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Quantifying Strategic Choice Along the Vertical Coordination Continuum[1]

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Abstract

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The qualitative and quantitative results of a study undertaken to test a decision framework firms might consider in choosing a vertical coordination strategy are presented. The posited five-step decision making process tested that a change in coordination strategy would occur if and only if a "yes" decision was made at each step. The results reported as case-based frequencies and as a discriminate analysis function provide strong support for the study's research propositions. The ability of an alternative to reduce the costliness of a coordination error and the acceptability of the risk/return tradeoff were critical to the willingness of a sample of producers to change coordination strategy. Implementability was significant, but not to the same extent as costliness of a coordination error or acceptability of the risk/return tradeoff.

Keywords: vertical coordination, vertical coordination continuum, discriminate analysis, willingness to change, unwillingness to change, coordination error, programmability, implementability, risk/return tradeoff.

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Fundamental changes are underway in the U.S. agri-food system, which is altering traditional marketing relationships. Although many firms see these changes as threatening traditional open market relationships, the changes are creating opportunities based on specifications contracting, strategic alliances, and vertical integration. Given the increasing variety of vertical coordination strategies available to agri-food firms, it seems appropriate to develop and test a decision model on how to select among these alternatives.

This paper builds upon the earlier work of Peterson, Wysocki, and Harsh (2001), and Wysocki (1998) that posited a framework for decision-making along the vertical coordination continuum. In this paper, the case-based and quantitative results of a study undertaken to test their framework are presented. The paper proceeds with the following sections: a brief overview of the vertical coordination continuum and the related decision framework, research propositions, presentation of qualitative and quantitative research results, and areas warranting further research.

Decision Making Along the Vertical Coordination Continuum

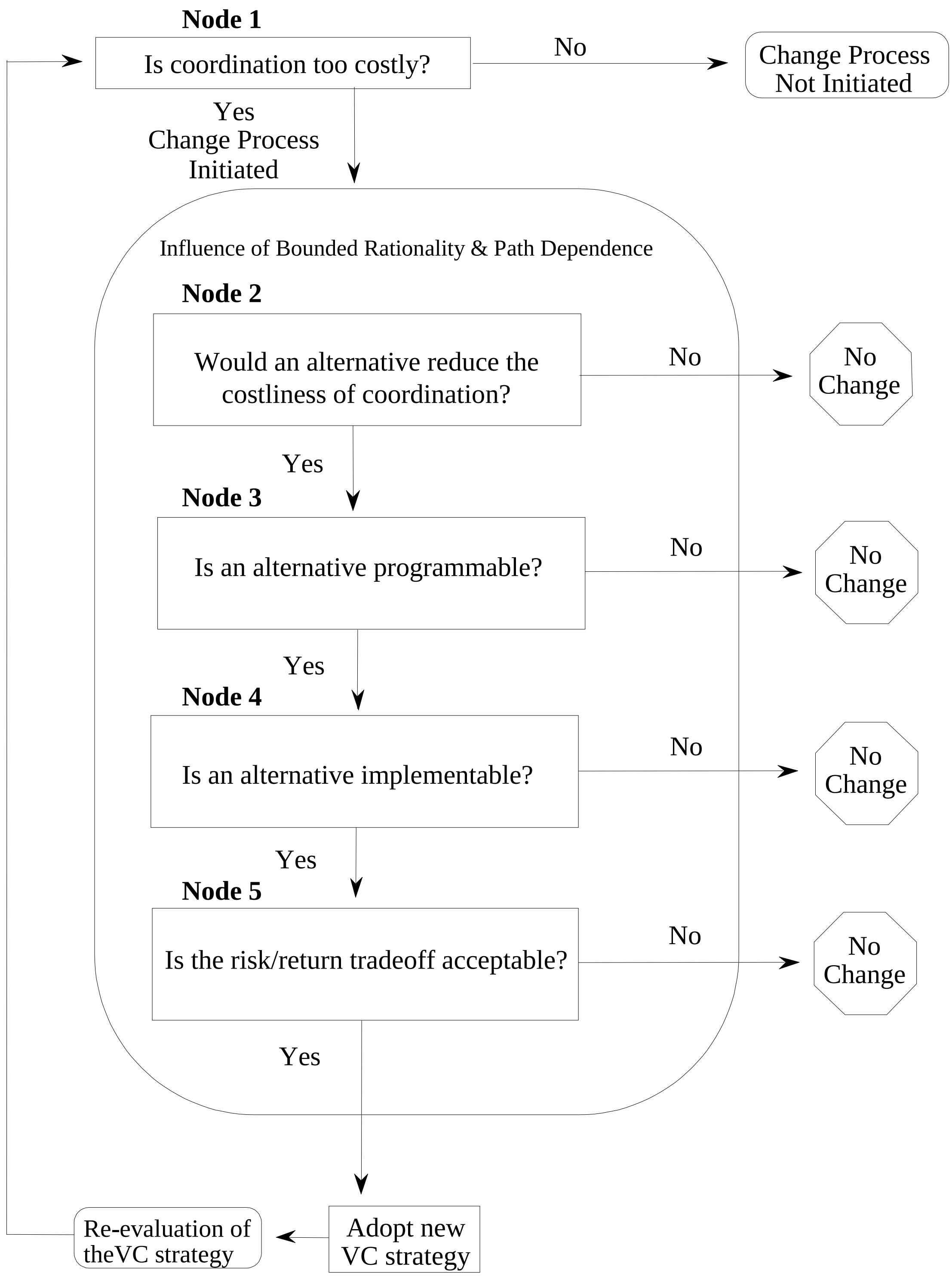
Based on the work of Williamson (1973, 1975), Mahoney (1992), and Milgrom and Roberts (1992), Peterson, Wysocki, and Harsh (2001) posited that the vertical coordination continuum has five major categories of vertical coordination strategy: spot markets, specification contracts, relation-based alliances, equity-based alliances, and vertical integration. Exhibit 1 contains a table of the relevant definitions for each category of vertical coordination strategy. The latent variable linking the five categories into a true continuum is the intensity of control that the alternative strategies employ to assure that proper coordination occurs (i.e., coordination with minimum potential for error). Coordination strategies move from low levels of *ex ante* control intensity (spot markets) to high levels of *ex post* coordination control (vertical integration) while passing through several transitional levels of ever increasing intensity (specification contracts, relations-based alliances, and equity-based alliances).

