International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Reducing Hold-up Risks in Ethanol Supply Chains: A Transaction Cost Perspective

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Abstract

Ethanol plants sit at the intersection of three main supply chains, involving the procurement of feedstocks and the marketing of ethanol and distillers grains. A transaction cost framework assesses the extent to which uncertainty, asset specificity, and transaction frequency create incentives for opportunistic behavior by exchange partners leading to problems of hold-up. Using case study evidence from the western Canadian ethanol sector, solutions to the hold-up risks facing ethanol plants are explored. Contracting and integration feature strongly in downstream output markets. The positioning of the ethanol enterprise within a firm's overall business model, whether as a stand-alone investment or as a forward or backward integration strategy, is an important consideration for future supply chain research in this sector.

Keywords: vertical coordination, opportunism, asset specificity, distillers grains, feedstocks.

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Introduction

The biofuel sector in many countries has undergone rapid development over the past decade, with ethanol, in particular, emerging as a major biofuel in the U.S. and Canada. While public sector subsidization or market interventions in the form of blending mandates frequently played a role in encouraging initial investments in the sector, 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. The structure of supply chain relationships in the ethanol sector affects the security and stability of critical input supplies, as well as the stability of output markets for an ethanol plant, and is the focus of this paper.

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 includes not only ethanol for fuel, but also co-products used in livestock feeding. Managers of ethanol plants must therefore coordinate supply chain relationships within three quite distinct sectors, facing different market conditions and sources of risk. Of interest therefore is the source and incidence of transaction costs that underpin the relationships, and the strategies which incumbent firms have taken to mitigate these transaction costs. Indeed, a striking feature of the North American ethanol sector is the existence of an array of governance mechanisms within input and output supply chains, from spot market transactions, to contracts, and vertical integration.

Transaction Cost Economics (TCE) (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. The approach has been applied extensively to numerous aspects of agri-food supply chains (see for example, 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, and make a strong case for the use of a transaction cost approach to examine organizational structures in the emerging bioenergy sectors, although their analyses do not focus solely on 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 and a lens through which to examine the juxtaposition of the multiple supply chain relationships that characterize the business environment for an ethanol plant. A particular focus of the analysis in this paper is the identification of contractual hazards, opportunism and uncertainty within these supply chain relationships. A case study analysis of three ethanol plants characterized by very different approaches to supply chain governance is provided. This paper addresses a research gap in the bioenergy economics literature by bringing an economics of governance lens to the bioenergy sector.

Following the introduction, an overview of the Canadian ethanol sector and its primary supply chains is presented. Insights from the TCE literature are then used to outline the expected relationships between transaction characteristics, transaction costs and governance outcomes in a

conceptual model. Applying this frame to the ethanol sector, the transaction characteristics that influence transaction costs in the input and output supply chain relationships facing ethanol plants are identified, along with an assessment of the threat of opportunism and hold-up in each case. Supply chain governance structures that reduce these transaction costs and mitigate hold-up risks are then assessed, using case study evidence from the ethanol sector in western Canada. The paper concludes with a discussion of the implications of the analysis for business management scholars and suggestions for further research.

The Canadian Ethanol Sector

A standard North American first generation ethanol plant uses wheat or corn as its primary feedstock and produces ethanol, as well as co-products in the form of wet or dried distillers grains (WDGs/DDGs) for livestock feed. 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), are primarily located in those areas[1]. In 2010 there were seven ethanol plants in Ontario, one in Quebec, and eight in the Prairie provinces (five of which are in Saskatchewan) (Canadian Renewal Fuels Association, 2013). Depending on the cost and availability of local feedstocks, some ethanol producers also import corn from the US to maintain their ethanol stream. Total ethanol production capacity (operational and under construction) in Canada in 2010 was approximately 2 billion litres, with approximately 78% generated from corn feedstocks and 30% from wheat (Canadian Renewable Fuels Association, 2013)[2].

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. Fuel blenders/refiners are major purchasers of ethanol. The Canadian fuel blending/refining sector is highly concentrated, 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 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 significant industry concentration is exacerbated by the high cost

[1] Second-generation ethanol production, which uses organic wastes as fuel, is a relatively minor contributor to 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. Consideration of the supply chain relationships for second-generation ethanol plants is beyond the scope of the present paper, and represents a fruitful area for further research, in particular, the extent to which holds-up exist which impede more extensive investment in the commercialization of second generation ethanol technologies.

