Agribusiness and Applied Economics Report No. 737 March 2015

VALUING SWITCHING OPTIONS IN INTERNATIONAL GRAIN MARKETING

Stephan Johansen
William Wilson
Bruce Dahl

Department of Agribusiness & Applied Economics
Agricultural Experiment Station
North Dakota State University
Fargo, ND 58108-6050

Acknowledgements

The authors would like to acknowledge the helpful comments on an earlier review of this manuscripts by Drs. Ryan Larsen, Greg McKee and William Nganje.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

VALUING SWITCHING OPTIONS IN INTERNATIONAL GRAIN MARKETING

ABSTRACT: An important strategy of commodity trading firms is geographical diversification and vertical integration, often justified with the need for multiple origins. This strategy can be interpreted as a 'switching option'. Strategic options have become increasingly apparent and important, but, tend to be undervalued using traditional valuation techniques. This paper develops a stochastic real options model to value networks of export elevators. It is applied to soybean trading for shipments from ports in the United States, Brazil and Ukraine. The paper estimates the option value of being able to switch origins in export trades. This value is determined by the distributions of margins and their correlations in a switching option algorithm. The results are roughly comparable to observed recent trade values of representative assets.

Key words: Switching options, vertical integration, export elevators, asset valuation

VALUING SWITCHING OPTIONS IN INTERNATIONAL GRAIN MARKETING

Introduction

An important strategy for commodity trading firms is to expand their origin networks and geographical reach. Expanding networks by acquiring strategically located assets, gives trading firms the opportunity for spatial arbitrage. Most firms indicate that a major reason for these strategic initiatives is for multiple origins to serve customers. This can be interpreted as a 'switching option' and can be valued using real option methodologies. There is a tendency to underinvest in strategic assets due to being undervalued if conventional techniques are used. The value of these strategic assets depend on the composition of existing assets. It also depends on volatility of spatial arbitrage margins and correlations among them.

International expansion and diversification, by trading firms provides a switching option, i.e., the option to switch where to originate commodity shipments. The purpose of this study is to estimate the value of switching options in international soybean trade. Specifically, we develop a stochastic binomial real option model to estimate values of assets with embedded flexibility called a switching option. The model derives the value of assets and how the switching option alters the distribution (risk) of profits in grain trading.

The network of physical assets modelled are export elevators located in the U.S. Pacific North West (PNW) and Gulf (USG), Brazil (Paranaguá), and the Ukraine (Black Sea) for shipments to China (Qingdao), the largest soybean market in the world. Results provide a quantitative estimate of the option value due to switching when operating geographically diversified networks of export elevators. These synergy effects are determined by two major factors: (1) the probabilities of positive spatial arbitrage margins for each export elevator, and (2) the correlation among spatial arbitrage profit opportunities.

Background and Related Studies

One of the important principals of industrial strategy is 'commitment' and ultimately to the ability to create flexibility, which gives the firm *option value* (Bensanko, Dranove and Shanley, p. 343, 1996; Dixit and Pindyck, 1994). This concept applies to many industries, but has become increasingly important in trading industries. The significance of options was recently highlighted in energy trading (Meersman, Reichtsteiner, and Sharp, 2012; Pirrong, 2014) but the analytics has not been developed in agricultural trading. Trading firms must exploit options embedded in their portfolio of assets. The value of optionality depends on the value of the commodity, price (or, margin) volatility, and the frequency and magnitude of events that disturb equilibrium prices (i.e. "grey swan" events). Importantly, Meersman, Reichtsteiner, and Sharp (2012) show how size and vertical integration matters across physical trading markets. First movers to grey swan events (PWC 2012), have the best opportunity to capture profits. Consequently, trading firms need global coverage and must become masters of optionality, they need complex networks of assets, and should develop long term agreements (Meersman, Reichtsteiner and Sharp, 2012; Pirrong, 2014). This suggests that successful trading firms are those that are vertically integrated with optional origins, and that the latter should be interpreted, and valued as real options.

Grain Trading Industries and Optionality

A similar evolution has been evolving in grain trading. Earlier studies suggested there were two sources of economies of scale (Caves, 1977). One is intangible and related to knowledge. International trading firms with knowledge about sea routes captured larger profits. Over time, other elements of price information became important and more transparent; even though commodity firms struggle to keep price data less transparent. The opaqueness of information is rapidly changing with more internet based information. The second source of competitive advantage, the economies of scale attributed to physical assets and capital, could be protected by building networks across geographical regions. To protect this advantage, commodity trading firms pursue acquisitions (Meersman, Reichtsteiner and Sharp 2012) to create optionality. The grain trading industry evolved from being highly vertically non-integrated (i.e., trading firms operating without extensive assets) to now one of being dominated by firms that are highly vertically integrated (Wilson and Dahl 1999) and geographically diversified. Further, most firms now recognize the strategic importance of diversified origination capabilities which can be interpreted as switching options.

Most (if not all) recent mergers and acquisitions in the grain industry, imply additional origins and a value of switching as motives for takeovers. For example, when Archer Daniels Midland (ADM) sought to acquire GrainCorp, they indicated: "GrainCorp would make an excellent addition to ADM's global network, with a geographic footprint and grain handling, marketing and processing operations that complement our existing assets," and "GrainCorp provides a strong origination platform that adds to our geographic diversity" (ADM 2013). ADM which is more U.S. focused than rivals, needs to expand its global reach (Thomson Reuters, 2014). Similar claims were made when Glencore acquired Viterra: "The acquisition will give Glencore critical mass in the key grain markets of North America, as well as expanding Glencore's existing operations in Australia," and "Viterra's first class assets in grain logistics and processing, with Glencore's global marketing capability, Glencore has the opportunity to become a true leader across the sector" (Viterra 2012). The acquisition was completed at a 50 percent premium. Similarly, Glencore has been looking to expand in the United States (Riseborough and Blas 2015). Their interpretation of the role or arbitrage is important: "agriculture, because it's so geographical, very small and prone to seasonality, you do get these big arbitrage opportunities," Finally, Glenore's recent divestiture of some of their Ukraine assets and expansion into Brazilian grain and oilseed exporting reflects these motives.

