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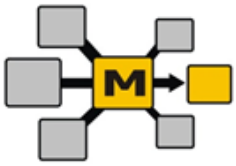

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EDITOR'S NOTE

Dear Readers,

We are pleased to publish the second issue of 2012. The IFAMR continues to grow and as a result expand the impact of authors. We received 20% more submissions in the first quarter of 2012 than all of 2008! We are on pace to set another new annual record, topping 2011's record levels. March 2012 was a record breaking month as well. Readers downloaded over 12,000 articles and case studies, up 27% from February and up 50% over March 2011. The IFAMR has just achieved a coveted A2 ranking in Brazil by the leading higher education organization CAPES.

I would also like to introduce our newest Managing Editor, Ram Acharya of New Mexico State University, U.S.A. The journal cannot run without the tireless work of our eleven editors. Managing Editors serve as the journal's face in a particular region. Submissions have risen dramatically in South America, Africa, and Asia so we would love to keep pace with additional Managing Editors in these regions. Interested scholars with a track record of publication and high quality reviews should contact me.

This issue contains seven scientific manuscripts, a great teaching case study on the European meat company VION, and a powerful industry commentary from the team at Alltech. Alltech is a leading veterinary pharmaceutical and livestock supply company headquartered in Kentucky/USA and Ireland.

Two years ago, IFAMA Board member Kristian Moeller, GlobalGAP, requested we ask authors to produce two minute video executive summaries of their articles. This was a great idea, and supplement of an IFAMR video production continues to grow. Take a look. This issue contains a number of great videos.

While English is the journal's first language, our authors and readers should know we have the ability to handle non English versions of articles and videos that could accompany your English versions. With our select mailing capabilities we can directly send your non-English video and article to a targeted mail list. Just contact us for more information.

Finally on a very serious note, we had a case of plagiarism in Volume 14 Issue 1 from 2011. The author took material without attribution from a 1996 article. We quickly and aggressively pursued the concern and removed the article and associated links. We also alerted the author's home institution. As policy we now check all articles prior to publication for plagiarism using specialized text analysis software. Certainly this episode was not one of the more pleasant aspects of our business.

Enjoy the issue!

Peter Goldsmith, Executive Editor, IFAMR

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How Large Commercial Producers Choose Input Suppliers: Expendable Products from Seed to Animal Health

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Abstract

This study uses cluster analysis to identify buying behavior segments of commercial producers who purchase expendable products including seed, crop protection, animal health and feed. For the crop expendable products we find four buying behavior segments: Convenience, Price, Performance, and a fourth segment, called Balance buyers, who equally value the aforementioned factors as well as customer service and support services. For livestock expendable products we find three buying behavior segments: Balance, Price and Performance. We find that producers have product-specific buying behaviors and this is especially true for livestock producers. We discuss the implications of these customer segments for expendable input marketers and salespeople.

Keywords: Cluster Analysis, Expendable Inputs, Market Segmentation, Commercial Producers

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Determining how current and potential new customers make purchasing decisions and choose a supplier is of particular interest to agricultural input retailers of expendable products, which are consumed by the farming enterprise and must be purchased frequently. Knowledge of producers' purchasing preferences enables input suppliers to market products targeted towards the needs of customers, which can increase sales and customer satisfaction (Gloy and Akridge, 1999). This task has become increasingly difficult with changes in the U.S. farm sector. As farm consolidation continues, purchasing decisions will be made by fewer operators who manage larger farms (Alexander, Wilson, and Foley, 2005). Therefore, the focus of this research is on U.S. commercial producers, who are defined as those running operations with annual sales of $100,000 or more. Though commercial producers account for only 16.2% of farms, they account for 87.2% of total farm production expenses (USDA, 2007). Therefore, agricultural suppliers must continually adapt their marketing strategies to retain this shrinking number of customers who are getting more powerful.

This paper presents a behavioral segmentation of commercial U.S. producers in the expendable input industry (seed, crop protection, animal health, and feed products) for the agricultural/agribusiness sectors. It extends prior research of Gloy and Akridge (1999) and Alexander, Wilson and Foley (2005) on buying segments for inputs in agriculture by providing comparisons of decision making process used by segment members in different input categories, as opposed to one broad category of expendable inputs. Cluster analysis is used to segment the commercial producer market based on survey data describing their buying behavior for expendable products. The goal of market segmentation is to classify producers into groups with homogeneous preferences within the group, and maximize the differences between the groups. Once these different segments are identified and profiled, specific marketing strategies of products, pricing, promotion, and distribution can be tailored to the preferences of targeted segments. Kotler (1997) suggests that customers will make purchases from firms that create the highest perceived value, and since the process of tailoring marketing strategies to specific market segments can increase customer's perception of value, firms will have the ability to attract and retain customers (Roucan-Kane et al., 2010).

Of particular interest in this study is how, if at all, these market segments differ between various types of expendable items. The study focuses on four expendable items: seed and crop protection products for crop producers, and animal health products and feed for livestock producers. Crop and livestock producers are respondents that considered the primary focus of their farm to be crop production or livestock production, respectively. The four categories of expendables chosen for this research are integral to the production of crop or livestock commodities. Because of the frequency and commonality of their purchase, understanding the nature of decision-making for them is important for researchers and suppliers. The results of this study suggest that producers differ in their purchasing decisions across expendable product categories indicating that input suppliers need to develop tailored marketing strategies for each expendable product category.

