i=1}^n P_i^L(e)\, u(\overline{w}) - v(e_H^L)$ $EB_H^L = \sum_{i=1}^n P_i^L(e)\, B[(R\,(1 - L\,) - \overline{w})]$
	Low	$EU_L^H = \sum_{i=1}^n P_i^H(e)\, u(\overline{w}) - v(e_L^H)$ $EB_L^H = \sum_{i=1}^n P_i^H(e)\, B(R - \overline{w})$	$EU_L^L = \sum_{i=1}^n P_i^L(e)\, u(\overline{w}) - v(e_L^L)$ $EB_L^L = \sum_{i=1}^n P_i^L(e)\, B[(R\,(1 - L\,) - \overline{w})]$

Figure 4: Payoff functions of ethanol producer and the logging firm under status-quo

Optimal contract under assymetric information

Contracting with one agent

The agent's effort is not verifiable but the output is observable. Hence wage (w) is not fixed, but is a function of output R. The principal would solve following maximization problem:

$$\text{Max } \sum_{i=1}^{n} P_i^H \, B(R_i) - w(R_i)$$
$$\left[e, \{w(R_i)\}_{i=1,2,\ldots,n}\right]$$
$$\text{s.t. PC: } \sum_{i=1}^{n} P_i^H \, u[w(R_i)] - v(e^H) \geq \overline{U}$$
$$\text{IC: } \sum_{i=1}^{n} P_i^H \, u[w(R_i)] - v(e^H) \geq \sum_{i=1}^{n} P_i^L \, u[w(R_i)] - v(e^L)$$

PC is the participation constraint, through which the principal ensures that the agent accepts the contract by paying him at least the reservation wage. IC is the incentive compatibility constraint through which the principal incentivizes the agent to choose the high effort over low effort. Here we have assumed that monitoring cost to be zero.

In the repeated game, the principal can induce the agent not to defect from the high effort strategy by paying efficiency wages w* (Moretti and Perloff, 2002). Efficiency wages are the wages above the market-clearing wage which is paid in order to provide incentives to the agent to provide higher level of efforts. The efficiency wage would increase the cost of defection for the agent and hence he would comply with the decision of the principal.

Contracting with multiple agents

Total output is observed but not the marginal output. Although it is not team production but the complexity of the production process gives rise to metering problem (Alchian and Demsetz, 1972). In the principal agent setup, the final output produced by individual agent is essential to determine the compensation of the individual agent. Since, effort cannot be linked to output, the optimal contract design is not possible. Prohibitive monitoring cost renders the payment of efficiency wages ineffective and adds to the principal cost. The probability of getting caught is very low hence the agents find it profitable to defect from the cooperation strategy.

The argument presented here is that moving away from specification contract towards vertical integration, for instance, joint venture, helps in solving the problem efficiently by correcting the incentives mechanism. If few of the big logging firms were to form a cooperative to supply wood and also have equity in the ethanol refinery, it is easier to ensure that the interest of both the parties is well aligned.

McAfee and McMillan (1991) work on optimal contracts for teams suggest that a team subject to both adverse selection and moral hazard, optimal contracts are linear in output under certain conditions. They conclude that the outcome is same whether the principal observes just the total output or each individual's contribution. Thus monitoring is not needed to prevent shirking by team members; instead the role of monitoring is to discipline the monitor.

Holmstrom (1982) showed that in team production under moral hazard, the principal can ensure a full information outcome by offering a contract that punishes each team member arbitrarily severely whenever team output falls below some target. However, this seems an impractical method of solving moral hazard. Moreover, for our purpose the principal cannot disentangle an agent's effort from his ability.

In the special case where agents' type is common knowledge, the moral hazard problem can be completely solved. The principal is needed to adjust the incentive constraint such that any increase in the marginal product is distributed among all the agents. This will give each agent enough incentive to exert desired effort. However principal's variable costs will increase. This can be easily counteracted in the linear form of the contract. The fixed part of the payments is negative in order to account for increase in the principal's cost.

The changed relationship would greatly reduce the monitoring costs and each member would get the share in the group compensation and not individual compensation and they would pay a fixed amount to the ethanol producer which will indicate t. The problem is hence again reduced to when principal contracts with one agent- the loggers' Cooperative.

