Transaction Costs, Hold-ups and Governance in Ethanol Supply Chains

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Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

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Introduction

Facing less secure sources of petroleum and rising greenhouse gas emissions, many countries in recent years have turned to biofuels as a potential alternative energy source. The development of the biofuels sector is not without controversy, however, often requiring substantial public sector subsidization or market interventions in the form of blending mandates and, in the midst of rising and volatile food prices, generating a heated 'food versus fuel' debate. Nevertheless, investment in biofuels production continues, particularly in Canada and the US, and the long-run commercial viability of ethanol production (with or without continued public sector support) depends on the ability to access an inexpensive and reliable supply of inputs as well as finding stable markets for ethanol and its co-products.

A unique feature of ethanol plants is their position at the intersection of multiple supply chains which result in the production of grain products, livestock, and fuel (blended gasoline). The primary feedstock, at least for first generation ethanol production, is cereal grain (usually corn or wheat), while output from ethanol plants include not only ethanol for fuel, but also co-products used in livestock feeding. Transaction Cost Economics provides a lens through which to examine the juxtaposition of the multiple supply chain relationships that characterize the business environment for an ethanol plant. This paper examines the supply chain relationships in the Canadian ethanol industry within a transaction cost context. Sources of transaction costs and hold-up are identified, and inferences are drawn for the types of governance structures that may emerge in the long-run.

The paper is organized into five sections. Following the introduction, an overview of the Canadian ethanol sector and its primary supply chains is provided. The third section begins with an exposition of transaction costs in the context of the ethanol sector, and then examines the

[1] Funding from the Feed Opportunities from the Biofuels Industries (FOBI) network, an Agricultural Bioproducts Innovation Program (ABIP) research network, is gratefully acknowledged.

transaction characteristics that influence transaction costs in the input and output supply chain relationships facing ethanol plants, providing an assessment of the threat of hold-up in each case. The fourth section presents a discussion of the types of governance structures that are likely to be effective at reducing these transaction costs and mitigating hold-up risks, providing illustrative examples from the ethanol sector in western Canada; while the final section presents conclusions.

The Canadian Ethanol Sector

The standard North American first generation ethanol sector uses wheat or corn as its primary feedstock and produces ethanol as well as wet or dried distillers grains (WDGs/DDGs) for livestock feed as co-products. Ethanol producers typically purchase grain feedstocks directly from grain producers or from a grain company. Canada's feedstock grains are produced primarily in the grain belt of the Prairie provinces of Alberta, Saskatchewan and Manitoba (wheat) and in the provinces of Ontario and Quebec (corn). First-generation ethanol plants (i.e. those using grain feedstocks[2]), are primarily located in those areas. In 2009 there were seven plants in Ontario, one in Quebec, and eight in the Prairie provinces (five of which are in Saskatchewan) (Ethanol Producer Magazine, 2009). Depending on the cost and availability of local feedstocks, some ethanol producers also import corn from the US to maintain their ethanol stream.

On the output side, the primary products of ethanol production are ethanol and either wet or dried distillers grains (although DDGs are far more common). Increasingly, there are other co-products resulting from ethanol production but these typically represent a small percentage of ethanol plant revenue and are therefore not considered here. Once ethanol is produced, it is blended with gasoline at various percentages and sold to consumers. Major purchasers of ethanol from ethanol plants are fuel blenders/refiners. This sector is highly concentrated in Canada, with only three companies operating nationally (Imperial Oil, Shell and Petro-Canada), and a further nine companies operating primarily on a regional basis, usually with one refinery each. The three

[2] Second-generation ethanol production, which uses organic wastes as fuel, is a relatively minor contributor to the Canadian ethanol supply at the present time. Three second-generation plants either operating or under construction, using straw, wood waste and municipal landfill waste, together account for only around 2.5% of total feedstock volume in Canada.

national companies have refineries located either close to oil production (e.g. Alberta) or in areas where gasoline consumption is high due to density of population (e.g. southern Quebec and southern Ontario). Ethanol producers are therefore dealing with an oligopolistic fuel blending industry. The effect of the high level of industry concentration is exacerbated by the high cost of transporting ethanol which requires an entirely separate transportation and storage system from gasoline until blending takes place (Natural Resources Canada, 2008). The conventional petroleum transportation system (pipelines) contains water which causes ethanol to separate from gasoline and become unusable as fuel. As a result, the blending of ethanol with gasoline typically occurs near to the last point of distribution.

Distillers grains (either wet or dried) are sold to livestock producers and used in high-protein feed rations. Beef and dairy cattle operations are the primary purchasers of distillers grains, although hogs and poultry can also use dried distillers grains (DDGs) to a lesser extent in feed rations. Wet distillers grains (WDGs) have a short shelf life and are costly to transport, and therefore tend to be sold only to cattle feedlots in close proximity to the ethanol plant. Drying distillers grains improves the nutrient concentration and reduces transportation costs, but also requires drying capacity and increases energy usage, resulting in higher utility costs. Dried distillers grains can be marketed over a larger geographic area relative to the wet counterpart and most ethanol plants dry their distillers grains and sell the product regionally. Nevertheless, transportation and storage costs are not insignificant and ethanol plants situated in more concentrated livestock production areas will be at an advantage in this regard.

As indicated, the Canadian ethanol sector sits at the intersection of three main supply chains: feed grains, gasoline and livestock production. The major participants and transactions occurring in the ethanol sector are summarized in Figure 1. Including the ethanol plant, there are four major supply chain participants, each engaging in separate transactions (T1-T3) with the ethanol plant. If parties to an exchange have unequal power opportunistic behaviour can inhibit transactions resulting in hold-up problems, wherein agreements for exchange are not reached and supply chains are disrupted. The analysis that follows identifies characteristics in each supply chain relationship that can increase transaction costs, potentially leading to a hold-up problem in which exchange may not occur or becomes more costly. A brief overview of transaction costs in the context of ethanol production is provided in the next section.

