A Transaction Cost Economics View of Agriculture Product Exchanges for Biopower:

Theoretical and Methodological Concerns

Ira Altman
Community Policy Analysis Center
Department of Agricultural Economics
University of Missouri – Columbia
216 Middlebush Hall
Columbia, MO 65211
Phone: (573) 882-7863
Fax: (573) 882-2504
Email: ija3z8@mizzou.edu

Tom Johnson
Community Policy Analysis Center
Department of Agricultural Economics
University of Missouri – Columbia
215A Middlebush Hall
Columbia, MO 65211
Phone: (573) 882-7863
Email: JohnsonTG@missouri.edu

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Introduction

This paper reviews theoretical and empirical advances in transaction cost economics with the intention of applying the theory to biopower input organization in future research. The theoretical value of transaction cost economics is contained in the discriminating alignment hypothesis that states that transactions are aligned with governance structures in a discriminating transaction cost minimizing way. This hypothesis has been extensively tested in the empirical literature. This paper includes a review of the transaction cost theory, empirical research on natural resource industries, and application to biopower fuel exchanges from agriculture.

There is much work being completed on the technical feasibility of producing electricity from renewable sources such as biomass residues from row crops, dedicated energy crops, agricultural livestock waste, food processing waste and fast growing trees in Missouri. Indeed, the development of a generation technology is key to establishing an electricity industry based partially on biomass. At least two power plants in Missouri are considering the adoption of a co-firing technology, one near Chamois and the other near Springfield, Missouri.

Recent advances in technology have shown production costs to range from 6.3-11.0cents/kWh for biomass. This compares to 5.2-5.5 and 3.9-4.9 for coal and natural gas technologies (Badger, 2003). These production costs ignore organizational costs that may be significant to biomass supply. Biomass technologies will have to compete against traditional sources of power on both production and non-production costs. This paper represents a start toward investigating the non-production costs of supply.

Regardless of the technology, the organization of an industry based on agricultural biomass should be considered. Changing from traditional technologies and fuels such as natural gas and coal to biomass fuel will require power generators and biomass producers or organize new exchanges. How should these exchanges be organized? At this stage in the research the main concern is on developing a theoretical perspective and understanding previous empirical studies to answer this question.

The Theory

There are various interpretations of transaction cost economics that can be traced to the writings of Coase (1937, 1960). The measurement branch associated with Alchain and Demsetz (1972) and Jensen and Meckling (1976) is concerned with ex ante incentive alignment, agency costs and team based externalities or non-separability of production. The incomplete contracting branch associated with Grossman and Hart (1986) and Hart and Moore (1990) presents a theory of ownership. However neither of these branches are especially represented in the empirical literature. More prevalent in the empirical literature is the governance branch or Williamson's transaction cost economics associated with Williamson (1979, 1985 and 1996).

Williamson's Transaction Cost Economics

This discussion of transaction cost economics (TCE) is meant to provide a deep understanding of the theory which will be applied to an emerging biopower industry based on agricultural products in future research. The basic assumption of the TCE model which breaks from the neoclassical model is the limited rationality assumption. The individual in TCE is assumed to be boundedly rational. In Simon's words individuals are "intendedly rational but only limitedly so" (Simon, 1961, p. xxiv). The bounded rationality assumption gives rise to contract incompleteness. All contracts are unavoidably incomplete because individuals are boundedly rational and thus can not write flawless contracts. Incomplete contracts imply renegotiation may be necessary if circumstances change. Two other assumptions are also necessary to make contract incompleteness and bounded rationality significant, positive transaction costs and opportunism.

Renegotiations as well as initial relationship formation will be subject to positive transaction costs. Transaction costs include ex ante search and negotiation costs and ex post enforcement, monitoring and in the case of complex contracts, renegotiation costs. Milgrom and Roberts (1992) define two types of transaction costs, those with regard to coordination and motivation. Coordination costs include buyer and seller search and negotiation costs in the case of the market organization and communication or administrative costs in the case of firms. Motivation costs include costs to safeguard against individuals

that may use information asymmetry or incomplete information to take advantage of trading partners. The assumption of positive transaction costs is necessary since all disagreements that may arise from contract incompleteness could be costlessly negotiated away if transaction costs were assumed to be 0.