Peterson, Wysocki, and Harsh (2001) modeled a firm's decision about which strategy to pursue on the continuum as a five-step decision process. Exhibit 2 presents this framework. The framework is based on the presumption that a firm already exists and by intention or habit has already established a position on the continuum. All firms would in fact find themselves in this situation. Given this, the first decision step involves a process initiation question: Is the perceived cost of the current coordination strategy too high relative to an available alternative strategy (Node1, Exhibit 2)? An existing strategy may be too costly for one of two reasons: (1) coordination errors regularly expose the firm to the opportunism of trading partners or result in chronic over or under production versus demand, or (2) the strategy is more costly to execute than the coordination errors it is designed to control.

Exhibit 1: Strategy Categories Along the Vertical Coordination Continuum

Strategy	***Definition***	***Example***
Spot Market	Coordination intensity is low. Parties engage in price discovery and make either a yes or no decision to enter the transaction. It is easy to walk away from the transaction.	A Midwest corn farmer who calls up local grain elevators to find out the current cash price for corn. The corn farmer decides to sell his corn to the highest bidder.
Specification Contract	Coordination intensity is moderately low. Contracts are based on the legally enforceable establishment of specific and detailed conditions of exchange.	A potato farmer that signs a production contract with a potato processor for a specific quality and quantity of potatoes at a specified delivery time.
Relation-Based Alliance	Coordination intensity is moderate. Relationship based on shared risk and benefits emanating from mutually identified objectives.	Wal-Mart and Procter & Gamble, where Wal-Mart agrees to share propriety sales and inventory information and P&G physically locate their employees at Wal-Mart's headquarters.
Equity-Based Alliance	Coordination intensity is moderately high.	Agricultural cooperative, private firms who form a joint venture.
Vertical Integration	Coordination intensity is high.	Tyson coordinates the entire poultry process from genetics to the retail shelf.

Exhibit 2: Decision Making Framework For Changing Vertical Coordination Strategies



Source: Peterson, Wysocki, and Harsh 2001. "Strategic Choice Along The Vertical Coordination Continuum," *The International Food and Agribusiness Management Review.* no 4: 149-166.

If a firm decides it is dissatisfied with the current strategy from a costliness viewpoint, the second critical question becomes: Would an alternative strategy reduce the perceived costliness of coordination (Node 2, Exhibit 2)? The answer to this question depends upon whether or not another strategy would better match the intensity (and cost) of coordination control with the costliness of coordination errors. The match is judged better or worse under the logical principle that the more costly the errors, the more intense the control needed and conversely, the less costly the errors the less intense the control.

Again, drawing upon Williamson (1973, 1975), Mahoney (1992), and Milgrom and Roberts (1992), Peterson, Wysocki, and Harsh (2001) we identify two criteria that can be used to assess the costliness of a coordination error for a given transaction: (1) asset specificity[1], and (2) complementarity[2]. The costliness of a coordination error thus rises with both the level of asset specificity and the level of complementarity. Managers need to assess both of these variables relative to specific transactions and then select a coordination strategy that matches the intensity of control with the costliness of a coordination error. If there is no better match, the perceived costliness diminishes or becomes less important to the decision maker.

If another coordination strategy offers a potentially better match between costliness of coordination errors and coordination control intensity, then a third question becomes relevant to the strategy change process: Is the potential alternative programmable (Node 3, Exhibit 2)? Mere existence of a potentially better strategy for controlling coordination errors is not enough for adoption. The decision maker must now ascertain, if effective, specific management routines exist for making the potential strategy workable.

The fourth relevant question becomes: Is the potential alternative implementable (Node 4, Exhibit 2)? Programmability only assures that specific management routines exist. It does not assure that a specific decision maker can effectively implement the routines. Implementability can be conceived as arising from four conditions: (1) capital availability (does the decision maker have the capital required to implement the strategy?), (2) existence of compatible partners (does the decision maker have a transacting partner who will meet the needs of the strategy being implemented?), (3) control competence (given that each coordination strategy has a different intensity of control, decision makers must examine their competence in exercising the type of control required by the strategy to be implemented;

[1] Asset specificity is the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value.