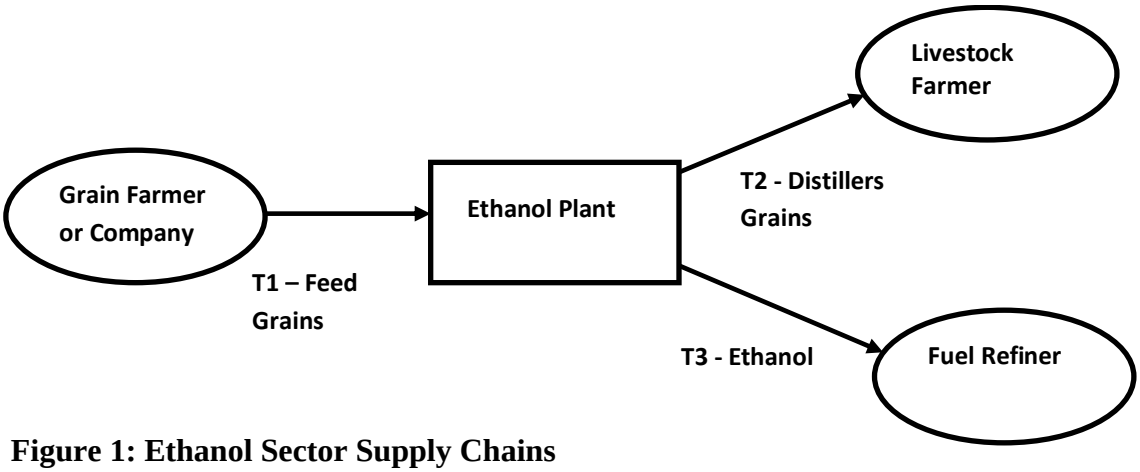

Figure 1: Ethanol Sector Supply Chains

Transaction Costs and Sources of Hold-up

Transaction Cost Economics (Coase 1937; Cheung 1969; Williamson 1979, 1985, 2002; North 1984) offers rich insights into the organization of economic transactions and the structure of supply chains. Transaction cost economics has been applied extensively to various aspects of the agricultural sector (Sporleder 1992; Hobbs 1997; Fearne 1998; Hobbs and Young 2000; Boger 2001; Ménard and Valceschini 2005), but there are few examples of its application to ethanol production and supply chains. Recent studies by Altman et al. (2007) and Altman and Johnson (2008) examine transaction costs broadly within the US "biopower" industry, but consider a variety of energy sources in addition to ethanol. Applying a transaction cost lens to the ethanol sector provides an opportunity to explore, at a micro-analytical level, the factors driving the governance structures of supply chains in the sector.

Two behavioural assumptions underpin the transaction cost approach: *bounded rationality* and *opportunism. Bounded rationality* (Simon, 1961) recognizes that although individuals and firms intend to make rational decisions, they are limited in doing so by their cognitive ability. It is not physically possible to evaluate all potential outcomes of a particular decision. For an ethanol plant, bounded rationality can arise, for example, in determining input prices: establishing long-term supply agreements at fixed prices only to have unforeseen events reduce the spot price of those inputs over the length of the agreement.

Opportunism is defined by Williamson (1979) as self-interest seeking with guile. Vulnerability to opportunistic behaviour increases in the presence of small numbers bargaining where there are few alternative suppliers of key inputs or buyers of outputs. In the context of the ethanol sector, opportunistic behaviour would include grain producers reneging upon a prior agreement to deliver grain to an ethanol plant at an agreed upon price and delivery schedule due to unexpectedly higher spot prices, or a gasoline blender reneging upon a commitment to source ethanol from an ethanol plant at a pre-agreed price. In the presence of information asymmetry, bounded rationality and opportunism result in more complex transactions and increase the vulnerability of exchange partners to a break-down in the exchange relationship. Transaction costs are incurred in reducing exposure to this vulnerability.

Transaction costs include the costs associated with activities carried out in preparation for, and after, an exchange. Coase's (1937) original insight led to the recognition that transactions do not occur in a frictionless economic environment; there are costs to carrying out transactions and these costs influence whether transactions occur within a firm or across a market interface. According to Williamson (1979), the governance structure that emerges will be the organizational form which minimizes the sum of production and transaction costs. These core insights have provided a rich basis on which to examine the use of spot markets, contracts, vertical integration, alliances, and other inter-firm relationships to govern transactions.

Transaction costs arise both prior to an exchange (*ex ante*), and after an exchange has transpired (*ex post*). *Ex ante* costs, often referred to as "search costs" and "negotiation costs" are incurred in an effort to obtain the best possible terms of exchange with a trading partner and include the costs of searching for an appropriate exchange (prices, exchange partners, etc.), in addition to drafting and negotiating an exchange agreement. In the context of ethanol production, *ex ante* transaction costs arise, for example, in the identification of a consistent and reliable source of inputs (e.g. feedstocks) for ethanol production, or in negotiating forward contracts or supply agreements with grain producers.

Ex post costs, often referred to as "monitoring and enforcement costs", are incurred after an exchange has been completed and are associated with ensuring that the terms of a contract are honoured, and in seeking recourse in the event of breach of contract or maladaptation of exchange terms. Examples of *ex post* transaction costs in the ethanol sector include ensuring that

grain is delivered to the ethanol plant in accordance with delivery commitments, or that blenders accept delivery of ethanol at pre-agreed terms, and in seeking recourse in the event that suppliers (buyers) renege upon delivery (purchase) commitments. The remainder of this section explores the transaction characteristics that lead to hold-up and transaction costs in the context of the three supply chains with which ethanol plants interact.