Marubeni's acquisition of Gavilon gives Japan's biggest agricultural trader the option to originate from a wider geographic area. This acquisition gives Marubeni the option to source grain from Brazil, Australia, Ukraine and the U.S. (Humber and Suzuki 2013). Heckman (the president and chief executive of Gavilon) stated that, as a part of a larger trading network, Gavilon would be better positioned to connect its supply with the growing global demand (Tabuchi 2012). The deal was also viewed positively by analysts because Gavilon's position in the Central Plains and Midwest complements Marubeni's position in the PNW through the shortest sea route connecting the U.S. and Asia (Emoto and Soyoung 2013).

CHS, ventured into Brazil and more recently Argentina (PRN newswire, 2014) to have the ability to supply soybeans to Chinese customers all year. This geographical diversification is thought to help CHS move commodities to the destination market even when logistics, weather, and political challenges distort the marketplace (Jordan 2013). In describing the project, CHS indicated it has been actively building its South American origination and export capabilities for more than 10 years and, the investment is aligned with CHS growth strategy to expand global commodity assets and infrastructure. Specifically, "Investing in this port on behalf of our farmer-owners further ensures market access to growing demand from customers in China and across the Asia-Pacific region." (Prairie Finance International, 2014).

A more recent venture representative of option motivations is that of COFCO who bought a majority stake in Nidera and acquired Noble Group's agricultural trading division (Thomson Reuters, 2014). The motive for these acquisitions was to be able to seek optional origin foods for China, and to provide competition to major trading firms. Another recent non-grain example is Brazil's Copersucar that is merging with Cargill to form the world's largest sugar trader. This deal is motivated by the potential of exploiting the ability to switch among sources of supply in the world sugar trade.

All of these mergers and acquisitions point to the importance of being able to switch among sources of supply. It is apparent that there is value to the option of switching. Indeed, not knowing the value results in underinvestment in that asset. Motives for the geographical diversification are in part attributed to gray swan events (PWC 2012), as opposed to black swan events (Taleb, 2010), which are interpreted like black swan events, but, are expected to occur with greater frequency. In grain trading, there have been a number of recent events along these lines. One is the periodic embargoes or export taxes placed on grains exported from Ukraine and Russia. Indeed, since 2007 there have been five such restrictions (Peterson 2014). Second is due to the periodic logistical problems in Brazil that has the impact of providing advantages to firms capable of shifting origination to the United States. This was notably true in the 2012/13 crop year in which as a result of anticipated logistical disruptions, there were large cancellations from Brazil, which were switched to U.S. ports. Similarly was the large-scale export (U.S.) cancellations of soybeans during 2014/15 which resulted in switching origins from the United States to Brazil. Finally, during 2013/14 while all North American shippers experienced logistical problems, those in Canada were far more severe. As a result those exporters capable of switching origins were advantaged. All these events clearly disadvantage trading firms operating networks with no optionality to switch origins. Diversified networks can provide great value in these scenarios, as the trading firm can ship from markets where the price is severely depressed.

Real Options

Meersman, Reichtsteiner, & Sharp (2012) suggested that leading firms are those that build the most cost effective logistical network, attract the talent needed to optimize them, and master embedded optionality. To successfully expand networks, it is necessary to value optionality embedded in assets allowing trading firms to participate in spatial arbitrage. Standalone assets can be valued with discounted cash flow analysis (DCF), however, optionality embedded in networks must be captured with real option analysis (ROA). Traditional DCF tends to undervalue projects that have option value, which can lead firms to underinvest in these strategic assets.

The concept of switching options has existed for some time. Some of the early examples of real options were related to switching, notably on production flexibility in power generation. The model described in Schwartz and Trigeorgis (2001) and recent texts have described the analytics of switching options (Guthrie 2009; Alizadeh and Nomikos 2009). The switching problem can be solved using the binomial option pricing model. The net cash flow (NCF) depends on a state variable which follows a binomial pattern. X_t^s represents the state variable at time *t* and state *s* where *s* = up (*u*) or down (*d*) at the end of period 1. The binomial tree of the state variable is shown in Pane 1 of Figure 1. The NCF depends on the state variable and the input selected (Pane 2). $C_t^s(m)$ denotes the NCF at time *t* if state *s* is realized when using input *m* (*m* = A, B) (Schwartz and Trigeorgis 2001).

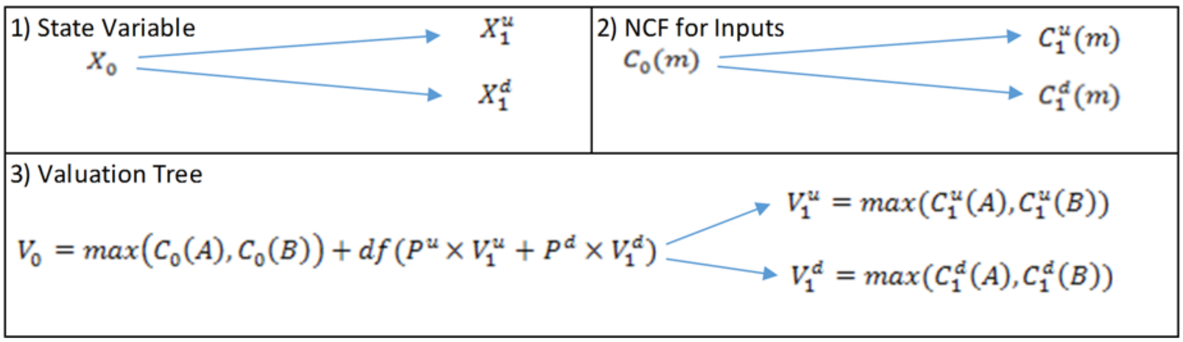

Figure 1: Illustrations of Real Options Providing Flexibility

A flexible production method, can be valued by specifying that its cash flow in each period is the higher of those two inputs. The value of the production method with the switching option is then calculated at the final node (V_1^s) (Panel 3). By using backward induction and the probabilities of up/down moves (P^s), the value at V_0 is derived. Each future V_t is discounted with the appropriate discount factor (df). Discounting the cash flows at each node in the future ensures that the actual NPV is found. The NPV of the flexible production method is higher than what is realized by either production method alone (A or B). The switching option therefore has a greater value. If the increase in value from switching exceeds the additional cost of implementing a flexible strategy, the flexible method should be adopted (Schwartz & Trigeorgis, 2001; Alizadeh & Nomikos, 2009).