[2] Complementarity exists when the combining of individual activities across a transaction interface yields an output larger than the sum of outputs generated by individual activities.

willingness as well as skill are key to competence), and (4) institutional acceptability: (an obvious test of institutional acceptability is whether or not a particular strategy is legal, e.g., not in violation of antitrust laws; institutional acceptability is a broader concept that defines what economic behaviors or strategies are deemed appropriate by given social, cultural, industrial, or group norms, the core values of the firm). Whether or not a particular alternative strategy is deemed implementable will depend on the decision maker's overall assessment of the above four conditions. Any one condition may create enough concern that a "no" decision about willingness to change will result.

Assuming that an alternative is deemed implementable, the fifth and final question in the change process becomes relevant: Does the alternative provide a risk/return tradeoff acceptable to the decision maker (Node 5, Exhibit 2)? With this fifth question, the explicit task of balancing these potential returns and risks is added to the framework. Obviously, the decision maker's risk preferences will be a critical input to answering this question. Based on the decision maker's risk preference it seems fair to predict that any alternative strategy must meet the test that the perceived risk/return tradeoff of the alternative is superior to the current strategy if change is to occur.

The framework of Exhibit 2 proposes that only a "yes" answer to all five of the relevant strategic questions will result in a changed coordination strategy. A "no" at any point stops the process from starting or continuing. A feedback loop is also presented in the framework to make it clear that the process of coordination strategy evaluation is a dynamic one. As transaction conditions, resource availability, and strategy potential change, the chance to create less costly coordination also changes. As an industry evolves, optimal coordination strategies for individual firms within the industry may move in either direction along the continuum depending upon changes in asset specificity, complementarity, programmability, feasibility, and risk/return tradeoffs.

Research Propositions and Methods

Empirical testing of such a complex framework is difficult. Research design decisions focused on how much of the framework was feasible to observe in an initial test, how to operationalize the decision nodes, and how to measure both the decision variables and the results. Given the exploratory nature of this research and the focus on a detailed decision process, a case study approach was deemed appropriate. Structured interviews were designed for use with 25 producers in two Michigan agricultural subsectors (seed potato producers and celery producers).

The ideal direct test of the decision framework would have entailed finding a group of producers who had recently changed or explicitly rejected changing their vertical coordination strategy and then interviewing them about their decision process.

Substantial difficulty in identifying such producers precluded this research approach. The researchers did have access to producers in two industries that were experiencing performance problems and changing vertical structures. A research design decision was made to use these producers in an interview setting in which they were asked to discuss changes in vertical coordination strategy that they had recently considered whether or not they had actually implemented the strategy. The dependent variable thus became the *interviewee's expressed willingness to change vertical coordination strategy* based on the decision factors suggested by the framework. Given this database, the initiation step of the decision process node 1 (Is coordination too costly?) was already completed and assumed to be a "yes." Therefore, the study focused on the remaining four decision nodes (decision nodes 2-5).

Based on the available case study base, the decision framework gives rise to four researchable propositions:

RP_1: IF a decision maker is willing to change vertical coordination strategy THEN a "yes" assessment has been made at ALL decision nodes (necessary conditions for strategy change).

RP_2: IF a "yes" assessment is made at ALL decision nodes, THEN a decision maker is willing to change vertical coordination strategy (sufficient conditions for strategy change).

RP_3: IF a decision maker is not willing to change vertical coordination strategy THEN a "no" assessment has been made at one OR more decision nodes (necessary conditions for status quo).

RP_4: IF a "no" assessment is made at ANY one decision node, THEN a decision maker is not willing to change vertical coordination strategy (sufficient conditions for status quo).

If the proposed framework is an accurate model of the decision making process for altering a vertical coordination strategy, then the four research propositions form the necessary and sufficient conditions for a willingness or unwillingness to change a vertical coordination strategy. These are strongly stated propositions. "No" at any one decision node results in an unwillingness to change while only all "yes" responses result in a willingness to change. The propositions do not allow for trade-off among the decision nodes, i.e., the potential of a large coordination cost reduction will not counterbalance implementation concerns. The propositions thus create a strict test of the decision flow of the framework.

Empirical testing of the research propositions was accomplished by using methodological triangulation[3] (Patton, 1980), i.e., the use of multiple methods to study a single problem (Ghauri, et al., 1995). This research relied on the following multiple data collection procedures: (1) conducting of multiple detailed case studies based on in-depth interviews that will apply observed events of two Michigan industries against the proposed framework, and (2) the historical evolution of these two industries as documented by scholarly articles, trade publications, and eyewitness testimony.

The structured interview procedure on the 25 seed potato and celery producer cases involved a series of open-ended and categorical response questions designed to capture information concerning decision factors and their impact on the ultimate willingness of the producer being studied to change from an existing to an alternative vertical coordination strategy. Each interviewee was asked to provide a description of a current strategy and an alternative that was being evaluated. Both the nature of the alternative and the decision process of evaluation were discussed in the interview. Of the 25 alternative strategies, 17 represented movement toward more intense coordination control while 8 represented movement toward less intense control. Of the 17 respondents who indicated they were considering a strategy change toward more intense control (e.g., spot market to vertical integration), ten said they were willing to change while seven said they were unwilling to change vertical coordination strategy. Of the 8 respondents who indicated they were considering a strategy change away from more intense control (e.g., vertical integration to spot market), only three said they were willing to change while five said they were unwilling to change vertical coordination strategy.

Operationalization of Key Decision Variables

A producer's willingness to change vertical coordination strategy (Dependent variable)

The variable was operationalized as a simple dichotomous variable, willingness or unwillingness to change vertical coordination strategy, based on the expressed preference of the interviewee.