[2] As two Canadian ethanol plants are able to use either corn or wheat feedstocks, the percentages do not sum to 100.

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 close to the final 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 consequently are usually only sold to beef 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.

From the above discussion it is clear that the Canadian ethanol sector sits at the intersection of three main supply chains: feed grains, gasoline, and livestock production. The major participants and supply chain transactions in the ethanol sector are summarized in Figure 1, which is a stylized representation of ethanol supply chain relationships focusing on the key transactions[3]. Including the ethanol plant, there are four major supply chain participants, each engaging in separate transactions (T1-T3) with the ethanol plant. 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. The paper explores three main research questions: (i) what are the sources of opportunism and potential hold-up in ethanol supply chains; (ii) how are these potential hold-ups expected to affect transactions costs in ethanol supply chains; and (iii) what supply chain governance strategies are in use to mitigate hold-up risks? The paper builds upon an existing body of literature examining governance structures within vertical supply chains (see for example, Zylbersztajn and Farina, 1999; Hobbs and Young, 2000; Raynaud et al., 2005). The next section outlines insights from the TCE literature that inform the conceptual framework used in the case study analysis.

[3] In a similar approach, Raynaud et al. (2005) analyses governance mechanisms in European agri-food supply chains as a series of transactions.

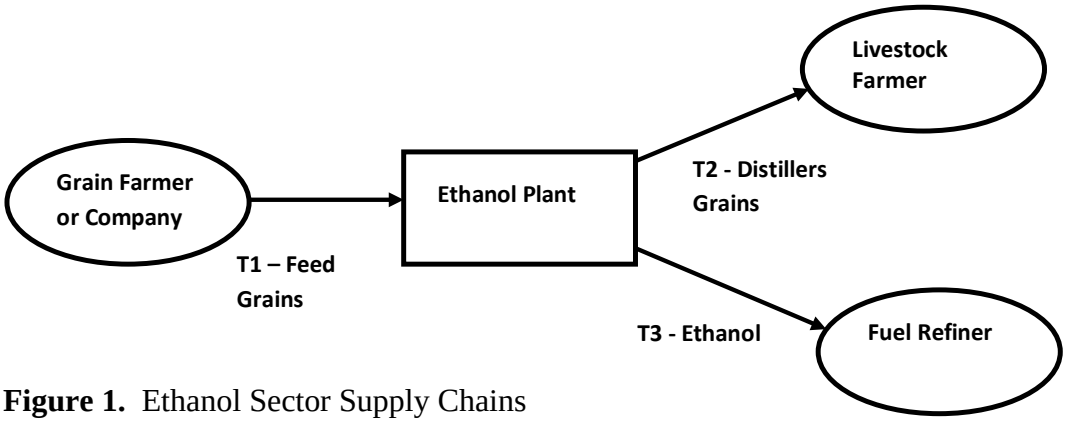

Figure 1. Ethanol Sector Supply Chains

Sources and Outcomes of Transaction Costs

The TCE literature has its roots in the original insights by Coase (1937) 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. Transaction costs include the costs associated with activities carried out in preparation for, and after, an exchange. Transaction costs arise both prior to an exchange (*ex ante*), and after an exchange has occurred (*ex post*). *Ex ante* transaction 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. *Ex post* transaction 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 honored, and in seeking recourse in the event of breach of contract or maladaptation of exchange terms (Hobbs, 1997).

According to Williamson (1979, 2005), the governance structure that emerges will be the organizational form which minimizes the sum of production and transaction costs. In particular, he argues that the comparative efficiency of alternative modes of governance depend on the attributes or characteristics of the transaction, thereby allowing the development of testable hypotheses or predictive assertions linking transaction characteristics to expected governance outcomes. 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.

Two behavioral assumptions underpin the transaction cost approach: *bounded rationality* and *opportunism. Bounded rationality* recognizes that although individuals and firms intend to make rational decisions, they are limited in doing so by their cognitive abilities (Simon, 1961). It is not physically possible to evaluate all potential outcomes of a particular decision. *Opportunism* is defined by Williamson (1979) as self-interest seeking with guile. Vulnerability to opportunistic behavior increases in the presence of small numbers bargaining where there are few alternative suppliers of key inputs or buyers of outputs.