Contract incompleteness combined with positive transaction costs and opportunism provides the platform from which the TCE is launched. Opportunism is the idea that individuals will break their promises if they can gain. Williamson defines opportunism as an adjusted version of the neoclassical concept of self interest seeking to "self-interest seeking with guile" (Williamson, 1979, p. 234). Contract incompleteness provides the opening for individuals to take advantage of their trading partners. The assumption of opportunism is that they will take the opening. If individuals were completely honest contract incompleteness would be irrelevant because trading partners would not take the opening. Individuals could count on trading partners keeping their promises and not taking advantage of information imperfections.

Different transaction costs will be present in different transactions. Therefore, different organizational forms will be more apt for different transactions. Aligning transactions with organizational form becomes central to the TCE.

The Core of TCE

Beyond the basic assumptions and definitions of the model the crux of TCE is the discriminating alignment hypothesis: "Align Transactions, which differ in their attributes, with alternative governance structures, which differ in cost and competence, so as to realize a transaction cost economizing result." (Williamson 1996, p.371).

The attributes of the transaction are identified by Williamson (1979) as: asset specificity, frequency and uncertainty. Milgrom and Roberts (1992) add other attributes including: complexity, duration, difficulty of measuring performance and connectedness. In TCE special emphasis is placed on asset specificity. Asset specificity refers to durable assets that have significantly lower value in alternative uses by alternative users.

Several types of asset specificity are also identified. Physical asset specificity is when assets are tailored to meet the needs of a particular trading partner. The value of such assets is significantly higher inside the relationship than outside. Spatial asset specificity is a second type where trading partners are located is such a manner that dependence is created through their location to each other. A third type of asset specificity is dedicated assets that are invested in specifically to fulfill the needs of a trading partner rather than the general market. Other types of asset specificity include human and temporal asset specificity.

Specificity of assets involved in the transaction is assigned primary significance because asset specificity creates bilateral dependence between otherwise independent actors. This change in relationship is referred to as the fundamental transformation. A situation of ex ante independence may be transformed into ex post bilateral dependence where trading parties are open to the potential of opportunism. Independent parties are less open to opportunism since assets hold relatively high values in their alternative uses. TCE holds that in many situations the efficiency of organizational forms depends on asset specificity.

Efficiency in TCE is defined in terms of feasible alternative organizational forms. The remediableness criterion as developed by Williamson states that, "…an extant mode of organization for which no superior feasible alternative can be described and implemented with expected net gains is presumed to be efficient" (Williamson, 2000, p.601). Thus, the theory holds that transactions that vary in degrees of asset specificity should be aligned with organizational forms which can be considered efficient if no feasible alternative can be implemented with net gains. This is an attractive approach since it appears to be an extension of the familiar decision rule which compares the benefits and costs or alternative choices. In this application it is the benefits and costs of competing organizational forms that need comparison.

Comparative Organizational Analysis

Comparative organizational analysis is the extension and formalization of Williamson's TCE. Two key papers are central to this approach, Riordan and Williamson (1985) and Williamson (1991).

Chapter four of Williamson (1985) also provides important background. In an attempt at formalization, Riordan and Williamson (1985) translate the TCE using a neoclassical framework combining production costs and transaction costs. Williamson (1991) further elaborates on the TCE model by identifying the essential attributes or dimensions of governance structures.

The basic theory behind the comparative organizational analysis is to define costs as some function of asset specificity. As asset specificity increases the governance costs of all potential organizational forms increase. But does asset specificity influence organizational forms equally?

Comparing the polar forms of organization, market and internal organization, Riodan and Williamson argue, "… internal organization enjoys a progressive governance cost advantage over market organization as the condition of asset specificity deepens" (Riodan and Williamson, 1985, p.368). This is the case because internal organization is more conducive to coordination that an increase in asset specialization and hence bilateral dependency imply. However, in the presence of no asset specificity the market has the advantage because less coordination is necessary when actors are not bilaterally dependent.

This explanation reinforces the theory of TCE. In cases of low asset specificity the market organization has the advantage but as asset specificity increases internal organization becomes more efficient. To illustrate the model the difference between firm organizational costs and market organizational costs (ΔG =firm costs – market costs) is diagramed in Figure 1 as some function of asset specificity (k) holding output constant. For completeness the change in production costs under the firm versus the market (ΔC) are also modeled in Figure 1. Riodan and Williamson (1985) argue that the market will always have a production cost advantage over the firm for different levels of asset specificity because the market organization can realize economies of scale and scope from aggregation of demand. However, this advantage diminishes as asset specificity increases because bilateral dependence and coordination requirements will increase.