An alternative's potential to reduce the costliness of coordination (Decision Node 2)

Measuring this independent variable required an exploratory design. There was no everyday language equivalent for costliness of coordination, let alone the potential

[3]Methodological triangulation is similar to what Bonoma (1985) describes "perceptual triangulation," as a method for providing a more complete picture of the business unit under study. Prime sources for perceptual triangulation include: financial data, market performance data, market and competitive data, written archives, business plans, and direct observations of management.

to reduce such costliness. A proxy for direct assessment of the variable was designed based on the theory underpinning the framework. The assessment for Decision Node 2 was "yes" if the alternative strategy being considered by a producer was closer to that producer's optimal strategy than the producer's current strategy, and "no" if the alternative being considered was further away from optimal. Movement toward optimal would be presumed to result in less costliness of coordination. The optimal strategy for a given producer was first determined by assessing the level of asset specificity (low, medium, or high; based on two interview questions) and the level of complementary (low, medium, or high; based on three interview questions) present in the producer's transaction situation. The asset specificity questions focused on how easy or difficult it would be for the producer to convert farm assets from current uses to other uses. The complementary questions focused on (1) a producer's strength of stand-alone competitive advantage (this is inversely related to complementarity), (2) how important the producer perceived working with others in the food system is as a means of improving firm performance, and (3) how important the producer perceived responding to changes in ultimate consumer needs and tastes in order to improve firm performance.

Based on these procedures, eleven producers revealed their optimal vertical coordination strategy to be specification contracting, three revealed relation-based alliance, ten revealed equity-based alliance, and one revealed vertical integration. In turn, there were 15 "yes" assessments for Decision Node 2, i.e., the alternative strategy under consideration moved the producer closer to the optimal, and 10 "no" assessments, i.e., the alternative considered moved the producer further away.

The research design for the Decision Node 2 assessment was clearly exploratory and presumed that the theoretical relationship of the framework was an acceptable model of the decision maker's thought process. In this sense, the variable was a true test of the framework's abstract concept. However, if the variable proved to have no explanatory value in the analysis, the potential existed that this approach would be unable to differentiate between the true impact of this decision variable versus an ineffective operationalization of it.

Programmability of the alternative strategy being considered (Decision Node 3)

An alternative was considered programmable (a "yes" at Decision Node 3) if the producer could identify effective management routines, which would be used to aid in the adoption of the alternative strategy being considered. Programmability was to be coded as low, moderate, or high by the original research design. However, all producers indicated the alternative strategies they were considering were programmable. That is, they all easily identified management routines consistent with their considered strategy. Given that producers were asked to volunteer an alternative strategy for use in the interview, it is not at all surprising that this resulted in high programmability. The producers were most likely to consider alternatives with known management routines. Because there was no variation across the 25 cases in the value of this variable, further research is needed to explore the relevance of programmability to the model.

Implementability of the alternative strategy (Decision Node 4)

The implementation variable was based on a combined assessment of four major factors: capital, compatibility of partners, control competence, and institutional acceptability. Seven interview questions were used to assess implementability. Two questions focused on financial capital (amount and access), while one focused on availability of labor (human capital). Another question focused on availability of compatible partners and one on institutional constraints. The remaining two questions focused on issues of control competence. These were complex questions that explored (1) a producer's preferred skill set in dealing with others in transaction relationships, and (2) a producer's preference for engaging in activities related to open market verses managed coordination.

Given that Likert and related ordinal categorical scales were used across all seven questions, a total implementability rating was constructed using standardized scores and a simple equal weighting for all components. The resulting ratings for the 25 cases separated into two logical groups; high implementability alternatives (a "yes" for Decision Node 4) and low implementability alternatives (a "no" for Decision Node 4). There were 19 "yes" cases and 6 "no" cases.

Acceptability of the risk/return tradeoff (Decision Node 5)

A direct question about the acceptability of the risk/return tradeoff was asked in the interview. In addition to a "yes" or "no," the interviewees were asked to elaborate on their reasoning. There were 11 "yes" responses for Decision Node 5 and 9 "no" responses. In five cases, the interviewees were not willing to give a clear yes or no response but chose to say they were unsure about the tradeoff. Four additional interview questions were asked with the notion that an index response might be more revealing than their response to the direct question. All reasonable index values confirmed the direct question responses. As a result, the direct responses were used in the qualitative analysis. A different approach became relevant to the quantitative analysis, and this will be presented later.

Qualitative Research Findings

Exhibit 3 presents the relevant decision node and the independent decision variable data from each of the 25 case studies. In this table the relationship between willingness to change vertical coordination strategy and the four decision variables based on decision nodes 2-5 (reduction in costliness of coordination, programmability, implementability, and acceptability of the risk/return tradeoff) are expressed as frequencies. These frequencies state the number and percentage of cases, which correctly predicted the direction of causality as stated by each of the four research propositions.

In ten out of thirteen cases where the producer indicated a willingness to change strategy, all four decision variables were "yes." This resulted in 77 percent of the cases being correctly classified as predicted by RP_1 (if a willingness to change is expressed, then all decision node answers are "yes" assessments). This is relatively strong evidence that RP_1 should be accepted (not rejected) as a necessary condition. However, RP_1 failed to hold in three cases.