A rich literature has emerged expanding upon the determinants and outcomes of transaction costs in the context of the opportunism problem. Dahlstrom and Ngaard (1999) present a theoretical model that frames opportunism as a determinant of transaction costs and examines control structures that alleviate opportunism. In their model, interfirm cooperation and formalization of contractual relationships influence the prevalence of opportunistic behavior, while firms incur bargaining (negotiation) costs, monitoring, enforcement and maladaptation costs in mitigating the effects of or controlling opportunism. Thus, opportunism leads to transaction costs. Similarly, Jap and Anderson (2003) discuss how a number of relationship safeguards are used to mitigate opportunistic behavior, including incentive structures and contractual provisions, monitoring, reputation, norms and trust. In an analysis of franchisor-franchisee relationships, Wathne and Heide (2000) distinguish between blatant or strong-form opportunism and passive opportunism, arguing that these arise differently depending on the exchange context – whether a new or existing relationship. Examples of strong-form or blatant opportunism include deliberate misrepresentation or abrogation of contract terms, while passive opportunism arises from a failure to act, such as failures to disclose information or refusals to adapt. Vulnerability to opportunism is therefore a key driver of transaction costs and governance outcomes.

In his original work, Williamson (1979) identifies three transaction characteristics that influence governance outcomes in the presence of opportunism and bounded rationality, namely uncertainty, asset specificity, and frequency. *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 arises when assets possess physical characteristics that are specific to a certain transaction and have little value in alternative uses. Dedicated assets are created 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 refers to investments 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.

Once a specific asset is committed to an exchange, the owner of the asset is vulnerable to opportunistic behavior 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 if a specific investment is made can prevent an exchange from occurring altogether. This is a source of ex ante “hold-up”.

Increased asset specificity usually results 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. To a large extent, asset specificity has been the primary focus of much of the subsequent TCE literature.

Ceteris paribus, increased *uncertainty* will lead to closer vertical coordination, as reducing uncertainty through increased coordination 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* behavior is known to be desirable. Many sources of uncertainty exist and can be broadly categorized as environmental (or external) uncertainty and behavioral (or internal) uncertainty (Robertson and Gatingnon 1988; Walker and Weber 1984). Environmental uncertainty includes both demand and supply (volume) uncertainty, leading to uncertainty over prices, as well as technological uncertainty. Behavioral uncertainty arises with respect to the actions of key transaction partners or in assessing the performance of the business relationship with suppliers or buyers[4]. Uncertainty is closely related to contract incompleteness: in the absence of uncertainty, buyers or sellers can specify all relevant contingencies in an enforceable contract. Conversely, uncertainty over the price and/or supply of inputs, the price of outputs or the actions of transaction partners increases the transaction costs of drawing up and enforcing contractual agreements.

The effect of *frequency* on vertical coordination 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 behavior increases. An alternative view holds that frequently occurring transactions lend themselves to more closely coordinated 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 coordination 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.

A related point is the role of trust in reducing transaction costs. Williamson (1993) observes that trust is an elusive concept, with many meanings, and argues (controversially) that most business relationships characterized as trust-based relationships have other explanations, such as a self-

[4] In an analysis of the classic "make or buy" decision, Walker and Weber (1984) focus on two types of external uncertainty: volume uncertainty and technological uncertainty. The authors argue that volume uncertainty creates unexpected production costs or unexpected excess capacity for suppliers and stock-outs or excess inventory for buyers. Volume uncertainty is hypothesized to lead to a "make" rather than a "buy" decision. As Robertson and Gatignon (1998) point out, the effect of technological uncertainty is less clear: while some studies hypothesize that technological uncertainty increases the costs of recontracting, thereby favoring vertical integration, other researchers have found the opposite relationship, whereby flexible organizational structures are better able to respond quickly to a changing technological environment (Robertson and Gatignon, 1988)

enforcing institutional environment—including the presence of social network or community reputation effects that penalize opportunistic behavior—or differences in risk attitudes, knowledge and experience. Other authors, however, have argued that trust and trust-based relationships exist, and a considerable literature has emerged exploring the role of trust in the development of sustainable supply chain relationships (see for example, Fischer et al. 2009; Morgan and Hunt 1994). Gulati (1995) examines the emergence of interfirm trust from repeated alliances between the same firms, arguing that experience engenders trust among partners and trust reduces the transaction costs of their future alliance relationships. Trust therefore reduces behavioral uncertainty.