Transaction Characteristics and Hold-ups in Ethanol Supply Chains

A transaction cost lens predicts that the governance structure that emerges in ethanol supply chains will be influenced by the characteristics of the transaction, including the *specificity of assets* involved in the exchange, the degree of *uncertainty* that characterizes the exchange relationship, and the *frequency* with which transactions occur (Williamson, 1979).

Asset specificity occurs when assets are specific to an exchange with little or no value in an alternative use or to an alternative user (Klein et al., 1978). Asset specificity takes a number of forms, including site specificity, physical asset specificity, dedicated assets, human capital specificity and time specificity (Williamson, 1985). Site specificity occurs when assets are specific to a certain location and are highly immobile, thereby rendering the holder of the asset vulnerable to opportunistic recontracting. Physical asset specificity occurs when assets possess physical characteristics that are specific to a certain transaction and have little value in alternative uses. Dedicated assets occur when a transaction-specific investment is made in anticipation of selling a significant amount of product resulting from that investment to a specific customer. Human asset specificity occurs when an individual invests in knowledge or a skill that is specific to an exchange relationship. Time specificity is related to the perishability of the asset or time sensitivity of the transaction which leaves one party vulnerable to opportunistic recontracting by an exchange partner. Wet distillers grains suffer from a degree of time specificity since their quality deteriorates rapidly if they are not sold and consumed relatively quickly. For this reason, WDG tend to transported over distances of less than 200km prior to being consumed by livestock.

Once a specific asset is committed to an exchange, the owner of the asset is vulnerable to opportunistic behaviour by the exchange partner in attempting to renegotiate the terms of the exchange to appropriate rents from the specific asset, which is now a sunk cost. The threat of re-negotiation after a specific investment is made can prevent an agreement of exchange from

occurring altogether. This is a source of ex ante "hold-up". In the context of the ethanol industry, the ethanol plant infrastructure represents a highly specific investment with few alternative uses and often, due to small numbers bargaining, few alternative users (buyers) of ethanol. In the absence of appropriate governance structures to mitigate the effects of asset specificity on transaction costs, ethanol plants are at risk of opportunism in both input and output exchanges.

Increased asset specificity tends to result in more formal governance structures to guard against the risk of opportunism. Williamson (2002) presents a *contracting schema* that differentiates between components produced by non-specific "general purpose" technology and components produced using highly-specific "special purpose" technology. General purpose technology requires no safeguards and is exchanged in the spot market. As the specificity of technology increases, so too must the level of safeguards necessary to ensure that a successful transaction occurs. In some cases, contracting alone can provide adequate safeguards, while in cases of extreme specificity, safeguards will approach their limit, and "unified ownership" or complete vertical integration becomes the transaction-cost efficient method of governance.

Ceteris paribus, increased *uncertainty* in the ethanol supply chain will lead to closer vertical co-ordination, as reducing uncertainty through increased co-ordination typically costs less than dealing with opportunism resulting from the uncertainty. If firms were certain that they could predict the actions of those with whom they exchange, the effects of bounded rationality, opportunism, and asset specificity could be avoided by safeguarding input and output contracts with preventative clauses or by choosing to deal only with individuals whose *ex post* behaviour is known to be desirable. Uncertainty over the price and/or supply of inputs and the price of outputs increases the transaction costs of drawing up and enforcing contractual agreements.

The effect of *frequency* on vertical co-ordination is ambiguous. On the one hand it can be argued that highly frequent transactions will occur through spot markets because the necessity of repeated exchanges and the value of reputation create natural incentives against acting opportunistically to jeopardize future transactions. According to this logic, as transactions between individuals become less frequent, the incentive for opportunistic behaviour increases. An alternative view holds that frequently occurring transactions may lend themselves to more closely co-ordinated governance structures because the familiarity and trust developed though repeated exchange can facilitate the development of more formal relationships, and highly

frequent transactions allow investments in transaction-specific infrastructure to be internalized. An assessment of the effect of the frequency of transactions on vertical co-ordination outcomes must therefore be taken in the context of the other two transaction characteristics: uncertainty and asset specificity, which are the primary drivers of transaction costs.

The transaction cost analysis of ethanol supply chains presented below proceeds by examining the characteristics of each of the relationships illustrated in Figure 1. An assessment of the degree of asset specificity, uncertainty, and transaction frequency is used to identify potential sources of transaction costs and the extent to which ethanol plants are vulnerable to opportunistic behaviour by their exchange partners. Implications are drawn for the types of governance structures that will emerge to reduce transaction costs.

In each relationship, it can be assumed that bounded rationality is endemic; it exists for both parties. Further, it is apparent that in each relationship, the ethanol plant owner has made an investment in a highly specific asset, namely the ethanol plant itself. The plant is physically specific because it has little value in alternative uses and is site specific because its location relative to its source of inputs as well as its output markets is important. The presence of physical asset specificity for the ethanol operator suggests that there is at least some threat of opportunism in each of its supply chain relationships.

Relationship One: Grain Farmer/Company and Ethanol Plant (T1)

The first relationship of interest is between the ethanol plant and its primary input providers, grain producers or grain companies. The ethanol plant must ensure that it has a consistent supply of either corn or wheat (or in some cases both) delivered on demand throughout the year. Although the ethanol plant represents a specific asset, grain is a non-specific asset and therefore has numerous alternative uses (or markets). This means that grain producers or grain companies would not necessarily have to sell their grain to the ethanol plant, thus providing little incentive for opportunistic behaviour on the part of the ethanol plant. Similarly, given the large number of producers with whom potentially to transact, the consequences of any individual producer acting opportunistically against the ethanol plant may not be significant because the plant can simply purchase grain from a different farmer. Of course, the consequences of widespread opportunism by suppliers of feedstock grains in response to higher spot prices are more severe. In this regard, it can be concluded that the degree of asset specificity is dependent

on the existence of small numbers bargaining, which can differ by region depending on the existence of an active spot market in feedstocks[3]. Moreover, a region with a relatively diverse agriculture, that is, with both grain producers and livestock producers or mixed-farming operations, would tend to reduce the asset-specific nature of the feedstock grain still further.