The change in total costs is represented by the $\Delta C + \Delta G$ curve in Figure 1. Taking all costs into account, the market organization would be preferred (at low levels of k) until asset specificity reaches the value of k' in Figure 1. Beyond values of k' the firm or internal organization will have lower costs hence $\Delta C + \Delta G$ <0. Determining the level of asset specificity is key to choosing the most efficient organizational form for any industry.

Riordan and Williamson (1985) also integrate this theory using familiar neoclassical maximization framework. Due to space constraints the mathematical representation is not presented in this paper. However the essence of there presentation is that TCE is compatible with a neoclassical framework rather than neoclassical results. By ignoring transaction costs neoclassical economics can not explain the existence of markets or firms.

Two important implications result from the TCE logic:

1. When k=0, market governance costs are lower than internal organization governance costs and
2. Marginal governance costs of the market are greater than that of internal organization.

This explains when and why players will choose to form a firm or use a market organization. TCE predicts that for low levels of asset specificity the market will have lower costs and at relatively high levels the firm will come to be more efficient.

Williamson (1991) explicates the model by analyzing the governance cost curves and further examining the dimensions of organizational forms. Williamson follows up on the two important conclusions of the above model; that the market will be more efficient when asset specificity is 0 and the marginal governance costs of markets are greater than internal organization, which Williamson often refers to as hierarchy.

Let M represent market governance costs, H hierarchy and X represent an intermediate organizational form termed hybrid. These governance cost curves are modeled as a function of asset specificity (k) and a vector of shift parameters (θ). Shift parameters include technological change, policy

and uncertainty. The governance cost equations become: M=M(k;θ), H=H(k;θ) and X=X(k;θ). As predicted by TCE theory it is assumed that M(0)<X(0)<H(0) and M'>X'>H'>0. However, instead of modeling the difference in the governance costs as diagramed in Figure 1. Williamson (1991) compares actual governance costs. Figure 2 demonstrates this version of the model.

Figure 2 shows that for k< $\bar{k}_1$ the market will be most efficient, that is M (k) is the lowest over that range. For values of k between $\bar{k}_1$ and $\bar{k}_2$ hybrid has the lowest governance costs, thus it will have the advantage. Finally hierarchy will have the lowest costs for values of k> $\bar{k}_2$. The lower envelope becomes the collection of low governance costs. The organization forms that correspond with those points will be most efficient. If additional curves were added for multiple organizational structure including different contractual arrangements, firm organization and even government production the resulting lower boundary would be a concave envelope of least cost organizational forms.

The benefit of this version of the model is that comparative statics can be easily completed. For instance if policy changes encourage hierarchy this would shift H(k) down. The change in policy would reduce $\bar{k}_2$ and make hierarchy more likely compared to hybrid. However, the incidence of market may remain unaffected unless $\bar{k}_2 < \bar{k}_1$.

To answer the question why differing organizational forms have different governance costs Williamson (1991) argues that the dimensions of organizational forms must also be understood. Research in the TCE originally focused of understanding the dimensions of transactions. However, in order to align transactions with organizational forms, characteristics of organizational forms must also be understood.

Following both Hayek and Barnard, Williamson (1991) argues the main function of economic organization is adaptation. Two types of adaptation are identified: autonomy (A) and coordination (C). The type A adaptation refers to the flexibility of actors to react to exogenous shocks. The market usually has the advantage in terms of adaptation of type A since individuals are autonomous and free to react to market forces. Type C adaptation refers to getting parties to act in a unified way. Hierarchy usually has

the advantage with adaptation of type C since firms use more command and control mechanisms (what Williamson calls fiat) rather than market signals. Hybrid forms possess intermediate degrees of adaptations of Type A and C.

Other differences between organizational forms include contract laws which support dispute resolution within and between firms. Market transactions are supported by more formal contract law and the courts. Hierarchy is less supported by the courts and usually utilizes internal rules for exchange. Hybrid forms of governance may be supported by a mixture of internal rules and contract law.