To summarize, asset specificity, uncertainty, frequency and opportunism are core concepts underpinning the TCE literature. Figure 2 maps out the relationships between these concepts and is the basis of the transaction cost analysis of ethanol supply chains used in this paper. Thus, the extent to which asset specific investments are required, the degree of environmental and behavioral uncertainty within which a transaction is conducted, and the frequency of transactions influence the threat of opportunism and risk of hold-up. Ex ante and ex post transaction costs are incurred in an attempt to mitigate the threat of opportunism, and determine the relative efficiency of different governance outcomes, whether spot markets, hybrids, or vertical integration. If effective, these governance outcomes mitigate vulnerability to opportunism and reduce transaction costs, as shown by the feedback arrows in Figure 2. The next section identifies the transaction characteristics and sources of hold-up in ethanol supply chains.

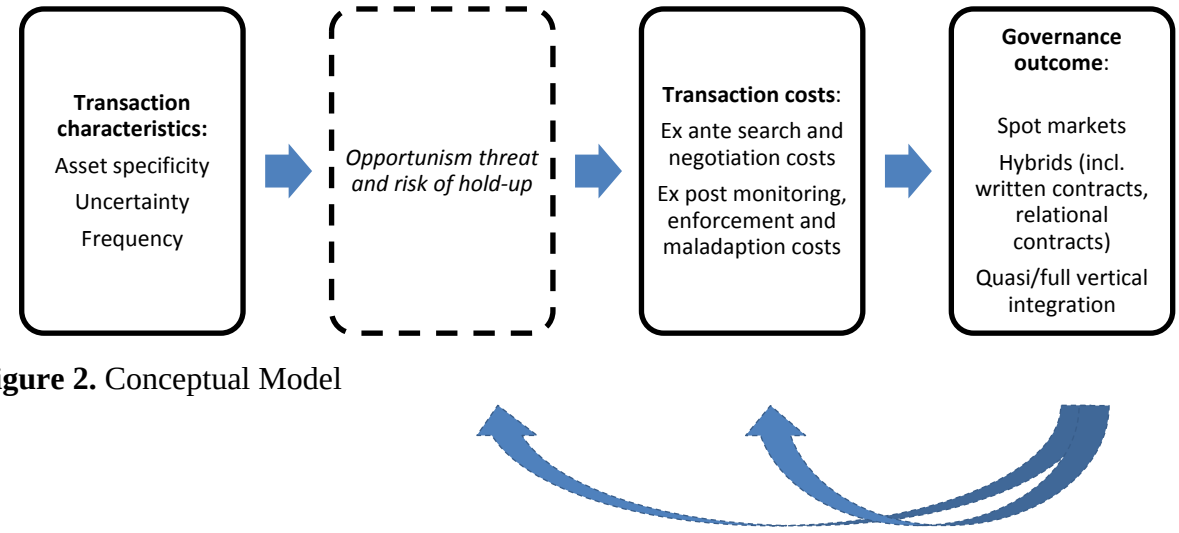

Figure 2. Conceptual Model

Transaction Characteristics and Hold-ups in Ethanol Supply Chains

The transaction cost analysis of ethanol supply chains presented below examines the supply chain relationships illustrated in Figure 1 in the context of the conceptual model presented in Figure 2. An assessment of the degree of asset specificity, uncertainty, and transaction frequency at each supply chain interaction is used to identify potential sources of transaction costs and the extent to which ethanol plants are vulnerable to opportunistic behavior by their exchange

partners. This allows inferences as to the types of governance structures that are expected to reduce transaction costs.

In each relationship, it can be assumed that bounded rationality is endemic: it exists for both parties. For example, managers of an ethanol plant face bounded rationality in determining input prices for feedstocks: 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. Similar environmental uncertainties exist at the ethanol plant-fuel refiner interface.

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. 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. In particular, wet distillers grains suffer from a degree of time specificity since their quality deteriorates rapidly if they are not sold and consumed relatively quickly. 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.

Potential opportunistic behavior includes grain producers reneging upon a prior agreement to deliver grain feedstocks 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. *Ex ante* transaction costs arise in the identification of a consistent and reliable source of inputs (e.g. feedstocks), or in negotiating forward contracts or supply agreements with grain producers. Examples of *ex post* transaction costs 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 risks and transaction costs in the context of the three supply chains relationships for ethanol plants.

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 (T1 in Figure 1). 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. In a survey of the procurement and marketing practices of 60 U.S. ethanol producers, Schmidgall et al. (2010) report that the vast majority (73%) of plants are limited to one type of feedstock, and for the most part this is also true of the Canadian ethanol sector. 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 behavior on the part of the ethanol plant. Similarly, given the large number of potential grain producers with whom to transact, the consequences of any individual grain producer acting opportunistically against the ethanol plant is unlikely to 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[5]. 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[6]. Moreover, a region with 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.