Siclari and Castellacci (2005) analyzed the real option value in electrical power plants and the spark spread. The payoff from this option is:

(1) $$R = \max\{PP - HR \times FP, 0\},$$

where R represents revenue, PP denotes power price, HR represents heat rate, and FP denotes fuel price. Interpretation of this value for power-plant management is that if the spark spread is positive, power should be produced (de Jong 2008).

The revenue generated is a call option on the spark spread. Siclari and Castellacci (2005) take this model a step further by modeling it as a power plant that consists of generators that can run on different fuels. The payoff is the spread between the price of power and the minimum of two stochastic cost factors. Adjusting the payoff for the flexibility provided by a generator that can run on three different fuels (denoted by subscripts 1, 2, and 3), the option's payoff then becomes:

$$R = \max\{PP - \min\{HR_1 \times FP_1, HR_2 \times FP_2, HR_3 \times FP_3\}, 0\} \quad (2)$$

The spark-spread option can be supplemented by an option that allows the power plant to select the cheapest input fuel (Siclari and Castellacci 2005).

Allowing the power plant to switch fuels is conceptually similar to changing the location for soybean origination. An export elevator can be seen as a call option for shipping grain from the location when that market is profitable. These opportunities come from the correlations and volatility in the spread among different origins and the final destination (Pinto, Brandao, & Hahn, 2007; Adkins & Paxson, 2011). The major difference between a power plant and a network of export elevators is the need for a potential adverse outcome to give value to the switching option. For flexibility to have value something needs to be avoided. Conceptually, the same would be the case for an option. If there is zero likelihood that the option will be exercised, it would not have value.

Power plants use the switching option to produce electricity with the cheapest fuel (avoiding more costly production). Two export elevators, can ship at the same time if both origins have arbitrage opportunities. If only one origin were able to ship grain trading firms can operate the elevator without shipping, incurring only their fixed costs (no losses from shipping). The flexibility to react to market changes, renders the option to switch locations worthless (as there is no switching). Supply contracts creates a barrier for this flexibility. Export elevators with supply contracts receive a value from the option to switch origins.

Contracts, or sales commitments, reduce the flexibility to not ship grains which is the inflexibility that a switching option affects. Contracting in this paper is defined as an agreement between the trading firm and a buyer which forces the trader to deliver. A switching option would be valuable if the contract can be cancelled and the obligation shifted to another temporally lower cost origin which is indeed an increasingly common practice in grain trading. As indicated by Meersman, Reichtsteiner, and Sharp (2012), trading firms who seek to succeed in the future must manage their long term supply and purchase contracts perfectly.

Empirical Model

Several recent studies empirically estimated the value of switching options (Fisch & Ross, 2013; Gitelman, 2002; Siclari & Castellacci, 2005). Here, the empirical model seeks to value the cash flows facing a trading firm based on assets with embedded flexibility in their origination network. The network, supplies Qingdao with soybeans from the U.S. Pacific Northwest and Gulf (i.e. PNW and USG respectively), Paranaguá and the Black Sea. Physical assets across these origins provide the ability to export. An important feature for valuing flexibility is contracting which is embedded in the model. The ability to change export locations gives the trading firm the option to take advantage of temporarily attractive margins. The model is developed to value this advantage which is the switching option. Here the value is the cash flows from purchasing soybeans at track prices at export elevators, then shipping to Qingdao i.e., delivered C+F (Cost + Freight). The switching option is the difference in value between an export elevator as a standalone asset (no switching), and the export elevator comprising part of a network that allows switching.

There are 3 steps to the empirical methodology. First, prices and shipping costs are used to derive arbitrage margins for each origin, from which distributions and correlations are derived using historical recent data. Second, a stochastic binomial option tree is specified. The last step uses stochastic methods to simulate the model firstly assuming no switching, and then, allowing for switching. These results are used to derive the value of switching.

Modeling Distributions of Trading Margin

Prices and shipping costs are used to derive trading margins for each month from each origin. Once derived, these values are used to determine empirical distributions and correlations which are used in the binomial option tree and simulation model (Pinto, Brandao, & Hahn, 2007; Adkins & Paxson, 2011). The value of the switching option comes from differing margin distributions across origins. Indeed, if the margins were non-random and did not vary across origins, the value of switching would be nil. Because margins vary across locations and are random, trading firms with diversified networks have the option to fulfill their contracted commitments from the origin with the best potential for spatial arbitrage.

The arbitrage margin for an export elevator is defined by M and is a net trading margin, less cost of shipping (excluding handling cost)

$$M_{ij} = X - (T_{ij} + X_i), \tag{3}$$

where X denotes the C+F price at the destination market, X_i equals the price at origin i, and T_{ij} represents the shipping cost from origin i to the destination market i. The historical (2008-2013) average margin (M) and standard deviation are shown in Figure 2. These values are then converted to stochastic variables. Alternative distributions were compared based on the Akaike Information Criterion and the normal was chosen for each. Correlations among these trading margins, and for comparisons, prices, are shown in Table 1.