Incentive intensity is another difference between organizational forms. Markets have high powered incentives because outcomes are strongly linked to the actions of individuals. If prices received are higher than the costs to produce a good parties will be rewarded with profit. Thus the outcome (profit) has a direct relation to the low cost actions, especially in the case of low asset specificity and thus no bilateral dependency. Hierarchy does not usually have as high a degree of incentive intensity since it relies on fiat rather than market signals. Command and control instruments have more effect on employees if they are isolated from market conditions. Hybrids have a medium level of incentive intensity as some market signals may be masked by fiat.

However, there is an extra cost to hierarchy not included in the reduction of incentive strength, an increase in bureaucratic costs from administrative controls. Administrative controls represent a final difference between organizational forms. Bureaucratic costs associated with administrative controls are the cost of using the command and control mechanisms in hierarchy. Thus bureaucratic costs are usually high in hierarchy, less high in hybrids and nonexistent in market organization since the latter relies on market signals to spur action by individuals.

Overall Williamson (1991) identifies five important differences between governance structures: 1) Adaptation autonomous (type A); 2) Adaptation coordination (type C); 3) Contract law; 4) Incentive intensity; and 5) Administrative controls. The first two are characterized as performance attributes while the last two are referred to as instruments.

Identifying characteristics of organizations adds to the explanation of the discriminating alignment hypothesis. The TCE explanation for business behavior is that transactions which differ in asset specificity, frequency and uncertainty are aligned with organizational forms that differ in adaptation, contract law, incentive intensity and administrative controls. But how has this theory stood up in empirical testing?

Empirical Literature

Overall the empirical testing has been rather supportive of TCE theory although studies do vary in their methods. Empirical studies that test TCE range in the level of focus and type of analysis. Types of analyses include qualitative case studies, quantitative case studies and cross sectional analyses (Shelanski and Klein, 1995). The focus has ranged from contract provisions to the governance level to the institutional environment. The types of industries analyzed range from the auto sector, airline industry, coal markets and oil and natural gas industries. Shelanski and Klein (1995) and Boerner and Macher (2001) provide a more broad review of this literature. Analysis on natural resource industries will be of primary concern in this review, however, themes from this sample of the literature appear to be similar to the more general evidence.

The procedure in the empirical literature, following TCE theory, is to model the choice of organizational form as some function of asset specificity and other explanatory variables. It is an implicit assumption that the organizational form observed are the most efficient. Cross sectional analyses often utilize a logit or probit model to deal with the qualitative nature of the dependent variable. This is especially the case when the level of analysis is the governance level. Since this data is usually non-continuous ordinary least squares regression analysis can not be utilized. An example of analysis at the governance level is Wiggins and Libecap (1985). The authors use a dummy variable as the dependent variable indicating whether a particular oil field is organized as a unit or separate production. This may be interpreted as an integration decision measure. Other studies such as those on automobile parts model the make or buy decision.

Studies on the contractual provision level are able to use continuous dependant variables such as prices, length of contracts, or other measurable contract provisions. Examples include Joskow (1987, 1990) in his study of coal exchanges and Masten and Crocker (1985) in their study of take-or-pay provisions in the natural gas industry. However, the presence of a contract provision could also be measured as a qualitative dummy variable.

Other studies examine both governance and contract provisions. Mulherin (1986) studies the relationship of natural gas producers and pipelines by examining the ownership of gathering lines (governance) and contract provisions such as safeguards and price adjustment features. In the first model of this paper delivery point is used as an indicator of governance. If the well head is the delivery point the natural gas producer owns the gathering line and if the pipeline is the delivery point the pipeline company owns the gathering line. In a second and third model Mulherin uses the presence of take-or-pay and price adjustment provisions as dummy dependent variables.

The use of independent variables is another method of describing the cross sectional studies. Joskow in his studies of coal markets uses the location of power plants in relation to coal mines as a dummy explanatory variable to measure spatial asset specificity. In Joskow (1987) mine mouth plants are shown to have contracts that are 16 years longer on average compared to non-mine mouth plants. Spatial asset specificity is identified as the main reason for the longer term contracts. Similarly Wiggins and Libecap (1985) use firm acres contiguous to oil field leases as a measure spatial asset specificity. Masten and Crocker (1985) and Mulherin (1986) use the number of buyers and sellers as a proxy for asset specificity. It is contended that as the number of buyers and sellers decrease alternative values will decrease implying an increase in asset specificity.