With respect to transaction frequency, it is likely that the ethanol plant will have repeated transactions with farmers and/or grain companies located near the ethanol plant, as both parties benefit from reducing transportation costs associated with delivery. The greater the distance between the ethanol plant and any given producer, the lower this incentive is likely to be as closer alternatives become available. The incentive for ethanol producers to transact with a grain company or perhaps a large producer group (e.g. a co-operative) rather than with individual farmers may be higher, since this would enable the ethanol plant to reduce the number of separate transactions required to obtain the large quantities of grain that it needs on a regular basis. Regardless of whether purchases are made from grain companies or individual farmers, repeated transactions provide a disincentive for opportunistic behaviour because this would jeopardize future transactions. In this regard, transaction frequency should mitigate the incentive for opportunistic behaviour, lowering transaction costs and allowing looser forms of co-ordination. In a spot market situation, monitoring and enforcement costs are likely to be low for the ethanol operator, since once an agreement is reached, physical possession of the grain can be taken. On the other hand, if an agreement for purchase is reached in advance, there may be monitoring and enforcement costs associated with ensuring that delivery occurs in a timely manner. In such cases, the ethanol plant will have an incentive to seek closer vertical co-ordination with its grain suppliers.

In the context of uncertainty, the price and supply of feed grains are likely to be major concerns for both grain feedstock suppliers and ethanol plant operators. As grain prices are influenced by developments in the ethanol industry, the livestock sector, and the grain farming

[3] An active grain market will offer a variety of options for grain farmers. Some grains can be marketed to millers or their agents as lower-quality milling grains rather than as an ethanol feedstock. Even grains that are indisputably of feedstock quality can be marketed directly to livestock producers, either under contract or on the spot market (depending of course on the livestock producer's access to alternative supplies, and the price thereof).

industry, forecasting long run prices is challenging. Given the need for cost and revenue stability, this uncertainty should provide a strong incentive for ethanol plants to form closer relationships with grain producers so that prices can be agreed upon well in advance of delivery (perhaps though forward contracting).

Overall, several transaction characteristics play a role in determining the type of governance structure that exists in the relationship between ethanol producers and grain suppliers, and have counter-acting effects. On the one hand, recurring transactions between the same firms may increase transaction costs due to the potential for opportunistic behaviour if the relationship is perceived as a "captive" market. However, if through repeated transactions trust is established, transaction costs will be lower and the risk of hold-up declines. Rather than asset specificity, which is medium-to-low in this relationship, uncertainty is likely to be the stronger determinant of the governance structure that emerges. There exists ongoing uncertainty associated with grain prices, whether due to weather-induced forage deficiencies in the livestock sector or weather-induced differences in crop quality in the grain sector. Either situation would, in the short term, increase the risk associated with spot market transactions, and thus provide an impetus toward forward contracting as a safeguard against this risk. In the current environment of volatile grain prices, the prospect of increased transaction costs seems likely to provide an added incentive for closer vertical coordination on behalf of both parties.

Relationship Two: Ethanol Producers and Livestock Farmers (T2)

Distillers grains account for between 10% and 20% of total revenue generated from ethanol production, and in many cases can be the determining factor in whether or not an ethanol plant is profitable. Distillers grains are a highly specific asset and therefore place the ethanol plant at risk of opportunistic behaviour by buyers (livestock farmers). The specificity of distillers grains occurs in several forms, including site (or time) specificity, physical asset specificity, and in some cases, dedicated specificity. Site (or time) specificity occurs because distillers grains in their original wet form are perishable and expensive to transport long distances. The short storage life and high water content of WDGs makes this specificity larger than is the case with DDGs, which can be transported longer distances and have a much longer storage life (ranging from 40 days up to a year). Physical asset specificity occurs in distillers grains because they have little value in uses other than as livestock feed. In cases where an agreement is made in advance

of ethanol production, distillers grains become dedicated assets because there is anticipation that they will be sold to a specific customer. Given the abundance of asset-specific characteristics inherent in WDGs in particular, it can be expected that the threat of opportunism is likely to lead to closer vertical co-ordination along the supply chain, perhaps through extensive contracting or vertical integration between an ethanol plant and livestock feeding operation.

The threat of opportunistic behaviour by buyers of distillers grains is exacerbated by the oversupply of these grains resulting from rapid expansion in ethanol plant capacity. For example, the WDGs resulting from a 13 million litre ethanol plant operated by Pound-Maker Agventures in Lanigan, Saskatchewan provide protein rations for approximately 30,000 head of cattle (Pound-Maker Website, 2010). Applying this ratio to ethanol production across North America, current and projected ethanol production (approximately 60 billion litres including plants under construction) would produce enough distillers grains to feed 140 million head of cattle. As of January 2011, the total cattle herd in North America was estimated to be approximately 105 million, including calves (ERS, 2011), by no means all of which have ready access to distillers grains as a food supplement. Further exacerbating this situation are the ethanol mandates in the US requiring that ethanol and biodiesel production reach 136 billion litres by 2022.

The expanding supply of distillers grains also creates substantial price, and therefore revenue, uncertainty regarding this co-product. Predicting prices in the long run would require information related to the rate of ethanol expansion, and the mobility and transportation patterns of these grains, as well as the availability of substitutes. These uncertainties further enhance the incentives for increased vertical co-ordination between ethanol producers and livestock producers.