A review of these cases (denoted as "D" in Exhibit 3) indicated a situation where the producer was uncertain about adopting the alternative strategy based on the risk/return tradeoff associated with the alternative variable. A response of uncertain meant the producer would not make a clear assessment as to whether the risk/return tradeoff would improve. Therefore, these cases indicated that the decision maker was willing to change strategy even with uncertainty about its ultimate performance impact. A weaker form of RP_1 (if willingness to change, then no decision node has a "no" assessment) would have been 100% confirmed. Further empirical testing of this issue is warranted.

The testing of RP_2 revealed that in ten out of ten cases, when all decision nodes were "yes" assessments, there was a willingness to change the considered vertical coordination alternative. This is strong confirmation of RP_2 as a sufficient condition.

RP_3 was predicted correctly in 100 percent of the cases. Twelve out of twelve times when there was an unwillingness to change, at least one of the four decision variables was also "no." In those cases where the producer was uncertain about the risk/return tradeoff and they were unwilling to change, there was at least one other decision variable that was also a "no." There where only two cases where only one "no" answer resulted in no change, four cases where two "no" answers resulted in no change, and four cases where three "no" answers resulted in no change. This is extremely strong evidence for the support of RP_3 as a necessary condition.

The percentage of correctly classified cases used in the testing of RP_4 was also 100 percent. Twelve out of twelve cases showed when any one "no" response occurred at any of the decision nodes, there was an unwillingness to change strategy. This is strong evidence that RP_4 should be accepted (not rejected) as a sufficient condition.

Missing cases and the primary decision variables

The case approach to testing the four research propositions would require at least one case for all possible combinations of yes/no responses across the four decision

Exhibit 3 Frequencies of the Relationship between the Willingness to Change, the Four Decision Variables, and the Four Research Propositions

Case No.	Willingness to Change?	Producer Response At Decision Nodes				Research Proposition			
		Node 2 (a)	Node 3 (b)	Node 4 (c)	Node 5 (d)	RP_1	RP_2	RP_3	RP_4
1	No	No	Yes	Yes	No			**H**	**H**
2	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
3	No	No	Yes	No	No			**H**	**H**
4	No	No	Yes	Yes	No			**H**	**H**
5	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
6	No	No	Yes	No	No			**H**	**H**
7	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
8	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
9	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
10	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
11	Yes	Yes	Yes	Yes	Uncertain	**D**			
12	Yes	Yes	Yes	Yes	Uncertain	**D**			
13	No	Yes	Yes	No	Yes			**H**	**H**
14	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
15	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
16	No	No	Yes	No	No			**H**	**H**
17	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
18	No	No	Yes	No	Uncertain			**H**	**H**
19	Yes	Yes	Yes	Yes	Uncertain	**D**			
20	No	No	Yes	Yes	Uncertain			**H**	**H**
21	Yes	Yes	Yes	Yes	Yes	**H**	**H**		
22	No	Yes	Yes	Yes	No			**H**	**H**
23	No	No	Yes	Yes	No			**H**	**H**
24	No	No	Yes	No	No			**H**	**H**
25	No	No	Yes	Yes	No			**H**	**H**
Number of cases in which the research proposition holds						10/13	10/10	12/12	12/12
Percent of cases in which the research proposition holds						77%	100%	100%	100%

(a): Does an alternative strategy reduce the costliness of a coordination error?
(b): Is the alternative programmable?
(c): Is the alternative implementable?
(d): Is the risk/return tradeoff of the alternative acceptable?

H = relevant research proposition holds.
D = relevant research proposition does not hold..

variables. The 25 cases used only represented five out of the sixteen possible yes/no combinations. However, eight of the eleven missing cases resulted from the problem of having no "low programmability" cases. Given the nature of the four decision variables, there is no reason a priori to expect that any of the combinations would not have been observed. Decreasing the number of missing cases identified above could be accomplished by doing more cases and refining the variables (especially programmability).

Subject to further case testing for the missing combinations, the findings of the previous sections can be used as evidence supporting the research propositions. Potential reduction in the costly nature of a coordination error, implementability, and risk/return acceptability were found to be necessary and sufficient conditions for respondents to change their current vertical coordination strategy.

Quantitative Analysis Based on Discriminate Analysis

In the last section, qualitative observations reported as simple frequencies from the case studies provided strong support for the four research propositions. This section extends the analysis of the in-depth interview database by using discriminate analysis[4]. This analytic tool was employed to examine how the variables in the interview database are related, and, when the data permit, to assign causality about the decision process for altering a vertical coordination strategy. The reason economists have recognized the importance of qualitative response models such as discriminate analysis is that the models' structures are particularly well suited for examining yes/no choices (e.g., a willingness or unwillingness to change vertical coordination strategy) and/or selections made from a small number of alternatives (e.g., choice of five vertical coordination strategies).

Application of discriminate analysis to the interview database

The linear discriminate function minimizes the probability of mis-classification (the cases were divided into two groups: willing to change and not willing to change their vertical coordination strategy), if in each group the variables are from multivariate normal distribution and the covariance matrices for all groups are equal. Appropriate variable transformations were tested for univariate normality based on the Shapiro-Wilk's test (Norusis, 1994). SPSS® (Statistical Package for the Social Sciences) uses the Lilliefor's significance correction to adjust for small sample size when testing for normality. Multivariate normality held for each of the discriminate functions reported in this research. The Box's M test, which is based on the determinants of the group covariance matrix, was used to test the equality of

[4] Although logistic regression would be an appropriate quantitative tool for analyzing the interview responses, the relatively small number of cases (25), ruled out this approach.

the group covariance matrices. The Box's M test is designed to test the null hypothesis that the covariance matrices are equal. A small probability (e.g., at the .05 level) might lead an investigator to reject the null hypothesis that the covariance matrices are equal. The Box's M procedure confirmed the presence of equal group covariance matrices in all of the discriminate functions used in this research.