Turning to transaction frequency, ethanol plants 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 incentive for ethanol producers to transact with a grain company or perhaps a large producer group (e.g. a cooperative) rather than with individual farmers may be higher, since this enables 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 build trust and provide a disincentive for opportunistic behavior because this would jeopardize future transactions. In this regard, transaction frequency should mitigate the incentive for opportunistic behavior, lowering transaction costs and allowing looser forms of coordination. In a spot market situation, monitoring and enforcement costs are expected 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, monitoring and enforcement costs are incurred in ensuring that delivery occurs in a timely manner. In such cases, the ethanol plant will have an incentive to seek closer vertical coordination with its grain suppliers.

In the context of uncertainty, the price and supply of feed grains are relevant for both grain feedstock suppliers and ethanol plant operators. As grain prices are influenced by developments in the ethanol industry, the livestock sector, and in the grain farming industry, forecasting supply volumes and therefore long run prices is fraught with uncertainty, and there is evidence that ethanol plants regard input costs and securing predictable feedstock supplies as some of the most challenging aspects of their business (Schmidgall et al. 2010). 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 delivery volumes and prices can be agreed upon well in advance of delivery, for example, through forward contracting.

[5] At the time their survey was conducted, Schmidgall et al. (2010) report little concern among U.S. ethanol plants with respect to the availability of feedstocks, however, the extent to which this has remained the case given price volatility in the grains sector since 2008 remains to be seen.

[6] 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).

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 behavior if the relationship is perceived as a "captive" market. If through repeated transactions trust is established, however, 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 volumes and prices, be it due to weather-induced forage deficiencies in the livestock sector or weather-induced differences in crop quality in the grain sector. Either situation, in the short term, would 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 often determine 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 behavior by buyers (livestock farmers). The specificity of distillers grains occurs in several forms, including time specificity, physical asset specificity, and in some cases, dedicated specificity. Time specificity occurs because distillers grains in their original wet form are perishable and expensive to transport long distances. For this reason, WDGs tend to transported over distances of less than 200km prior to being consumed by livestock. 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 supply chain coordination through forward contracting or vertical integration between an ethanol plant and livestock feeding operations.

The threat of opportunistic behavior by buyers of distillers grains is exacerbated by the oversupply of these grains resulting from rapid expansion in ethanol plant capacity. Current and projected ethanol production across North America is estimated at almost 60 billion litres[7] (Nebraska Energy Office 2013; Canadian Renewable Fuels Association 2013). The WDGs resulting from a 12.5 million litre ethanol plant operated by Pound-Maker Agventures in Saskatchewan, for example, provides protein rations for between 36,000 and 48,000 head of cattle annually in the company's adjacent feedlot (Pound-Maker Annual Report 2012). Applying this ratio to total US and Canadian ethanol capacity, 60 billion litres would produce enough

[7] Approximately 16 billion U.S. gallons

distillers grains to feed around 170 to 225 million head of cattle annually. As of January 2012, the total cattle herd in the US and Canada was estimated to be approximately 103 million including calves (ERS 2013), 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 requires 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 environmental uncertainties further enhance the incentives for increased vertical coordination between ethanol producers and livestock producers.

A final relevant 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 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. Repeated transactions build trust. As is the case with feedstock grains, this reduces the risk of opportunistic behavior given the importance of reputation in sustaining ongoing business relationships. Nevertheless, these relationships could evolve into closer coordination 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 ethanol 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[8].

Ethanol production has asset specific characteristics that create vulnerability to opportunistic behavior. 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 coordinated relationship with gasoline-ethanol blenders.

[8] 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)

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. 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 may 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 behavior by fuel blenders. Ethanol plants are 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[9].

Uncertainty associated with input prices in both industries is a strong incentive for closer supply chain coordination for both ethanol producers and blenders. For ethanol producers, there is uncertainty with respect to the supply and price of feedstock grains and, to a lesser extent, the price of utilities. For blenders, the uncertainty is related to the price of oil and to a lesser extent the price of ethanol, which factor into demand uncertainty. In this regard, both parties benefit by negotiating a long-term price for ethanol. With more certainty about the demand for and 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 and are better able to forecast their feedstock demands. This represents a further incentive for ethanol plants to seek closer vertical coordination with fuel blenders, rather than relying purely on the spot market to sell ethanol.