A final important characteristic of the exchange of distillers grains is the high frequency of transactions between ethanol plants and livestock producers. As the ethanol industry in Canada is relatively concentrated and individual ethanol producers can benefit from having relationships with large feedlot operators (which are common in Alberta and parts of Saskatchewan) who can purchase large quantities of distillers grains, the probability of engaging in repeated transactions with the same firm is increased. As is the case with feedstock grains, this reduces the risk of opportunistic behaviour given the importance of repeat transactions.

Nevertheless, these relationships might well evolve into closer co-ordination in order to minimize some of the uncertainties discussed above.

Relationship Three: Ethanol Producers and Ethanol Blenders (T3)

Since ethanol is the primary product and generates approximately 80% of total revenue for ethanol plants, reducing transaction costs and minimizing the threat of hold-up in marketing this product are important considerations for ethanol producers. Similarly, the obligation of having to fulfill ethanol mandates provides an incentive for fuel blenders to formalize their relationship with ethanol plants[4].

Ethanol production has specific asset characteristics that create vulnerability to opportunistic behaviour. First, it is site specific because ethanol can only be transported by truck or rail (as opposed to pipeline) and is expensive to transport long distances. It is physically specific because, although it is used for other purposes, in the large quantities in which it is produced its value in these uses is greatly reduced. Finally, it is a dedicated asset in cases where it is expected that the ethanol will be sold to a specific customer. In a highly concentrated gasoline refining industry the probability of this is high. This relatively high degree of asset specificity provides an incentive for the establishment of a closely co-ordinated vertical relationship with gasoline-ethanol blenders.

The risk of hold-up arising from the asset specificity of ethanol plants depends on the extent to which ethanol mandates have been fulfilled. Blending ethanol with gasoline represents an additional cost for fuel blenders and will only occur until mandates are met. Therefore, finding markets for ethanol produced beyond the existing blending mandates is likely to be challenging. Current ethanol production in Canada has not yet exceeded federal mandates but will likely do so in the not-too-distant future. Provincial mandates will also factor into the equation for similar reasons and will increase the threat of opportunistic behaviour by fuel blenders. Ethanol plants are therefore particularly vulnerable to policy reversals with respect to the existence and level of blending mandates, which adds an intriguing political economy dimension to the uncertainty faced by these firms.

[4] Ethanol blending mandates (proposed or in place) in Canada include a 5% Federal mandate, together with provincial blending mandates ranging from 5% (British Columbia and Ontario) to 7.5% (Saskatchewan) and 8.5% (Manitoba) (Auld, 2008)

Uncertainty associated with input prices in both industries is a strong incentive for increased vertical co-ordination for both ethanol producers and blenders. For ethanol producers, there is uncertainty with respect to the price of feedstock grains and, to a lesser extent, utilities. For blenders, the uncertainty is related to the price of oil and to a lesser extent the price of ethanol. In this regard, both parties may benefit by negotiating a long-term price for ethanol. With more certainty about the price of this key output, ethanol plants are better able to determine the level of feedstock grain (input) prices that they can establish with grain producers. This represents a further incentive for ethanol plants to seek closer vertical co-ordination with fuel blenders, rather than relying on the pure spot market to sell ethanol.

A final characteristic of the relationship between ethanol producers and blenders that affects vertical coordination is the frequency with which these transactions occur. The relative concentration that exists in both the ethanol production and blending industries suggests that transactions between firms will be highly frequent. As is the case in each of the other relationships discussed, this has ambiguous implications for the vertical co-ordination outcome. Consequently, reducing price uncertainty, as well as securing a stable market for the product, are expected to be the main determinants of the governance structures that emerge.

In summary, several transaction characteristics influence the degree of vertical co-ordination in each of the relationships described above. Table 1 summarizes the transaction characteristics for each of three major relationships. Transaction costs and the threat of opportunism associated with these characteristics are posited as low, medium, and high. In each case we assume that there exists some bounded rationality and that an ethanol plant represents an asset-specific investment, thereby exacerbating the vulnerability of ethanol producers to opportunistic behaviour by trading partners.

Table 1: Transaction Characteristics and Governance Outcomes in Ethanol Supply Chains

	Transaction Characteristics			Hold ups & Governance outcome	
Relationship S=Seller; B=Buyer	***Price/Supply Uncertainty***	***Transaction Frequency***	***Asset Specific Investment***	***Opportunistic Threat***	***Vertical Co-ordination***
Ethanol Inputs					
Transaction 1					
Feed (S) Ethanol Producer (B)	High	High	Grain - No	Medium/Low	Mixed: spot markets, forward contracts
Ethanol Outputs					
Transaction 2					
Ethanol Producer (S) Livestock Producer (B)	High	High	Distillers Grains - Yes	High	Hybrids & Hierarchy: contracts & integration
Transaction 3					
Ethanol Producer (S) Ethanol Blender (B)	High	High	Ethanol - Yes	High	Hybrids & Hierarchy: contracts & integration

For transactions involving feedstock grains used for ethanol production, Table 1 suggests that the threat of opportunistic behaviour and resulting degree of vertical co-ordination is medium to low. While complete vertical integration is unlikely, neither is relying solely on spot market transactions, therefore forward contracting or some other form of hybrid relationship is likely to characterize the relationship between ethanol plants and grain producers, with spot markets providing residual supplies of grain. The high level of uncertainty associated with grain prices/supply drive this relationship. In transactions involving the exchange of primary and secondary outputs, ethanol and distillers grains respectively, the threat of opportunism is high, arising from both the short run price/supply uncertainties associated with these products and from physical characteristics that make them specific to the particular relationship. The high frequency of transactions in each relationship, coupled with price volatility, seems likely to strengthen the case for closer vertical co-ordination in the form of long-term contracts, quasi or full integration. The following section examines in more detail the type of governance structures that facilitate a reduction in transaction costs, drawing upon case study evidence from the ethanol sector in western Canada.