Analyzing the differences between groups was undertaken to determine whether the observed differences between the two sample means was due to random variations from one sample to the next, or whether the data came from populations where the means were truly different (Iversen and Norpoth, 1987). Based on a one-way ANOVA procedure, the means from 17 interview variables were statistically different between those producers who exhibited unwillingness to change and those producers who exhibited a willingness to change vertical coordination strategies. These variables became potential discriminating variables. These 17 interview variables were operationalized into the three decision node variables from nodes 2, 4, and 5 discussed in the qualitative research findings of this paper. Programmability fell out of the model due to no variability in responses, i.e., all cases were "yes." To meet the normality requirement of the discriminate function, node 5 (acceptability of risk/return tradeoff) was represented by two variables, one for uncertainty and one for risk.

Calculating and interpreting the discriminate functions

In discriminate analysis, a linear combination of the independent variables is formed and serves as the basis for assigning cases to groups. Discriminate analysis establishes weights on the predictor variables so they result in the best separation between the groups. The linear discriminate equation is represented by: $D=B_0 + B_1X_1 + B_2X_2 + ...B_pX_p$ where the X's are the values of the predictor variables and the B's are coefficients estimated from the data.

Betas are chosen so the values of the discriminate function differ as much as possible between the groups, or so that for the discriminate scores, the ratio (between-group sum of squares ÷ within-groups sum of squares) is a maximum (Norusis, 1994). Returning to the relevant decision variables of this research, the equation for the discriminate function would be: $D=-4.369 + .814X_1 -.747X_2 +.430X_3 + .569X_4$.

Where

D = is the discriminate score

X_1 = the reduction in the costliness-of-a-coordination-error variable,

X_2 = the implementability variable,

X_3 = the uncertainty (risk) variable, and

X_4 = the profitability (return) variable.

The X_1 (decision node 2) and X_2 (decision node 4) were operationalized as outlined under the qualitative research section, while X_3 and X_4 now operationalize the decision node 5 variable from the qualitative research. The coefficients for the discriminating variables were taken from the unstandardized coefficient matrix generated by SPSS®.

Eigenvalues, Canonical Correlation, and the Wilk's Lambda Measures of Discriminate Function Efficiency

Eigenvalues are simply the ratio of between-groups sum of squares divided by the within-groups sum of squares. The larger the eigenvalue, the greater the discriminating power of the function. The eigenvalue associated with the four decision variables of Exhibit 4 is 3.907. The actual number representing the eigenvalue cannot be represented directly. A better measure of the discriminating power of the function is the canonical correlation (Klecka, 1980).

Canonical correlation is a measure of the degree of association between the discriminate scores and the groups. The canonical correlation for a discriminate function is the square root of the ratio of the between-groups sum of squares to the total sum of squares. Squared, the canonical correlation is the proportion of the total variability explained by differences between groups. The canonical correlation for the four decision variables is .892. When squared, the canonical correlation shows approximately 80 percent of the total variability explained by differences between unwillingness and willingness to change groups.

Wilk's lambda is the ratio of the within-groups sum of squares to the total sum of squares. It is the proportion of the total variance in the discriminate scores not explained by differences among groups. Lambda plus the canonical correlation squared by definition equals one. The four decision variables had a Wilks' lambda of .204, which implies approximately 20 percent total variance in the discriminate scores was not explained by differences between groups, but by differences within the unwilling and willing to change vertical coordination strategy groups.

Interpretation of the structure matrix coefficients

The structure matrix coefficients presented in Exhibit 4 are variables standardized to a mean of zero and a standard deviation of one. These are arranged in order of absolute correlation with the discriminate function.

Variables with large absolute coefficients can be thought to contribute more to the overall discrimination function, if the variables do not differ greatly in the units in which they are measured. The signs of the coefficients on the variables in Exhibit 4 make sense intuitively. An increase in the level of uncertainty (uncertainty is considered to be more constraining) and an expected lower profitability (profitability that was considered to be more constraining), leads to an unwillingness to change. A reduction in the costliness of a coordination error (moving from no to maybe to yes) and increases in the implementability (from low to moderate to high) of the alternative result in higher levels of willingness to change. This particular combination of variables in the discriminate function provides good predictive ability. The percent of cases correctly identified was 92 percent for the original group and 88 percent for the cross-validated cases[5].

The structure matrix also provides insight into the relative importance each of the discriminating variables plays in the differences between the groups being studied. Uncertainty had the largest absolute value (.698), followed by how constraining the expected profit was (.597), whether or not an alternative reduced the costliness of a coordination error (-.560), and implementability (-.330). Uncertainty, expected profit and the costliness of a coordination error variable were all close in absolute size or close in their correlation with the discriminate function. These variables were clearly important factors in the decision process to alter a vertical coordination strategy. Implementability was far less important. Based on this finding, the sequential nature of the proposed framework represented as five distinct decision nodes may not be the best way to represent the decision making process. Further research is warranted to explore the construction of a non-sequential decision node framework.