A time dummy is also popular for measuring demand side uncertainty. Joskow (1990) investigates whether coal contracts in the 70's have lower prices than contracts in the 80's. Demand uncertainty is taken into consideration by using time dummies for different time periods of the sample when demand is more or less variable. Contracts in the 70's did not take demand shocks into consideration and were thus found to be biased upward because demand for fuel was shifting towards

natural gas and oil at the time. It is contended that the lack of demand considerations in the contracts isolated the value of coal from these effects. Saussier (2000) uses similar techniques dividing his sample into two periods, one where demand variability is low and one where it is high.

Case studies fall into two types. Qualitative case studies provide antidotal evidence to support choice of organization. Wilson (1980) on New England fresh fish markets determines that for larger more trust worthy fisherman it is more likely that buyers will enter into long term arguments where the buyer communicates consumer preferences since the buyer is more dependent on the fishers supplies. For smaller less trust worthy fishers short term consignment exchange is more likely because buyers are less dependent on these types of fishers. Size of the fisher could be interpreted as a indicator of dependency.

Libecap and Smith (1999) and Joskow (1985) take a quantitative case study approach where the proportion of organizational arrangements with various characteristics is reported as evidence supporting TCE hypotheses. For Joskow (1985) a high proportion of mine mouth power plants are found to use contracts of 30years in length or more. This is provided as evidence of the effects of spatial and physical asset specificity. Libecap and Smith examine 60 oil and gas unit contracts. Statistics are provided that determine that simple profit sharing agreements occur when the geological formation of the oil field is known and stable. The condition of the oilfield is like a proxy for specificity. It is observed that when oil field geological conditions are more complex the timing and type of drilling specifications become more complex to organize.

A final group of studies are those that focus on the institutional level. Troesken (1997) examines municipal versus private ownership in the natural gas industry. The primary finding is that private sector investment is more likely when government can commit to not acting opportunistically ex post or when governments can credible promise to not lower prices or raise taxes on utilities. Crocker and Masten (1996) examine regulation versus franchise bidding as public policy for utility regulation. Parallel to Williamson they find that with high degrees of asset specificity and uncertainty regulation (integration) is preferred over franchise bidding (market exchange).

Econometric problems in the cross sectional analyses include measurements for asset specificity. Simple proxies such as the number of buyers and sellers as an indicator for asset specificity may not correlate with the recoverable value of the asset in alternative uses. Survey methods such as the Likert scale have been used in other studies to estimate explanatory variables such as asset specificity (Boerner and Macher, 2001). Survey measures are less direct means of measuring asset specificity and are open to survey biases. More direct measures of asset specificity may include independent indicators. Measures for spatial asset specificity appear to be less controversial. However, general agreement on the best method to measure other types of asset specificity remains an issue.

A related econometric issue is the endogeneity problem. Traditionally asset specificity is treated as an independent variable. However in reality it is a choice variable. In the biopower context when generators choose their generation type they are also choosing the level of asset specificity. The choice of technology then may be modeled as a simultaneous choice to the choice of governance. Sassier (2001) attempts to endogenize asset specificity in a simultaneous model on the French power industry. The results of this adaptation do not reduce the support of TCE in that study.

The unobserved dependent variable or the truncation problem is another econometric issue. In most data sets only the current organization or contract provision adopted can be observed. Joskow (1987) and Masten and Crocker (1985) use maximum likelihood techniques to address the truncation problem. In neither case did this manipulation change the support of the data for TCE hypotheses.

Most studies that address econometric problems have found that the results in terms of testing the theory remain unaffected. Variables contrived to measure asset specificity have been shown to be statistically significant whether the methodological problems are addressed or not.

Other weaknesses include that usually TCE studies do not consider other theories. The data is shown to be consistent with TCE hypotheses but is not tested against other theories. Could the data also support other theories? There are some studies that address this problem. Mulherin (1986) forms hypotheses consistent with market power, risk allocation and non price competition literature for his data on natural gas contracts. The data are found to be more supportive of the TCE hypotheses. Leffer and

Rucker (1991) also find that data on timber-harvest contracts are more consistent with TCE then risked based hypotheses. However, for the most part authors do not consider this problem. The empirical literature testing TCE although subject to some empirical problems seems to have progressed to a point where the theory can be applied more generally.