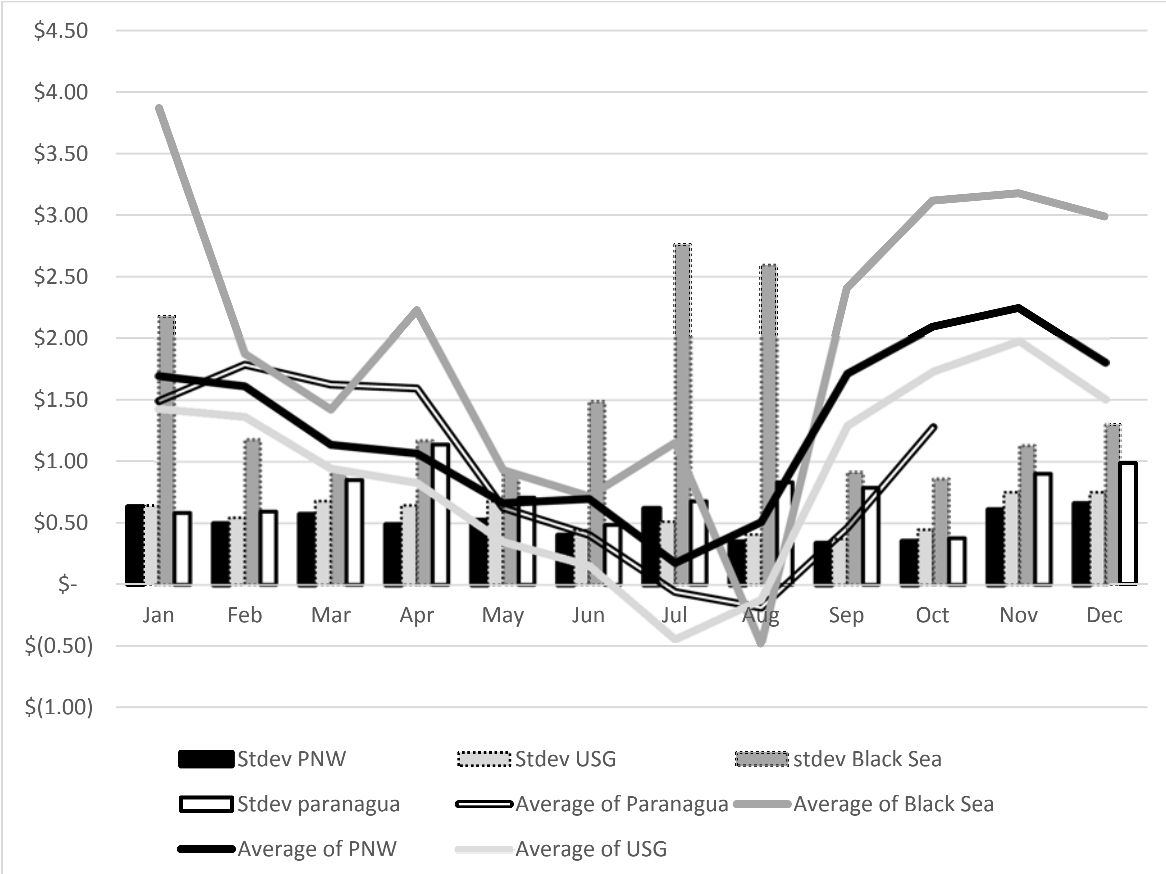

Figure 2: Average Margin and Standard Deviation by Origin

Table 1. Correlations Among Prices and Trading Profits

	Paranaguá, Parana	Black Sea port	PNW	Gulf
	Correlations among FOB prices			
Paranaguá	1			
Black Sea	0.54	1		
PNW	0.93	0.50	1	
USG	0.94	0.54	0.99	1
	Correlations among Trading Profits			
Paranaguá	1.00			
Black Sea	0.35	1.00		
PNW	0.76	0.35	1.00	
USG	0.80	0.46	0.96	1.00

A binomial tree with the soybean trading margin at each origin is defined. The binomial tree changes either up or down in accordance with draws from the distributions of monthly price changes for soybeans. Each future up/down move is associated with a probability. The binomial tree extends 120 months forward and therefore quickly reaches a large size (121 x 121).

Valuation of Network with no Switching

First we define different operating states for export elevators. States considered in this model are (1) operating and shipping, and (2) operating and not shipping (fixed costs are incurred in both). Trading firms with contracts receive their value from: (1) the value of the contracted capacity and (2) the value of the free capacity (contracted capacity subtracted from total capacity). Contracted capacity is denoted by Z. Additional binomial trees are used to keep track of each value: (1) the contracted capacity V_Z (Equation 4), and (2) the value of free capacity denoted by V_{1-Z} (Equation 5).

(4) $$V_Z = \left(M \times Z + df(P_u \times V_u + P_d \times V_d)\right)$$

The fixed cost is not a part of Equation 4. This is from the fact that the fixed cost is accounted for in every period regardless of shipping activity (in Equation 5). The latter element of the equation ($df(P_u \times V_u + P_d \times V_d)$), refers to the discounted (*df*) value in the next step in the binomial tree. *df* equals .0995, and represents the monthly discount factor, is applied in each step of the binomial tree, and is derived from the annual discount rate assumed at 6% ($.995 = 1/(1 + (\frac{6\%}{12}))$). P_u is the probability of an up move, and V_u is the value of this up move. Subscript *d* refers to the potential and value of a down move.

(5) $$V_{1-Z} = Max\left(M \times (C - Z) - FC + df(P_u \times V_u + P_d \times V_d), -FC + df(P_u \times V_u + P_d \times V_d)\right)$$

The value of an export elevator that engages in no switching is the value of Equation 4 added to Equation 5. The value of a network that does not utilize the optionality to switch ($V_{n,r}$) is simply this value for each elevator.

Valuation of Network with Switching

The value of the contracted amount must be valued for a network of export elevators exploiting optionality embedded in their network. This valuation is done using Equation 6 to elevators needed to fulfill the contracted amount. Managers seek to maximize profits. Therefore, the logical behavior would be to use the export elevator with the highest arbitrage margin to fulfill the contracted amount (Equation 6).