Additional discriminate analysis findings

Exhibit 4 presents a discriminate function consisting of four variables. One must test the possibility that the set of four decision node variables may be controlled or moderated by the other possible combinations of variables based on the producer interviews.

A total of seventeen variables, based on interview questions, which passed the F test for significant differences in group means were analyzed for combinations that may have led to additional valid discriminate functions. While more than 15 combinations of variables passed the equal covariance test, only eight combinations passed both the equal covariance and normality tests.

Exhibit 5 is a collection of all eight of these combinations. The decision node variable combinations highlighted in Exhibit 4 are presented in the column marked "Dec. Node Comb." There is a relative ordering of the functions according to the

[5]Cross-validation involves leaving out each case in turn, calculating the function based on the remaining n-1 cases, and then classifying the left-out case. Since the case being classified is not included in the calculation of the function, the observed (or apparent) mis-classification rate is a less biased estimator of the true one (Norusis, 1994: p. 15).

following criteria: (1) percent of total variation explained between groups, and (2) the percentage of cases correctly classified in the original and cross-validated cases.

The inclusion of additional variables did not substantially increase the amount of total variance explained by difference between groups of the discriminating variables, or increase the predictive ability of the original and cross-validated cases. As a result of each of the variables having the same signs, relative magnitudes, and grand centroids with the same signs across the eight functions, general interpretations can be made regarding how a shift in the discriminating variable affects the willingness to change. As the following variables increase, the willingness to change improves: (1) increased adoption of an alternative strategy given the risk/return tradeoff, (2) the reduction of the costliness of a coordination error, and (3) the implementability of an alternative strategy increases. There were no differences in the interpretation of these functions as compared to the function based on just the four decision node variables presented in Exhibit 4.

As the following variables increase in value, the willingness to change from a current strategy to an alternative becomes lower: (1) uncertainty becomes more constraining, (2) the potential for profit becomes more constraining, (3) satisfaction with the current strategy increases, (4) the perceived size of the strategy shift increases, (5) the acres of rented land increases, (6) the number of people on the management team increases, (7) the mismatch between the revealed coordination characteristics of the producer and the alternative strategy increase, and (8) the longer the decision maker or his farm has been in business.

Most of these associations are intuitively appealing. It should not be surprising that increased numbers of people on the management team can lead to unwillingness to change given the problems in managing with more people grows geometrically. The longer a person has been in business and its association with an unwillingness makes sense because these decision makers may have tried many alternative strategies in the past, they may be nearing retirement, or a certain amount of path dependence may be prevalent. The association between increased acres of rented land and unwillingness of change is somewhat confounding. Perhaps increased acreage of any kind represents a larger number of landlords to deal with, more reports to complete (especially if on a share-crop basis), resulting in higher transactions costs, thus making it harder for the decision maker to change. Another plausible explanation is that rental agreements often span many years and are relatively difficult to break. Producers maybe unwilling to try alternative strategies that may lead to higher costs associated with breaking rental agreements.

Exhibit 4 Discriminate Analysis Results: Decision Variables Passing the Normality and Equal Covariance Tests

Variable Group	Values
Uncertainty of the alternative (Not constraining to Extremely constraining) Profitability of the alternative (Not constraining to Extremely constraining) Reducing Costliness of a Coordination Error (No, Maybe, Yes) Implementability (Low, Mod, High)	*Structure Matrix Coefficients* .698 .597 -.560 -.330
Grand Centroids	Unwilling= 1.973 Willing = -1.822
Eigenvalue	3.907
Canonical Correlation	.892
Wilk's Lambda	.204
Variation Explained Between Groups	80%
Variation Explained Within Groups	20%
Percent of Cases Correctly Classified Original Group	92%
Percent of Cases Correctly Classified Cross-validated	88%

Exhibit 5: Discriminate Analysis Summary: Other Combinations of Variables Passing the Normality and Equal Covariance Tests

Variable Groups and Characteristics	Structure Matrix Coefficients[8]								
	Dec. Node Comb	Comb 1	Comb 2	Comb 3	Comb 4	Comb 5	Comb 6	Comb 7	Comb 8
Adopt given Risk/Return Tradeoff? (No, Unsure, Yes)		-.685							
Uncertainty of the alternative? (Not to Extremely)	.698		.670	.675	.677	.569	.630	.630	.645
Profit potential constraining? (Not to Extremely)	.597		.574	.578	.580	.487	.540	.540	.552
Reducing Costliness of a Coordination Error (No, Yes)	-.560	-.558	-.537	-.542	-.544	-.484	-.506	-.506	-.517
Satisfaction with current strategy? (Not to Extremely)		.373		.362	.362	.305	.338	.338	
Implementability of Alternatives? (Low, Moderate, High)	-.330	-.329	-.317	-.320	-.321	-.269	-.298	-.298	-.305
Perceived size of strategy shift? (Small or Large)			.298						.287
Acres of rented farm land in 1997? (3 categories)		.254	.245	.247		.208	.230	.230	.235
Number of people in management? (3 categories)		.249				.203	.225	.225	.231
Mismatch w/ coordination characteristics (Low, Moderate)		.246				.201		.223	.228
Years in the business? (continuous variable)		.211				.173	.191	.191	.196
Percent of Total Variation Explained Between Groups	80	80	81	81	81	85	83	83	82
Percent of Total Variation Explained Within Groups	20	20	19	19	19	15	17	17	18
Percent of Cases Correctly Classified Original Group	92	96	96	92	92	100	96	96	100
Percent of Cases Correctly Classified Cross-validated	88	88	88	88	88	84	84	80	76

[8]Each column represents a separate discriminate function where the Low centroid (Unwilling to change) is positive and the High centroid (Willing to change) is negative.