Minimizing Transaction Costs and Hold-Up in Ethanol Supply Chains

Having identified relationships along the ethanol supply chain where the risk of opportunistic behaviour exists, this section discusses governance structures that can ameliorate this risk, thereby reducing transaction costs. Potential solutions range from various types of contractual arrangements (hybrids) to quasi or full vertical integration. If the risk of opportunism is perceived to be low, simple spot market exchanges may be the preferred method of exchange. The use of spot markets, contracts and vertical integration in the context of the western Canadian ethanol sector is explored below.

Spot Market

Spot market transactions usually arise where the threat of opportunistic behaviour is low, and involve the simple exchange of a product at current market prices without committing either party to a long-term supply relationship. Given the transaction characteristics that exist in the ethanol supply chain, this type of transaction should be less common. Nevertheless, some interesting examples of spot market transactions in the ethanol sector exist and are worth exploring. One example is the sale of DDGs by an ethanol plant in Saskatchewan, North West Terminal, to livestock farmers across the Canadian Prairies. North West Terminal is a producer-owned inland grain terminal which recently diversified into ethanol production. Having dual roles as a grain marketer and ethanol producer, North West Terminal sells a combination of feed grains (wheat and barley) and DDGs into the regional livestock industry and therefore can provide a range of livestock feed requirements. Offering more feed options than ethanol plants selling only distillers grains gives North West Terminal a marketing advantage. It has a sufficiently large and diverse customer base that it can operate primarily as a spot market seller of livestock feed, thus avoiding the necessity of entering into long-term contracts that are sought by other ethanol plants. North West Terminal also has the ability to store 3000 tonnes of DDGs, allowing it to accommodate changes in demand that occur throughout the year (Holman, 2009).

Spot market transactions can arise in the purchase of grains used in the production of ethanol. Although a majority of grain is contracted with grain farmers well in advance (described below), most ethanol producers will accept delivery of grain at spot prices when contracted grain does not satisfy requirements for contracted ethanol production. In these circumstances, the spot market acts as a residual market for the sourcing of grain feedstocks when contracted amounts

are not available or are unsuitable. Opportunistically reneging upon previously agreed contracts with grain farmers to take advantage of lower spot prices, however, would lead to a break-down in these supply relationships in the long-run. Thus, the spot market is likely to remain a residual source of supply for most ethanol plants.

Contracting

Contracts are formal agreements between transacting parties, ranging from market specification contracts, where key elements of the marketing of the product (price, delivery details, etc.) are specified but control over production remains with the seller; production management contracts, where the buyer specifies aspects of the production process such as the use of designated inputs; to resource providing contracts, where the buyer provides key inputs as well as providing a market for the output. Contracting seeks to reduce the risk of opportunistic behaviour by writing safeguards into the agreement, for example, specifying a fixed price or the basis on which price will be determined, or specifying a quantity and a duration to the contractual relationship that is sufficient to recover sunk investment costs. Similarly, contracts may reduce the transaction costs of sourcing specific quality attributes by requiring the use of certain production processes. Safeguards are also likely to stipulate compensation in the event that a contract is broken. For this reason, monitoring and enforcement costs can be high in the case of contracting, although this depends on the efficacy of the institutional environment governing the transaction (Hobbs 1996).

Given the volatility in the prices of feedstock grains and distillers grains, as well as uncertainty regarding the market for ethanol in the fuel blending market, ethanol plants often attempt to achieve price stability through contracting for both the supply of inputs and the disposal of output. One of the primary goals of contracting is to “lock in” prices that make ethanol production profitable and to specify recourse in the event that contracts are broken. Since the inputs and outputs being considered here are relatively homogeneous in terms of quality, it is unlikely that complex production-management or resource-providing contracts would be pursued. Instead, in most cases, market-specification contracts will emerge in which two parties agree to the exchange of feedstock grains (either corn or wheat), distillers grains or ethanol at a specified price in advance of production for a set time period. In each relationship, it is likely that both parties would benefit from reducing price uncertainty.

There are numerous examples in the ethanol industry where market-specification contracts are used by ethanol producers to reduce price uncertainty, especially as it pertains to grain procurement. North West Terminal, for example, offers its producer shareholders the option to sign a contract to deliver grain for five years at a fixed price for the entire time period. Once this initial contract expires, farmers have the option of renewing this contract on an annual basis for up to ten years. Prices for these contracts are determined by North West Terminal's annual posted bid price, and farmers can lock in the price of wheat at any time up until the specified delivery date of the wheat (Holman, 2009). The Pound-Maker ethanol plant in Saskatchewan has a similar contracting system with its shareholders, although the right of shareholders to deliver is on an annual basis rather than over multiple years. Price is established through a similar process to North West Terminal in its "renewed" contracts, with producers able to lock in prices in advance (Reuve 2009). An ethanol plant owned by Husky Energy in Lloydminster, Saskatchewan offers local grain farmers a similar option to enter into market-specification advance contracts.

Contracting is also a common feature on the output side of ethanol supply chains (T2 and T3 in Figure 1). In Saskatchewan, both the North West Terminal and Pound-Maker ethanol plants enter into one- to several-year contracts for the sale of ethanol to fuel blenders. In contrast to grain contracts with farmers, these contracts are quite extensive and specify many details including volume and quality attributes, elaborate pricing formulas, transportation obligations and payment schedules, as well as contingency plans that specify what happens in the event of changes in government policy (for example reduced incentives) or factors of production that can affect output levels. Contracts also contain elaborate compensation scenarios, liabilities and warranties in the event that obligations are not fulfilled. Overall, these contracts represent a fairly high degree of coordination.