Further work & recommendations

There is a vast literature on optimal contracting when more than one agent is hired by the principal to perform task(s). The implicit assumption is: marginal productivity of the agent is observed by the principal. The investigation of scenarios in which metering of individual output is not possible, would be an important addition to the literature and would also find relevant application in fields where group production is an important element in the relationship. Apart from conducting case studies in a theoretical framework for analyzing possible outcomes of such a relationship, empirical econometric based studies would significantly enhance our understanding.

References

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

Chung, W., Talluri, S. and R. Narasimhan (2010). Flexibility or Cost Saving? Sourcing Decisions with Two Suppliers. Decision Sciences, 41(3): 623-650

Donner, S. and Christopher, J. K. (2008). Corn-based ethanol production compromises goal of reducing nitrogen export by the Mississippi River. Proceedings of the National Academy of Sciences, 105(11)

Egan, P. K. (2009). Uncertainty clouds plans to extract biofuel from Michigan's Forests. The Michigan Messenger, December.

EISA (2007). Energy Independence and Security Act of 2007. http://www.afdc.energy.gov/laws/eisa, accessed on 24 April, 2010

Gopal, A. and Koka, B. R. (2010). The Role of Contracts on Quality and Returns to Quality in Offshore Software Development Outsourcing. Decision Sciences, 41(3): 491-516.

Green, D.W. and R. J. Ross (1997). Linking Log and Product Quality for Structural Wood Products. Madison, WI: USDA Forest Service, Forest Products Laboratory

Holmstrom, B. (1982). Moral Hazard in Teams. The Bell Journal of Economics, 13(2): 324-340.

Khanna, M. (2008). Cellulosic Biofuels: Are They Economically Viable and Environmentally Sustainable? Choices, 23(3): 16-21.

Khanna, M. (2009). Meeting the Demand for Biofuels: Implications for Land Use and Green House Gas Emissions. Paper presented at MSU Agriculture, Food, and Resource Economics, Department Seminar.

Kish, S. (2007). Tress: A Poplar Sources for Biofuels. Washington DC: U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service, October.

Macho-Stadler I. and D. Perez-Castrillo (2001). An Introduction to the Economics of Information, 2nd ed. Oxford University Press.

Maser, C., Robert F. Tarrant., M. Trappe and Jerry F. Franklin (1988). From the Forest to the Sea: A story of fallen trees. Gen Tech. Rep.

McAfee, R. Preston and John McMillan (1991). Optimal Contracts for teams. International Economic Review, 32(3): 561-577.

Michigan DNRE (Department of Natural Resources and Environment). The Stumpage Price Reports. http://www.michigan.gov/dnr/0,1607,7-153-10368_22594-81536--,00.html, accessed on 24 April , 2010

Moretti, E. and J. M. Perloff (2002). Efficiency Wages, Deferred Payments, and Direct Incentives in Agriculture. American Journal of Agricultural Economics, 84: 1144-1155.

Pedersen, L. (2005). Michigan State Forest Timber Harvest Trends: A Review of Recent Harvest Levels and Factors influencing future levels. Michigan Department of Natural Resources.

Prescott, E. (1999). A Primer on Moral-Hazard Models. Reserve Bank of Richmond Economic Quarterly, 85(1): 47-77.

Sebastiao, H. J. and S. Golicic (2008). Supply Chain Strategy for Nascent Firms in emerging Technology Markets. Journal of Business Logistics, 29(1): 75-91.

Shi, Rui., Ying-Hsuan Sun., Quanzi Li., Steffen Heber., Ronald Sederoff and Vincent L. Chiang (2010). Towards a Systems Approach for Lignin Biosynthesis in Populus trichocarpa: Transcript Abundance and Specificity of the Monolignol Biosynthetic Genes. Plant and Cell Physiology, 51(1): 144-163.

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

Velasco, J. (2008). Welfare Economics and Policy Analysis of U.S. Biofuels Policy. Review of Agricultural Economics, 30: 422-424.

Williamson, O. E. (1991). Strategizing, Economizing, and Economic Organization. Strategic Journal Management, 23: 75-94.