Concluding remarks regarding the use of discriminate analysis

The results of the discriminate analysis of the interview responses revealed that the ability of an alternative to reduce uncertainty was critical to the willingness and unwillingness to change strategies. The acceptability of the risk/return tradeoff, the final decision variable, was as important as the reduced costliness of a coordination error in the analysis. Implementability was found qualitatively and quantitatively significant, although, not to the same extent as costliness of a coordination error or acceptability of the risk/return tradeoff. However, the magnitude of the structure matrix variable and the small decreases in predictive power that showed up when the variable was removed from the model suggest implementability has less explanatory power than either of the other two variables. Programmability was not directly assessed because all producers indicated high levels of programmability whatever their willingness to change strategies.

There was strong quantitative and qualitative evidence to support research propositions two, three and four and moderately strong evidence to support research proposition one. Even with the relatively imprecise instruments (i.e., the decision variables), it appears the proposed framework was a reasonable model of how decision makers view the decision process for altering a vertical coordination strategy.

Areas Warranting Future Research

One broad area warrants further study. Steps could be taken to improve the overall measurement ability of the decision variables and other key variables of the framework.

Improving the measurement ability of selected variables

Two of the decision variables: (1) Would an alternative reduce the costliness of a coordination error?, and (2) Is the risk/return tradeoff acceptable?, were very good predictors or indicators for a decision maker’s willingness or unwillingness to change from their current vertical coordination strategy to an alternative strategy. However, these were imprecise instruments in the sense they were either dichotomous or trichotomous measures of a complex process. Additional research should incorporate finer measurements of these important variables.

The variable requiring the most measurement improvement was programmability because it was not found to be low (or anything other than high) for any of the producers who were interviewed. Producers were allowed to self-select strategies they were considering, making the programmability variable irrelevant. The significance of programmability could be tested if additional research is able to ask questions related to programmability prior to having the producer identify possible vertical coordination strategies.

It was suggested that implementability, although significant in discriminate analysis, was less dominant than the other decision variables. Further theoretical inquiry is needed to reexamine the variables used in the coding of implementability. Although the interview responses did not reveal any omitted areas of implementability, a clearer mapping of the relationship between implementation and these variables is needed.

Although acceptability of the risk/return tradeoff variables proved to explain a great deal of the decision process for altering a vertical coordination strategy, further refinement of this variable is possible. This research was not designed to capture the true risk preferences of the producers (risk averse, risk neutral, or risk loving), although respondents' answers do provide some insight into their risk preferences. There is an entire body of research and associated research methodologies, which could be used to better test for these effects on the vertical coordination strategy decision process. Additionally, more testing needs to be done on the interrelatedness of risk/return with the costliness of a coordination error, programmability, and implementability.

Finally, reduction-in-the-costliness-of-a-coordination-error variable should be tested further. More significant assessments of this complex variable are likely needed.

Concluding Remarks

A decision making framework for selecting a vertical coordination strategy (Exhibit 2) was tested based on 25 case studies of producers who were considering changes in their vertical coordination strategy, i.e., a "yes" decision had already been made for decision node 1. Based on both qualitative (strictly case-based) and quantitative (discriminate analysis) tests of interview responses from these cases, the research findings support the validity of the framework. Specifically, yes/no decisions for framework node 2 (potential reduction in costliness of coordination error), node 4 (implementability), and node 5 (risk/return acceptability) were found to be necessary and sufficient conditions to predict willingness and unwillingness to change vertical coordination strategy. Node 3 (programmability) proved not be explicitly testable based on the cases because all alternative strategies were deemed programmable by the producers, i.e., a "no" response at this node never occurred across the cases. An additional concern about confirmation of the framework was raised by the presence of several "uncertain" responses for node 5. In three of these cases, the producers were willing to change strategy even though they were uncertain about the risk/return tradeoff, i.e., a failure of the strict need for a "yes" at each decision node. If the producers in these three cases were risk neutral or risk loving, it would not be at all surprising that they would be willing to change vertical coordination strategy under uncertainty. However, this suggests that a weaker form of the framework may actually be valid.

The validity of nodes 4 and 5 is not very surprising. Implementability and risk/return tradeoff would seem obvious determinants of any managerial decision. The validity of node 2, the potential reduction in costliness of coordination, is not so obvious. There is no common language equivalent of this concept among producers. However, the concept as operationalized here held up well in both the qualitative and quantitative testing, even as implementability proved rather weakly supported in the discriminate analysis. Being so directly related to the transaction cost theory that underpins the vertical coordination continuum, this variable and its significance in the empirical findings provides an especially relevant test of the broader theory.

Further research is needed to improve the overall measurement ability of the decision variables and to fill in the missing cases. The key managerial implication of this work is that the framework is potentially relevant to decision making about vertical coordination strategy. In particular, managers need to assess costliness of coordination error through consideration of asset specificity and complementarity as well as the potential of a change in strategy to reduce this costliness.

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