(6) $$V_{n,Z} = M_1 \times Z_{a,1} + M_2 \times Z_{a,2} + M_3 \times Z_{a,3} + \cdots + M_i \times Z_{a,i} + df(P_u \times V_u + P_d \times V_d),$$

where $V_{n,Z}$ denotes the network value of contracted capacity and Z_a denotes part of the capacity contracted carried by each elevator. Equation 7 accounts for fixed costs accrued by operating the export elevators, and additional elevators with geographical arbitrage opportunities and free capacity (in addition to the locations used to fulfill contract obligations in Equation 6).

$$(7) \qquad V_{n,1-Z} = M_1 \times (1 - Z_{a,1}) + M_2 \times (1 - Z_{a,2}) + M_3 \times (1 - Z_{a,3}) + \cdots + M_i \times (1 - Z_{a,i}) - (FC \times QE) + df(P_u \times V_u + P_d \times V_d),$$

where QE denotes the number of export elevators in the network and $V_{n,1-Z}$ denotes the value of the network's free capacity. The total value of the network with the optionality to switch is the sum of Equations 6 and, 7, and denoted by $V_{n,s}$. The actual value of the switching option ($V_{o,s}$) is defined in Equation 8:

$$(8) \qquad V_{o,s} = V_{n,s} - V_{n,r}$$

Trading Regime

The trading firm has a network of four export elevators and we model two trading regimes. In the first trading regime each export elevator operates independently. Here, the trading firm has 40 million bushel to ship each month in the spot market. Shipments are made whenever and from export elevators having positive trading margins (defined in Equation 3). The trading firm buys at current spot prices, ships using current shipping costs, and sells at current C+F price delivered at Qingdao. In the second regime, the trading firm makes sales, or contracts, for a portion of capacity (e.g., 50%). This trading firm has to deliver 20 million bushel each month for 10 years to Qingdao. For this, the trading firm exports from origins with the greatest (or positive) trading margin, and, has the ability to switch origins if/when the margins change. The remaining 20 million bushels are marketed at Qingdao spot prices, and shipped whenever there is an arbitrage opportunity.

The trading regimes can be viewed as either a network of independent export elevators or a network of export elevators that are collaborating. If export elevators are operated independently, one fourth of the contracted capacity is shipped from each origin, regardless of the respective margins. In the second case, the network has an option to switch origins. In trading regime 2, the network with optionality has an obvious advantage. The contracted amount is shipped from export origins with the best margin (elevators with lesser trading margins do not ship if the margin is negative) which leads to better outcomes.

Simulation Procedures

The model is developed using equations 4 through 7 and the stochastic binomial option tree. The base case values the optionality to participate in spatial arbitrage between the PNW, USG, Paranaguá, and the Black Sea to Qingdao. Thereafter sensitivities (contracting levels, correlations, and margin distributions) are changed to illustrate how these factors impact the value of the switching option.

Simulations were conducted using Monte Carlo techniques and Palisade's @Risk software. The model was iterated 10,000 times. The results were used to define the value of the switching option.

Data Sources

All data in the models are monthly and for the time period from January 2008, to August, 2013. Prices for soybeans delivered C+F in Qingdao are from Bloomberg (2014). Track and FOB prices at the USG and PNW export elevators are from Tradewest Brokerage (daily market reports used to derive monthly average values for these prices). Ocean freight rates from Brazil to China are from USDA Agricultural Marketing Service (USDA-AMS, 2014) and those from Ukraine to China were derived using data adjustments due to distance and trends in the grain shipping industry (aggregate of the other transportation costs).

Fixed costs are assumed constant through time and derived from Wilson & McKee (2013). The elevators monthly capacity is 10 million bushels, and the monthly operating costs are $1 million. These were from industry sources and are thought to be representative of plant level costs in the industry. The discount rate is 6%.

Results

The values of switching options can be easily illustrated. Margins are random and correlated. These random and correlated values, along with distributions and correlations of ocean shipping costs ultimately mean that margins for shipping from different origins vary stochastically. The distributions and correlations of values mean that in any single period, one option may be favored relative to others. Trading firms that have the ability to shift to a favored origin, gain in value relative to others. This is ultimately the option we are seeking to value. Base case results are presented first and then some interesting simulations are presented.

Base Case Results

The model was simulated first assuming each origin operates independently. The option value depends in part on how much the trading firm contracts for sales. In the base case, we assume the trading firm has not contracted and therefore operates a network with full flexibility. No contracting allows the trading firm to keep the optionality to not ship whenever the elevator faces unfavorable market conditions. This is treated as the base case. The data showed the probability of a negative margin (or no arbitrage opportunity) were .08, .15, .06 and .22 respectively for shipments from Paranaguá, Black Sea, PNW and USG.

In the base case (Table 2) the values of each export origin are: Paranaguá: $0.90 billion (standard deviation: $0.57 billion); the Ukraine (Black Sea): $1.77 billion (standard deviation: $1.09 billion); PNW: $1.20 billion (standard deviation: $0.43 billion), and USG: $0.83 billion (standard deviation: $0.44 billion) for a total NPV for the network of $4.7 billion. Because there are no contracts, there is no value added by operating the assets together. The sum of these are shown in Table 2, are the aggregation of the values above, and represent the value of the network of origins.

Table 2. Export Elevator Network Value with no Switching (in $ Millions)

Bushels Contracted (million)	0	10	20	30	40
Percentage of Total Capacity Contracted	0%	25%	50%	75%	100%
Minimum Value	-79	-1362	-2593	-3824	-6214
Mean Value	4700	4611	4522	4433	4344
Standard Deviation	2087	2186	2279	2374	2470

Contracting and no Switching Option

If the trading firm contracts, the optionality to not ship is removed. If the trading firm contracts 25% of shipments, the NPV of cash flows for this network decreases from $4.70 billion to $4.61 billon. Thus, the trading firm would only contract at this level (25%) if contracting implicitly provides a value of $89 million or more in benefits.

The value provided by the flexibility to alternate origins is only relevant for the network, not for individual origins (due to the fact that one location cannot switch). Table 2 shows the network values assuming there is no switching. Additional contracted capacity decreases the network's mean value by an average of $89 million per additional quarter of capacity contracted. The standard deviation increases as the share of contracted capacity increases, which is caused by the lack of flexibility which makes the trading firm more vulnerable to the market's adverse change in margin.