A final characteristic of the relationship between ethanol producers and blenders that affects governance outcomes is the frequency with which these transactions occur. The relatively high degree of concentration that exists in both the ethanol production and blending industries suggests that transactions between firms are highly frequent. As is the case in each of the other relationships discussed, this has ambiguous implications for the vertical coordination 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 coordination in each of the relationships described above and are considered within the context of the conceptual framework outlined in Figure 2. Table 1 summarizes the transaction characteristics for the three major supply chain 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 behavior by trading partners. The governance outcomes that are expected to arise as a result of the threat of hold-up are also indicated in the table.

For transactions involving feedstock grains used for ethanol production, Table 1 suggests that the threat of opportunistic behavior and the resulting degree of vertical coordination is medium to low. While complete vertical integration is unlikely, neither is relying solely on spot market

[9] Interestingly, Schmidgall (2010) find that 'government policy' was the second most important challenge identified by U.S. ethanol producers (after input costs).

transactions, therefore marketing contracts or another form of hybrid relationship is expected 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, strengthens the case for closer vertical coordination in the form of long-term contracts, quasi or full integration (hierarchy). The following section examines in more detail the type of governance structures that mitigate opportunism risks and facilitate a reduction in transaction costs, drawing upon case study evidence from the ethanol sector in western Canada.

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

	Transaction Characteristics			**Hold-Ups and Governance Outcomes**	
Relationship S=Seller; B=Buyer	*Supply/Demand Price Uncertainty*	*Transaction Frequency*	*Asset Specific Investment*	*Opportunistic Threat*	*Vertical Coordination*
Ethanol Inputs ***Transaction 1 (Feedgrains)*** Feed (S) Ethanol Producer (B)	High	High	-No	Medium/Low	Mixed: Spot markets, marketing contracts
Ethanol Outputs ***Transaction 2 (DDGs/WDGS)*** Ethanol Producer (S) Livestock Producer (B)	High	High	-Yes	High	Hybrids & Hierarchy: Contracts & integration
Transaction 3 (Ethanol) Ethanol Producer (S) Ethanol Blender (B)	High	High	-Yes	High	Hybrids & Hierarchy: Contracts & integration

Mitigating Hold-Up Risks: Case Study Evidence of Governance Outcomes

Having identified relationships along the ethanol supply chain where the risk of opportunistic behavior 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 (hierarchy). If the risk of opportunism is perceived to be low, simple spot market exchanges may be the preferred method of exchange. The analysis draws upon case study evidence from three ethanol plants in western Canada: Husky Energy Inc., North West Terminal Ltd., and Pound-Maker Agventures Ltd. Together these three plants represent approximately 30% of the ethanol production capacity in the Canadian prairies. Given their location, all three plants use wheat as a feedstock, and range in

size from an annual capacity of 12.5 million litres (Pound-Maker) to 130 million litres (Husky Energy), thereby capturing among the smallest and largest capacity commercial ethanol producers on the prairies (Canadian Renewal Fuels Association, 2010). These firms were chosen for the case study analysis because they are located in the same geographic region within western Canada and because they operate very different business models in terms of size, scope and the core focus of the business activity. As such, the case studies offer insights into how supply chain relationships differ across the sector and are affected by the positioning of ethanol production within the broader business model of the enterprise. As is explained in more detail below, Husky Energy Inc. is primarily an energy producer and fuel refiner, North West Terminal Ltd is a farmer-owned inland grain terminal, while Pound-Maker is an integrated cattle feedlot-ethanol producer. Information for the case studies was gathered through document analysis and interviews with key industry stakeholders. Focusing on governance outcomes, the analysis explores the use of spot markets, contracts and vertical integration by these three western Canadian ethanol producers.

Spot Markets

Spot market transactions usually arise where the threat of opportunistic behavior 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 exist of spot market transactions in the ethanol sector and are worth exploring. One example is the sale of DDGs by North West Terminal Ltd. to livestock farmers across the Canadian Prairies. Located in Saskatchewan, North West Terminal is a producer-owned inland grain terminal which diversified into ethanol production in recent years. With an annual capacity of 25 million litres, the plant lies below the median plant capacity for the region (42 million litres). 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, supplying a range of livestock feed requirements. Offering more feed options than ethanol plants selling only distillers grains gives North West Terminal a potential 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 the company to accommodate changes in demand that occur throughout the year (Holman 2009).