Application of the Theoretical and Empirical Model

The main point of this section is that based on the theory and empirical evidence taking a TCE approach may be a good way to study and inform the development of a biopower industry. Basic data is available from the Energy Information Administration although primary data may have to be collected for the dependent variable. Future research must make the connection between testing the theory and informing the industry. It is important to observe that the assets the players need to invest in may create contractual hazards. The best way to address these potential hazards is to study the current industry. The current industry mainly uses either self procurement of biomass supplies (in the case of most cogeneration plants) or short term contracts (which are used in power from wood waste plants). How do these organizational forms correspond with the level of asset specificity involved in the exchange? Answering this question will help future players organize biomass procurement.

The focus of this paper has been on developing the theory to be applied to the study of the exchange of biomass and competing organizational forms in an emerging biopower industry based on agricultural products. In this section consideration is given to how this theory fits the biopower case.

Following Williamson's TCE the transaction can be made the basic unit of analysis. In this application the basic unit of analysis is the exchange of biomass. In this exchange there are those who want to sell biomass, the biomass producers, and those who want to purchase biomass, the power generators. Who are biomass producers and power generators?

Biomass producers may be difficult to identify. They probably do not even consider themselves biomass producers because the focus is on producing other products. Potential

biomass producers in agriculture are a collection of grain producers, livestock producers, industrial food, fiber, livestock and forestry producers with excess biomass.

Power generators are easier to identify. Currently there are four types of power generators in Missouri: cooperative, private, government and non-utility. In areas other that St. Louis and Kansas City, electricity cooperatives, such as the Associated Electric Cooperative Inc. are dominant. For the biopower industry rural electric cooperatives and non-utilities may be very important because of prior relationships with biomass producers. In the case of non-utilities the biomass producer and the power generator may be the same entity. The biomass exchange in that case is likely to be internal exchange.

The TCE procedure is to align the transactions (which vary in asset specificity, frequency and uncertainty) with least cost governance structures (which vary in incentive strength, administrative controls, adaptation ability and contract law). What are the important characteristics of the transaction and potential governance structures in the biopower application?

The biomass exchange may require new investments to be made on the part of both biomass producers and power generators. The key investment is in the power generation facility. New power units that are dedicated to power from biomass or adaptations to current power units will be required. These investments may be considered asset specific to varying degrees. The main types of asset specificity in this case are physical asset specificity where the complexity of the assets binds the trading partners; however spatial asset specificity and dedicated assets are also important.

The co-fire technology which requires adaptation to current facilities would be considered the least asset specific. This technology allows for a mixture of coal or natural gas and different types of biomass with the option of going back to coal or natural gas fired power. Direct fire technology is more asset specific. This technology requires separate power units to be built and the units are dedicated to producing electricity from biomass. A final asset that is the most asset specific is the bio-digester technology that uses livestock waste to produce methane which is used to produce electricity. This

technology will be specific to one input provider for physical specificity reasons and because of spatial asset specificity. To economize on transportation costs this technology is likely to be located very close to the point of input production. Spatial asset specificity may also be present in technologies that use input from industrial sources such as agricultural food and fiber processors and forestry producers. These conditions suggest internal exchange or long term contracts may be efficient.

Assets on the other side of the exchange, the biomass producers, are also specialized. The main type of asset specificity is dedicated assets. Many potential biomass producers currently do not own the transportation, collection and storage equipment to supply biomass to power generators. If these investments are required they will be considered dedicated assets. These assets may be dedicated toward supplying a single user, the power generator.

Overall, the assets involved in the biomass exchange have varying degrees of physical asset specificity, spatial asset specificity and dedicated assets. These investments should be further evaluated to identify the potential contractual hazards. Future research should focus on this area. Other characteristics of the transaction include uncertainty.

Uncertainty is another characteristic of the biomass exchange. There are several sources of uncertainty that exist. Biomass production variability, substitute products value variation both on the demand and supply side, environmental policy and technological improvement all pose possible uncertainties to the biomass exchange. These uncertainties may also vary depending on the particular fuel. Power producers will not want to adapt technologies they will have difficulty sourcing inputs for, will not get political support for, or might only be short term technologies. Suppliers would not want to make investments if other uses of the product or land are more profitable. Changes in technology, regulation and uncertainty will shift the governance cost curves hypothesized by Williamson.

Biomass exchanges in agriculture have traditionally been ad hoc relying on barter and informal information, as mainly crop producers trade biomass for feed and bedding to livestock producers. Further, livestock waste and waste from the forestry industry often go un-traded. However some organizational business models may be emerging from the current biopower industry. It may be productive to study the

current industry in order to inform future expansion into products from agriculture. Determining what current industries practices are is important since few agricultural biomass plants exist. Mostly municipal solid waste and wood biomass are used in current biopower practices although some food processing materials have been used.