Trading with a Switching Option

The base case shows that without a switching option, the impact of increases in contracting is for a decreasing mean, an increased loss potential, and an increased standard deviation. Allowing for switching changes the results. If the trading firm operates the network as one (either through ownership or partnerships), these adverse value changes are lessened. Values for complete contracting and no contracting are the same for a network that engages in switching and for one that does not (Table 3). The value of the switching option increases from $82 million with 25% contracted, to $158 million when 75% of the capacity is contracted (4%, 3%, and 2% of network value, respectively for the 75%, 50%, and 25% contracting-level scenarios).

Table 3. Option Value of Switching for Export Elevator Network (in $Millions)

Bushels Contracted (million)	0	10	20	30	40
Percentage of Total Capacity Contracted	0%	25%	50%	75%	100%
Option Value of Switching Mean	0	82	140	158	0
Network Standard Deviation	2087	2107	2148	2227	2470

The value of the switching option varies across contracting levels. When 75% of capacity is contracted, the increase for the mean value is at its largest. Logically, if switching options gain their value from providing needed flexibility, the mean value of the switching option increases as contracted capacity increases until the amount of capacity is contracted so that the switching option no longer has sufficient free capacity to switch. At this point the option value begins to decline. By contracting 75%, the network does not reach this threshold because the margin distributions for the export elevators have relatively low probabilities of being negative. The threshold occurs somewhere between 75% and 100% contracting. Intuitively, the reason is that 100% contracting removes all flexibility, even in a network that can switch. No contracting (i.e., synonymous with selling spot) results in complete flexibility, and the optionality to switch has no value because it does not increase flexibility.

Figure 3 compares the base case with no switching to the network with switching. With no switching the NPV foregone as contracting increases is linear. When flexibility is allowed, the decrease in NPV is nonlinear and accelerates to the 50% level of contracting. The nonlinearity (and postponed network value reduction) is a result of the increase in the switching option value. The increase in contracting from 0% to 25% reduces network value by $89 million, while the switching option increases from 0$ to $82 million. This counteracts the negative effects of contracting (from -$89 million to -$7 million). At 25% contracting, the decrease in NPV is < 0.2%. Trading firms should contract the percent of capacity where the benefit of supply agreements exceed the reduction in NPV. This point is most likely somewhere between 25% and 50% contracting.

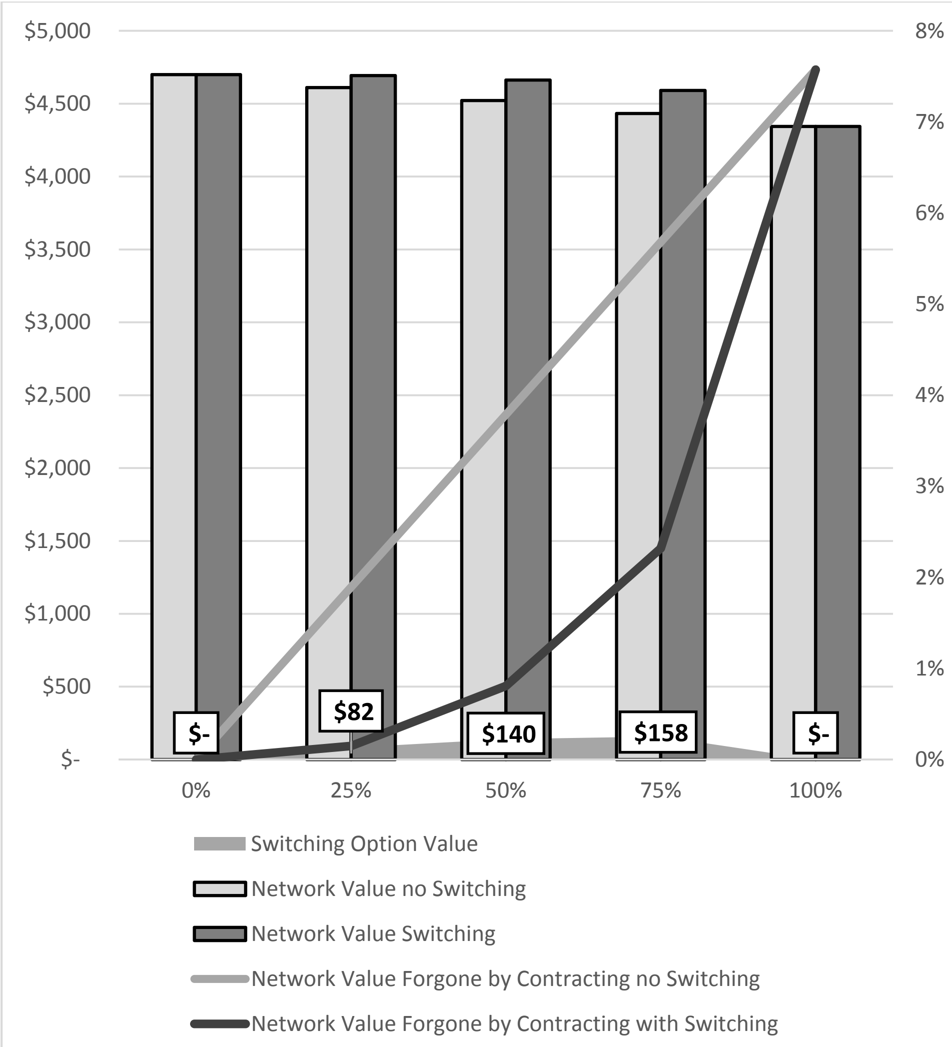

Figure 3: Changes in Network Value across Contracting Levels for Export Network

Option Value with Higher Correlation between Origin Locations

The correlations and standard deviations of trading margins impact the option values. In trading, firms with a switching option gain value by diverting contracted sales to more favorable origins. This diversion only occurs if there is a more favorable origin for the contracted sales. An important aspect of these results is the effect of correlations on the option value. To illustrate this, the original correlations (Table 1) were increased by 10% and 50%,[1] and one scenario with perfect correlations. Each was simulated at different levels of contracting.