While contracting can assist in reducing price uncertainty, it does not completely eliminate the threat of opportunism by either the ethanol plant or by others in the supply chain. Suppose, for example, that a grain farmer agrees via a forward contract to sell grain to an ethanol plant at some point in the future at a specified price. If the price of feed grain increases substantially by the time the transaction is to occur, the grain farmer has an incentive to act opportunistically by breaking the contract and selling grain at the higher spot market price.

Similarly, the opposite scenario could occur if the price of feed grain has decreased after an agreement is made but before the crop is delivered. In this case, the ethanol plant has an incentive to break the agreement and purchase the crop at the spot price in the open market. Anecdotal evidence suggests that this problem occurs periodically in both Canada and the US, and is likely to be exacerbated by volatility in grain prices.

Quasi or Full Vertical Integration

In cases where contracts are either too costly to enforce or insufficient to prevent opportunistic behaviour, quasi or full integration are more appropriate governance structures. Quasi-integration, where two or more levels in a supply chain partially integrate through common ownership or other legal partnership, could be a solution for two firms wanting to remain autonomous or not having the expertise required to fully integrate but recognizing the need to align incentives. Both North West Terminal and Pound-Maker are quasi-integrated with grain farmers who are the primary shareholders in each company. While contracting alone, as described earlier, may work in the absence of joint ownership, the fact that the grain producers are shareholders in the ethanol plant decreases (although does not entirely eliminate) the incentive for opportunistic behaviour on the part of grain producers.

In addition to aligning incentives, quasi-integration is an effective strategy for minimizing price risk as a form of hedging. By investing up (down) the supply chain, grain farmers (ethanol plants) provide themselves a measure of protection against substantial increases or decreases in the price of grains. If grain prices are low, ethanol production becomes more profitable, while if grain prices are high, grain production becomes more profitable, *ceteris parabus*. Indeed, in an examination of the combined insights from transaction cost economics and positive agency theory, Mahoney (1992) identified output/input price advantages and joint profit maximization strategies as incentives for vertical financial ownership among firms.

In contrast to quasi integration, full vertical integration occurs when a single firm has complete control (ownership) over an upstream (inputs) and/or downstream (outputs) stage of the supply chain. This can arise in situations where the threat of opportunism is so high that hold-up problems are endemic. In these cases the perceived transaction costs associated with safeguarding an investment are higher than the perceived benefits and the exchange relationship breaks down.

Clearly, there are a number of scenarios under which vertical integration can occur, either upward or downward, along the ethanol supply chain. Indeed, there are several examples of vertical integration in the ethanol industry in Canada that could be interpreted as an attempt to reduce the threat of hold-up. In addition to being a farmer-owned ethanol business, Pound-Maker Investments is also fully integrated down the supply chain with a 30,000 head livestock feeding operation located adjacent to its ethanol plant. Pound-Maker is one of the few ethanol plants that produce wet distillers grains (WDGs) as part of the ethanol production process. Given the asset-specific attributes of WDGs, the threat of opportunism is sufficiently high that it is less costly to internalize the transaction within a single a firm than to transact with independent livestock operations. In addition to reducing the threat of hold-up, the combined operation is able to avoid the heating costs associated with drying its distillers grains, as well as costs associated with transporting these grains to feedlots located elsewhere.

Husky Energy, an Alberta-based energy company, provides a second example of the use of full vertical integration to reduce the risk of hold-up. As a gasoline producer, Husky Energy is mandated by federal and provincial governments to blend all of its fuel with ethanol at specified percentages. Rather than dealing exclusively with independent ethanol producers and risking not being able to ensure a consistent supply of ethanol, Husky Energy constructed high-output ethanol plants (in Lloydminster, Saskatchewan and Minnedosa, Manitoba) thereby internalizing the exchange of ethanol within the firm.

While these examples of vertical integration in the ethanol supply chain may be the exception rather than the rule, they demonstrate the difficulty in predicting when and why firms will choose to vertically integrate up or down the supply chain. In some cases, an initial assessment may suggest that vertical integration is the simplest solution, yet other forms of governance are chosen. This is often a result of challenges associated with vertical integration, including sourcing the necessary capital to purchase or develop a firm with which to integrate, as well as acquiring the knowledge and expertise required to operate what may be a completely new and unfamiliar business with different production processes, thereby going well beyond the core competencies of the firm. Mahoney (1992) categorizes the disincentives to vertical integration as bureaucratic (internal organizational) costs, strategic costs (high exit barriers, sunk investment costs), and production costs (capital costs, operating below capacity). All three are relevant to

ethanol supply chains. Despite these challenges, examples of vertical integration, particularly among larger firms, continue to emerge in the agriculture and energy sectors, and a transaction cost lens provides insights into the drivers for closer integration.

Conclusions

The purpose of this paper was to explore the nature of supply chain relationships in the Canadian ethanol sector within a transaction cost context. By examining three major relationships involving ethanol producers and the firms with which they transact, the paper assesses the extent to which the transaction characteristics of uncertainty, asset specificity and frequency provide incentives for opportunism, leading to increased transaction costs and in extreme cases, hold-up problems.

The analysis suggests that the threat of opportunistic behaviour in transactions involving feedstock grains used for ethanol production is medium to low, and this supply chain relationship is instead shaped by the high levels of uncertainty associated with grain prices/supply. The use of forward contracting to ameliorate these risks has been noted as a dominant strategy among ethanol plants.

Based on the predictions from Transaction Cost Economics we would expect to find closer vertical coordination in relationships between ethanol producers and buyers of distillers grains and buyers of ethanol (i.e. on the output side) than between ethanol producers and sellers of feedstock grains (i.e. on the input side). An examination of the industry in western Canada shows this to indeed be the case in the transaction with ethanol blenders, where either vertical integration or detailed long-term contracts are the norm. This is true to a lesser extent with buyers of distillers grains, where vertical integration occurs (in the case of Pound-Maker) but so too does some fairly basic short-term contracting (North West Terminal and Husky Energy). Perhaps the existence of large storage facilities and the fact that revenue from distillers grains is not the primary source of income in these cases is the reason why closer co-ordination has not been pursued.