Ethanol plants can make use of spot market transactions to procure grain feedstocks. Although a majority of grain is contracted with grain farmers well in advance (described below), most ethanol plants 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 (marketing) contracts where key elements of the marketing of the product (price, delivery details, etc.) are specified but control over production remains with the seller; to 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 behavior 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 or inputs. Safeguards often also 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 are needed. Instead various types of marketing contracts tend to be used, with two parties agreeing 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, both parties benefit from reducing price uncertainty.

Numerous examples exist of the use of market-specification contracts by ethanol producers to reduce price and supply 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). The ethanol plant owned by Husky Energy in Lloydminster, Saskatchewan offers local grain farmers a similar option to enter into market-specification advance contracts. Survey evidence from Schmidgall et al. (2010) confirms similar findings in the U.S. ethanol sector, with (in addition to cash sales) a variety of procurement contracts used to source feedstocks, including forward contracts, basis contracts, delayed price contracts, and minimum price contracts.

Contracting is also a common feature on the output side of ethanol supply chains (T2 and T3 in Figure 1). 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. Finally, Husky Energy markets its DDGs through a long-term relationship with a third party firm, Wilbur-Ellis, which specializes in the marketing and distribution agricultural products through its feed and agribusiness divisions.

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 due 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 these problems occur periodically in both Canada and the US, and are 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 behavior, quasi or full integration are more efficient 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 behavior 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 decreases (increases) 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 paribus*. 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 (input) and/or downstream (output) stage of the supply chain. If the threat of opportunism is so high that hold-up problems are endemic, the perceived transaction costs associated with safeguarding an investment are higher than the perceived benefits and the exchange relationship breaks down. Vertical integration mitigates these hold-ups.

Clearly, there are a number of scenarios under which both forward and backward vertical integration can occur in the ethanol sector. There are several examples of vertical integration in the western Canadian ethanol industry 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 Agventures is also fully integrated down the supply chain with a 28,500 head livestock feeding operation located adjacent to its ethanol plant. Pound-Maker is one of the few ethanol plants that produce wet distillers grains 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 Inc., 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 being unable to ensure a consistent supply of ethanol, Husky Energy constructed high-output ethanol plants (in Lloydminster, Saskatchewan and Minnedosa, Manitoba—both with 130 million litre capacities) 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 an existing firm or develop a new integrated business venture, 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 has been to explore the nature of supply chain relationships in the western Canadian ethanol sector within a transaction cost context. By examining three major relationships involving ethanol producers and the actors 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. Table 2 compares the theoretical predictions for governance structure outcomes with the results from the case study analysis of the three firms.

Table 2. Theoretical Predictions and Case Study Outcomes

	Governance Prediction	**Case Study**	**Governance Outcomes**
Transaction 1 (Feedgrains)	Spot markets & marketing contracts	NWT[a]	Marketing contracts/quasi integration Spot market-residual supply
		Poundmaker	Marketing contracts/quasi integration Spot market- residual supply
		Husky Energy	Marketing contracts Spot market-residual supply
Transaction 2 (DDGs/WDGs)	Long-term contracts and integration	NWT	Spot market
		Poundmaker	Vertical integration
		Husky Energy	Contract/alliance
Transaction 3 (Ethanol)	Long-term contracts and integration	NWT	Contracts
		Poundmaker	Contracts
		Husky Energy	Vertical integration

Notes. [a] NWT = Northwest Terminal, Ltd.

Based on the predictions from TCE we would expect to find closer vertical coordination in relationships between ethanol producers and buyers of distillers grains (T2) and buyers of ethanol (T3) (i.e. on the output side) than between ethanol producers and sellers of feedstock grains (T1) (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 coordination has not been pursued.

A somewhat unexpected finding involves the relationship between ethanol plants and grain producers (sellers of grain feedstocks) (T1), where the transaction cost analysis predicts a lower degree of vertical coordination but in fact there exist several examples of quasi 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 behavior. Indeed, in cases where the ethanol plant is not producer owned and operated, vertical coordination 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.

The three ethanol plants used in this case study analysis were chosen to illustrate different approaches to the management of supply chain relationships within the ethanol sector, therefore, the results of the case study analysis are somewhat determined by the choice of these three firms. While this is a potential limitation of the current analysis, the intent has been to illustrate how TCE can shed light on supply chain governance and to identify the varied means by which firms mitigate potential sources of opportunism and hold-up within the ethanol sector. While detailed information on all of the contracting strategies used by these firms was not available, the framework presented in this paper offers a basis for further in-depth analysis of contracting strategies, analysis of the development of new ethanol supply chains in other regions, or of the development of second generation ethanol plants using cellulosic feedstock technologies.