One of the main concerns in any project is data availability. The biopower sector is fractured and diverse. Data collection may be very costly. However secondary data sources such as the Energy Information Administration may be helpful. They currently collect data from power plants that produce electricity from biomass including scale, generation technology, biomass type, ownership type, transportation type and secondary sources of biomass. The latter may indicate the level of asset specificity since power plants that can use multiple sources will have low levels of asset specificity. This data source may be sufficient for a qualitative case study approach and important background work for cross sectional analysis. Primary data collection may be to collect information on the main dependent variables in TCE either on the governance level or contract level. Exchange type, internal or market exchange of exiting plants or detailed contract information could be collected for cross sectional analysis at the contract level. Both would be of interest to biopower development initiatives.

Ideally empirical research could involve the estimation of Williamson's governance cost curves. However, past research testing TCE has no proceed in such a fashion. Ample observations with quality data may not exist to proceed in such a manner. In this case Williamson's TCE could be tested on the biopower industry. Such studies could also provide evidence that would help inform industries looking to form around agricultural inputs.

Conclusion

Overall this paper reviewed the TCE empirical and theoretical literature in order to apply it to biopower. Taking an organizational perspective of an emerging industry has been a path less taken in the feasibility literature. TCE provides a useful framework for analyzing an emerging industry and may be used to recommend future organization arrangements for the development of a power industry based on agricultural products as a fuel source.

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Figures

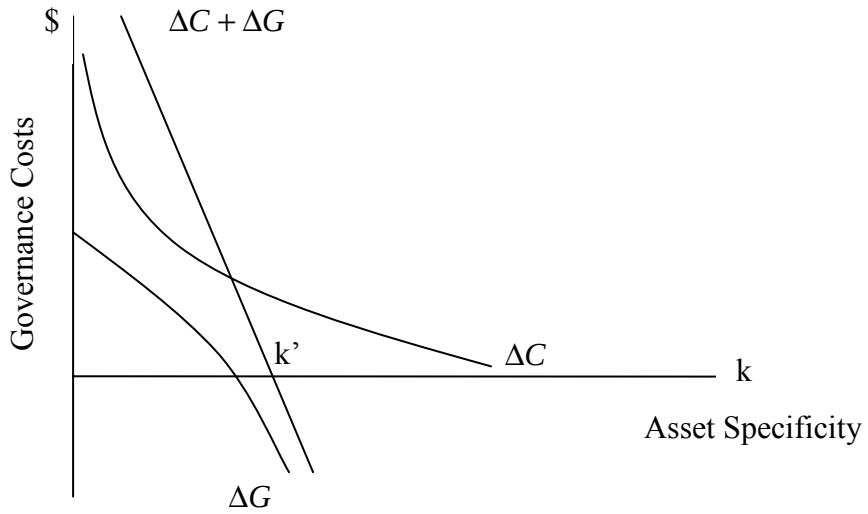

Figure 1: Comparative Production and Governance Costs

Source: Adapted from Williamson, 1985

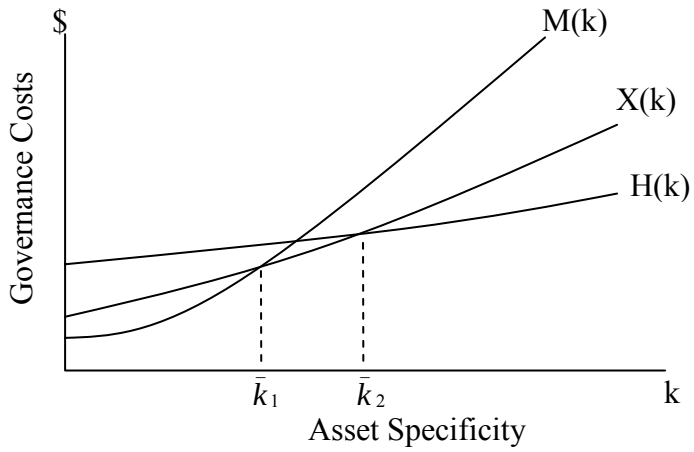

Figure 2: Governance Costs as a Function of Asset Specificity

Source: Adapted from Williamson, 1991