A somewhat unexpected finding involves the relationship between ethanol plants and grain producers (sellers of grain feedstocks), where the transaction cost analysis predicts a lower degree of vertical coordination but in fact there exist several examples of quasi or complete vertical integration (Pound-Maker and North West Terminal). In both of these cases the impetus

for ethanol production came from grain producers seeking additional markets for their grain, rather than ethanol plants integrating up the supply chain to reduce transaction costs and the threat of opportunistic behaviour. Indeed, in cases where the ethanol plant is not producer owned and operated, vertical co-ordination with grain sellers tends to be characterized by looser arrangements including simple market specification contracts and spot market transactions. Therefore, an understanding of the impetus behind forward/backward integration, whether led by the ethanol plant or by an adjacent set of supply chain actors, is an important corollary to any supply chain analysis of this sector.

A final observation to emerge from the analysis is that there are numerous factors that can influence the choice of governance structure, and reducing transaction costs is perhaps only one of a number of determinants of the degree of vertical co-ordination. Future analysis could draw upon resource dependence theory, positive agency and property rights approaches to provide a comprehensive understanding of the structure of supply chain relationships. The unique position of ethanol plants at the juxtaposition of multiple supply chains creates a competing set of motivations and demands that also drive governance decisions: whether ethanol plants emerge as a stand-alone investment, as a forward integration strategy by grain farmers seeking a secure output for grains, or as a backward integration strategy by gasoline blenders seeking a secure supply of ethanol, crucially affects the nature and evolution of their supply chain relationships. This remains a rich area for further research.

References:

Altman, I. J.; Klein, P.G.; and T.G. Johnson, 2007. Scale and Transaction Costs in the U.S. Biopower Industry. *Journal of Agricultural & Food Industrial Organization*, 5(1) Article 10.

Altman, I. and T. Johnson, 2008. The Choice of Organizational Form as a Non-Technical Barrier to Agro-BioEnergy Industry Development. *Biomass and Bioenergy*, 32(1): 28-34.

Auld, D. 2008. *The Ethanol Trap: Why Policies to Promote Ethanol as Fuel Need Rethinking*. C.D. Howe Institute, Toronto, Ontario, Canada.

Boger, S. 2001. Quality and Contractual Choice: A Transaction Cost Approach to the Polish Hog Market. *European Review of Agricultural Economics*, 28(3): 241-261.

Cheung, S.N.S. 1969 Transaction Costs, Risk Aversion, and the Choice of Contractual Arrangements. *Journal of Law and Economics*, 43: 23-42.

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

Economic Research Service (ERS). 2011. *US Beef and Cattle Industry: Background Statistics and Information*, United States Department of Agriculture, Economic Research Service, http://www.ers.usda.gov/news (cattle and beef). (Accessed October 26 2011).

Ethanol Producer Magazine. 2009. Canadian Ethanol Plants. November edition

Fearne, A. 1998. The Evolution of Partnerships in the Meat Supply Chain: Insights from the British Beef Industry. *Supply Chain Management: An International Journal*, 3(4): 214-231.

Hobbs, J.E. 1996. A transaction Cost Approach to Supply Chain Management. *Supply Chain Management*: *An International Journal*, 1(2): 15-27.

Hobbs, J.E. 1997. Measuring the Importance of Transaction Costs in Cattle Marketing. *American Journal of Agricultural Economics*, 79(4): 1083-1095

Hobbs, J.E. and L. M. Young. 2000. Closer Vertical Co-ordination in Agri-food Supply Chains: A Conceptual Framework and Some Preliminary Evidence. *Supply Chain Management: An International Journal*, 5(3): 131-143

Holman D. 2009. Personal Communication. Grain Merchant, Northwest Terminal, Unity, Saskatchewan, Canada.

Klein, B., Crawford, R.G. and Alchian, A.A. 1978. Vertical Integration, Appropriable Rents, and the Competitive Contracting Process. *Journal of Law and Economics*, 21(2): 297-326

Mahoney, J.T. 1992. The Choice of Organizational Form: Vertical Financial Ownership Versus Other Methods of Vertical Integration. *Strategic Management Journal*, 13: 559-584.

Ménard, C. and Valceschini, E. 2005. New Institutions for Governing the Agri-Food Industry. *European Review of Agricultural Economics*, 32(3): 421-440.

Natural Resources Canada, 2008. *Canadian Refining and Oil Security*. Oil Division Petroleum Resources Branch. Ottawa, Ontario, Canada.

North, D.C. 1984. Transaction Costs, Institutions, and Economic History. *Journal of Institutional and Theoretical Economics*, 140: 7-17.

Pound-Maker Website, 2010. http://www.pound-maker.ca/. Accessed March 2010.

Reuve, K., 2009. Personal Communication. Ethanol Plant Manager, Pound-Maker Investments Ltd., Lanigan, Saskatchewan, Canada.

Simon, H. 1961. *Administrative Behaviour*, 2nd edition, Macmillan, NY: New York

Sporleder, T.L. 1992. Managerial Economics of Vertically Coordinated Agricultural Firms. *American Journal of Agricultural Economics*, 74(5): 1226-31.

Williamson, O. E., 1979. Transaction Cost Economics: The Governance of Contractual Relations. *Journal of Law and Economics*, 22: 233-62.

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

Williamson, O. E., 2002. The Theory of the Firm as Governance Structure: From Choice to Contract. *Journal of Economic Perspectives*, 16(3): 171-195.