A final observation to emerge from the analysis is that several factors evidently influence the choice of governance structure, such that reducing transaction costs is perhaps only one of a number of determinants of vertical coordination strategies. 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 fuel 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 by business management scholars.

Acknowledgements

Research funding from the Feed Opportunities from the Biofuels Industries (FOBI) Research Network, an Agriculture and Agri-Food Canada funded Agriculture and Bioproducts Innovation Program (ABIP) grant, is gratefully acknowledged.

References

Altman, I. J.; P.G. Klein 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. Available at http://www.bepress.com/jafio/vol5/iss1/art10.

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.

Canadian Renewable Fuels Association. 2013. Industry Information. Plant Locations. http://www.greenfuels.org/en/industry-information/plants.aspx (Accessed August 14 2013).

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.

Dahlstrom, R. and A. Nygaard. 1999. An Empirical Investigation of Ex Post Transaction Costs in Franchised Distribution Channels. *Journal of Marketing Research* 36(2):160-170.

Economic Research Service. 2013. Statistics and Information: US Beef and Cattle Industry, United States Department of Agriculture, Economic Research Service, http://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx (Accessed August 14 2013).

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.

Fischer, C., M. Hartmann, N. Reynolds, P. Leat, C. Revoredo-Giha, M. Henchion, L. M. Albisu and A. Gracia. 2009. Factors Influencing Contractual Choice and Sustainable Relationships in European Agri-Food Supply Chains. *European Review of Agricultural Economics* 36(4):541-569.

Gulati, R. 1995. Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances. *The Academy Management Journal* 38(1):85-112.

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.

Jap, S.D. and E. Anderson. 2003. Safeguarding Interorganizational Performance and Continuity Under Ex Post Opportunism. *Management Science* 49(12):1684-1701.

Klein, B., R.G Crawford and A.A Alchian. 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 E. Valceschini. 2005. New Institutions for Governing the Agri-Food Industry. *European Review of Agricultural Economics* 32(3): 421-440.

Morgan, R.M. and S. D. Hunt. 1994. The Commitment-Trust Theory of Relationship Marketing. *Journal of Marketing* 58(3):20-38.

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

Nebraska Energy Office. 2013. Ethanol Facilities Capacity by State and Plant. Official Nebraska Government website, Nebraska Energy Office, Energy Statistics. http://www.neo.ne.gov/statshtml/122.htm Accessed August 15, 2013.

Ng, D. and P.D. Goldsmith. 2010. Bio Energy Entry Timing from a Resource Based View and Organizational Ecology Perspective. *International Food and Agribusiness Management Review* 13(2): 69-100.

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

Pound-Maker Investments Ltd. 2012. *Pound-Maker Investments Ltd 2012 Annual Report* 50pp. http://www.pound-maker.ca/. Accessed August 15, 2013.

Raynaud, E, L. Sauvee and E. Valceschini. 2005. Alignment between Quality Enforcement Devices and Governance Structures in the Agro-Food Vertical Chains. *Journal of Management and Governance* 9:47-77.

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

Robertson, T.S. and H. Gatingnon. 1998. Technology Development Mode: A Transaction Cost Conceptualization. *Strategic Management Journal* 19:515-531.

Schmidgall, T.K., K.W. Tudor, A.D. Spaulding, and R.J. Winter. 2010. Ethanol Marketing and Input Procurement Practices of U.S. Ethanol Producers: 2008 Survey Results. *International Food and Agribusiness Management Review* 13(4): 137-156.

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.

Walker, G. and D. Weber. 1984. A Transaction Cost Approach to Make-or-Buy Decisions. *Administrative Science Quarterly* 29(3):373-391.

Wathne, K.H. and J.B. Heide. 2000. Opportunism in Inter-firm Relationships: Forms, Outcomes and Solutions. *Journal of Marketing* 64(4):36-51.

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. 1993. Calculativeness, Trust and Economic Organization. *Journal of Law and Economics* 36:453-486.

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

Williamson, O.E. 2005. The Economics of Governance. *American Economic Review* 95(2):1-18.

Zylbersztajn, D. and E.M.M.Q. Farina. 1999. Strictly Coordinated Food Systems: Exploring the Limits of the Coasian Firm. *International Food and Agribusiness Management Review* 2(2): 249-265.