The network value under the 50% contracting condition and 10% higher correlations reduces the value of a network with the option to switch by $3 million (Table 4). This decrease

[1] These were increased for example purposes by multiplying existing correlation values by 1.1 and 1.5. While this may increase correlations more for higher values than lower values, our purpose was only to illustrate the effects of greater co-movement among random trading margins.

in value is completely reflected in the reduced switching option (which decreases by 2.1%). If correlation is 50% greater, the reduction in network value is $9 million, a 6.4% reduction for the switching option value. Interestingly, the effects of increased correlations are magnified as contracted capacity increases. With 75% contracted, the 50% increased correlation results in a 7.3% reduction in the switching option value (compared to 6.4%). This magnified reduction is a result of the need to shift a larger volume of the capacity towards cheaper markets and the lower likelihood of large differences in arbitrage margins due to the increased correlation.

With a perfect correlation, the switching option still has value. Here, the margins still differ across the locations as represented by their distributions (Table 4). Changes in the total value for a network with a switching option are far higher when correlations increase relative to a network which does not allow switching origins. With perfect correlations, a network with switching (and contracting 50%) will decrease in value by $27 million while a network without a switching option changes less than $0.1 million in value. Decreasing the standard deviations of the arbitrage margins has similar effects. For a network contracting 50% of capacity, a 50% reduction in margin standard deviations reduces the value of the switching option by $73 million (from $140 million).

Table 4. Impacts of Correlations on Value of Switching ($ Millions)

Contracting level	25%	50%	75%
Original Correlations	82	140	158
Changes in correlations:			
10% increase	81	137	153
50% increase	79	131	145
Perfect correlation	72	113	125

or commodity trading firms, the reduction in option value due to increasing correlations has important implications. One is that geographically diversified trading firms will have an advantage with markets where margin correlations are low. In fact, in these inefficient market conditions it is essential to be geographically diversified. As markets become more integrated and efficient, implying an increased correlations, the advantage of diversified trading networks' diminishes (as the embedded switching option in large networks loses value). These implications shows how larger geographically diversified trading firms benefit from market inefficiencies.

Finally, we evaluated the options impact on NPV. Using traditional DCF analysis which ignores risks and options, has the effect of undervaluing assets. This is important because the undervaluation would result in underinvesting in assets that provide option value. The model was used to assess this impact. To do this, we assumed a network contracting 10 million bushels, comprised of 3 origins, managed by a trading firm seeking to acquire the 4th origin. Without considering the switching origin provided by the additional export elevator, the export elevators located in the USG, Black Sea, PNW and Paranaguá are undervalued by $26, $67, $22, and $28 million respectively. The undervaluation is larger if the additional origin comes in addition to only 1 export elevator.

Similarly, consider a trading firm with the USG export elevator as the only origin, and currently contracting 50% of capacity (5 million bushel before, and 10 million bushel after the expansion). The trading firm considers to expand to the PNW or Paranaguá. Not accounting for the flexibility provided by the switching option; Paranaguá is undervalued by $80 million (10%), and PNW by $31 million (3%) (Table 5). Ignoring the option value embedded in these assets might lead the trading firm to not expand (i.e. underinvestment).

Table 5. Network Expansion from USG to Paranaguá vs. PNW (in $ Millions)

Network Expansion	**USG**	**Paranaguá**	**PNW**
Value Export Elevator Alone	787	816	1,090
Standard Deviation	481	624	447
Value as Network with USG	787	1,683	1,908
Standard Deviation	481	1,023	889
Increase in Network Value	-	896	1,121
Undervalued by	-	80	31
Undervalued by in %	0%	10%	3%
Option Value w/ Export Elevator	-	35	31

Summary and Conclusions

There has been a wave of mergers and acquisitions and an escalation in vertical integration in both energy and more recently, agricultural commodity trading. These strategic moves are often justified by the need for multiple origins. Commodity trading firms seek to capture returns from switching options geographically diversified networks. To build the optimal network of physical assets, the synergy effects (optionality) of the network should be accounted for. Without this, trading firms would undervalue assets. Ultimately, this leads to underinvestment in assets that have option value.

The purpose of this paper is to estimate the value of switching options in international soybean trade. To do so, we developed a stochastic binomial model of real options to value networks of geographically dispersed export elevators. Intertemporal differences in commodity prices and shipping costs across origins are important and provide motivations for trading firm's desire for optionality. The model provides a method to estimate the 'value' of assets that have optionality. Export elevators at different international origins should be valued as part of a trading firms existing network, as this includes embedded optionality. Indeed, by not including the value of optionality, these assets would be undervalued.

The results indicated that asset values depend on the distribution of arbitrage opportunities at each origin, and the correlations among them. These differences provide what determine the value of the switching option. The base case was specified of a trading firm with a network comprising of export elevators at Brazil, Ukraine, USG and PNW for shipments of soybeans to China. The results indicated:

1) Option values depend on the amount of contracting, or, sales commitment;
2) Margin distributions and correlations determine the option value;
3) Not accounting for the option value when valuing export elevators results in undervaluation of assets.

There are a number of implications of these results. First, the results illustrate the existence and value of switching options in the international grain trade. This is similar to the international energy trade in which having optionality is an essential element of strategy. In the case of grain, export elevators have option value which are impacted by margin distributions and correlations. Second, if the option feature is not valued, it would be underinvested. This is important because pursuing strategies of managing risks ultimately involves pursuing strategies that have options, but to do so requires some means to value these assets. The method provides a way to estimate the option value of assets in international grain trading. Third, option values are determined by many variables and their distributions. One of the most important is the correlations among margin distributions. These results show that the option value is greater in market conditions in which the correlations are lower. In markets with greater correlations, the value of optionality persist, but decline. Increasing standard deviations has the same effect on the option value. Indeed, Razgaitis (p. 434) emphasized that an important relationship is that option values depend on volatility, or, simply that volatility creates option value. This is important and points to the advantage of larger geographically diversified trading firms in inefficient and volatile markets.

Finally, one of the more important implications is that optionality provides an explanation about why the international grain trade is dominated by companies that seem to be pursuing strategies of geographical diversification. Indeed, many of these firms in recent acquisitions have pointed to the need of doing so is for having optionality. The synergy effects provided by geographically diverse networks in inefficient markets, contribute to explaining the success of some firms. An independent trading firm operating one export elevator would have a lesser value. Of course, this depends on correlations, margin distributions, and contracting strategy. In either case, the increased value from the optionality (as part of a network) enables commodity firms to consistently outbid trading firms in the pursuit of assets and control of trade flows. Valuation methods not accounting for the embedded optionality, undervalues the asset, as value of flexibility is ignored. The paper provides a methodology for trading firms to more accurately value physical assets that contribute to optionality.

REFERENCES

Adkins, R., and D. Paxson. 2011. "Real input-output switching options." *Turku: Annual International Conference on Real Options*. (2011): 1-22.

ADM. 2013. *Archer Daniels Midland and GrainCorp.* Sydney.

Alizadeh, A.H., and N.K. Nomikos. 2009. "Shipping derivatives and risk management." New York, NY.: *Palgrave Macmillan*.

Bensanko, D. Dranove and M. Shanley. 1996. "The Economics of Strategy." *Wiley*.

Bloomberg L.P. 2014. Data retrieved in 2014 from Bloomberg database.

Caves, R.E. 1997. "Organization, scale, and performance of the grain trade." *Food Research Institute Studies.* 16(3, 1977): 107-123.

de Jong, C. 2008. "Real options in energy markets." Maycroft Consultancy and Erasmus University.

Dixit, A.K. and R.S. Pindyck. 1994. "Investment Under Uncertainty." Princeton, NJ.: *Princeton University Press.*

Emoto, E. and K. Soyoung. 2013. "Marubeni nears $5 billion-plus Gavilon deal: sources." *Terra*. July 15, 2013.

Fisch, J.H. and J.M. Ross. 2014. "Timing the Start of Material Substitution Projects: Creating Switching Options under Volatile Material Prices." *Journal of Product Innovation Management.* 31(3, 2014):567-583.

Gitelman, G. 2002. "Use of real options in asset valuation." *The Electricity Journal.* 15(9, 2002): 58-71.

Guthrie, G. 2009. "Real options in theory and practice." New York, NY.: *Oxford University Press, Inc.*

Humber, Y. and I. Suzuki. 2013. "Marubeni to pay $1 billion less for Gavilon minus energy." *Bloomberg*, Jun 10, 2013.

Jordan, L. 2013. "Southern Star." *Your CHS Connection.* 6-12.

McKee, G., W.Wilson and B. Dahl. 2015. "Risk and return trade-offs in partnering strategies between co-ops and IOFs." *AgriBusiness: An International Journal,* Vol. 31 (1) 76–90 (2015).

Meersman, S., R. Reichtsteiner and G. Sharp. 2012. "The dawn of a new order in commodity trading." *Risk Journal.* 2(2012): 1-9.

Taleb, Nassim. 2010. "The Black Swan: Second Edition: The Impact of the Highly Improbable." *Random House,* New York.

Peterson, Vince. 2014. "Patterns of Unnecessary Government Intervention Undermines Russia's Role in World Trade, to the Small Grains Institute." available at http://smallgrains.org/2015/01/16/pattern-unnecessary-government-intervention-undermines-russias-role-world-trade/.

Pirrong, C. 2014. "The Economics of Commodity Trading Firms." *Trafigura,* University of Houston.

PRN Newswire. 2014. "CHS invests in deep-water port at Necochea, Argentina." St. Paul Minn., April 10, 2014.

Pinto, C.B., L. Brandao and W.J. Hahn. 2007. "Modeling switching options using mean reverting commodity price models." In Proceedings of the 11th Annual International Conference on Real Options at the University of California Berkley, May 23, 2007.

Port Finance International. 2014. "CHS invests in Argentinian deep-water port." April 11, 2014. available at http://portfinanceinternational.com/categories/finance-deals/item/1435-chs-invests-in-argentinian-deep-water-port.

PWC. 2012. "Black swans turn grey - The transformation of risk." London, 2012, available at www.pwc.co.uk/riskresilience.

Razgaitis, R. 2009. "Valuation & Dealmaking of Technolgy-Based Intellectual Propperty: Principles, Methods, and Tools." *Wiley,* Hoboken.

Riseborough, J. and J. Blas. 2015. "For Glenore's Next Move Watch Agriculture Rather Than Iron." *Bloomberg Business.* March 19, 2015.

Schwartz, E.S. and L. Trigeorgis. 2001. "Real options and investment under uncertanity: classical readings and recent contributions." Cambridge, MA.: Massachusetts Institute of Technology.

Siclari, M. and G. Castellacci. 2005. "Real options for flexible power generation modeling." *Energy Risk International.* http://www.olf.com/software/energy-commodities/articles/energy-risk-power_generation_modeling.pdf.

Tabuchi, H. 2012. "Marubeni of Japan to buy Gavilon for $3.6 billion." *The New York Times.* May 29, 2012.

Thomson Reuters. 2014. "Inside Agriculture." March 31, 2014.

Tradewest Brokerage. "Evening Wire Report." Tradewest Brokerage, Hillsboro, OR., Various.

USDA-AMS. 2014. Grain Transportation Report Data Sets. Accessed April, 3 2014.

Viterra. 2012. "Glencore Acquires Viterra." Regina: Viterra.

Wilson, W.W., and B.L. Dahl. 1999. "Transnational Grain Firms: Evolution and Strategies in North America." Agricultural Economics Report No. 412, Department of Agribusiness and Applied Economics, Fargo: North Dakota State University.

Winston, W. 2008. "Financial models using simulation and optimization II." Ithaca, NY.: Palisade Corporation.