Agricultural Producer Markets

There have been a variety of studies on segmentation in the agricultural producer markets. Mwangi (1991) performed a cluster analysis on a central Illinois-based producer survey to segment the retail fertilizer and agricultural pesticide market. Her study used a market segmentation

method that considered the benefits sought by customers as a basis for creating homogenous customer groups. The study identified four distinct groups based on these benefits: knowledge seekers, reputation seekers, price seekers, and integrity seekers. Based on these segments, Mwangi suggested possible marketing strategies for retailers. Those retailers actively targeting the knowledge seekers segment should train their salespeople to provide reliable advice on fertilizer and pesticide application to producers. Retailers targeting the price seekers segment need to deliver product packages with low prices. Retailers targeting reputation seekers need to be cognizant of their standing in the community, while retailers targeting integrity seekers need to emphasize the importance of integrity in their sales force.

Hooper (1994) used data from the inaugural large commercial producer survey conducted by the Center for Food and Agricultural Business (CAB) at Purdue University in 1993. His focus was segmenting the market for agricultural inputs for producers with gross sales greater than $100,000 and a primary operation of corn/soybeans, wheat, cotton, dairy, beef, or hogs. His cluster analysis was conducted on 30 factors ranging from farmers' expectations about the future of their farming operation to specific farming practices such as new product adoption and the use of agronomic consultants. He identified a total of eight market segments, with the largest segment being Traditionalists who expect their farm to stay the same and are likely to maintain the status quo. Like Mwangi, Hooper suggested a marketing strategy for each segments consisting of product, place, price, and promotion.

Gloy and Akridge (1999) conducted a study using CAB's second large commercial producer survey in 1998. Using a two-step clustering process, U.S. crop and livestock farms with annual sales in excess of $100,000 were segmented based on weights applied to six factors that affect the choice of an input supplier. The factors included convenience/location, customer service/information (e.g., responsiveness, follow-up, advice), personal factors (e.g., trust, working relationships), price, product performance (e.g., yield, durability, rate of gain), and support services (e.g., delivery, repair, application). They identified four market segments: balance, convenience, performance, and price. These market segments were then characterized by their demographics and responses to attitudinal and behavioral questions. Based on these market segment characteristics, the authors offered strategies that could be used to target specific segments. However, one limitation of the 1998 survey is that respondents were asked to describe their purchasing behavior for expendable items in general, which did not allow the authors to consider whether buying behavior may differ across expendable input categories, such as seed and feed.

Based on CAB's 2003 large commercial producer survey, Foley (2003) conducted an analysis parallel to Gloy and Akridge (1999) who analyzed the 1998 large commercial producer survey data. Prior to running the cluster analysis, Foley conducted a factor analysis on the six decision factors used by Gloy and Akridge and found that "personal factors" and "customer service/information" provided the same information. Thus, Foley combined these two variables into an overall customer service/information variable for a total of five decision factors. Again a two-step clustering procedure was used and five customer segments were identified, the same four from Gloy and Akridge (1999) with an additional service segment. Foley (2003) expanded on Gloy and Akridge (1999)'s work by introducing a multinomial logit model that was used to predict segment membership using descriptive and attitudinal variables. Foley's model was successful in identifying characteristics that can be used to predict segment membership. The 2003

version of the survey, much like the 1998 version used by Gloy and Akridge (1999), only asked respondents about expendable input items and so could not test if market segment membership varied for distinct categories of inputs such as seed.

Alexander, Wilson, and Foley (2005) used both data sets from the 1998 and 2003 versions of the large commercial producer survey to compare the input market segmentation from 1998 to 2003. The data combination was possible as 76% of the questions that appeared on the 2003 survey were also on the 1998 survey. The two-step clustering method from Gloy and Akridge (1999) and Foley (2003) was used and identified the same five market segments as in Foley (2003) for both survey years 1998 and 2003. A multinomial logit regression analysis was also used to predict segment membership based on observable characteristics. Their study found that the convenience segment decreased in size from 1998 to 2003 with the performance, price, and service segments gaining substantial membership.

Data

This study uses the data from the Center for Food and Agricultural Business's 2008 Large Commercial Producer Survey which was conducted via phone during January and February 2008. The survey was specifically targeted to reach a representative sample of mid-size and large producers in six enterprise classes: corn/soybeans, wheat/barley/canola, cotton, dairy, swine, and beef. The sample was stratified by state with state quotas so that the sample would contain producers in states that accounted for 75 percent of 2007 U.S. production in each of the six target enterprise classes. Three versions of the survey were used: a crop version, a livestock version, and a joint crop/livestock version. Each respondent was assigned the version of the survey depending on whether they considered crop production or livestock production to be the primary focus of their farm. A total of 2,574 observations were obtained from the survey, with 980 from the crop version, 378 from the livestock version, and 1,216 respondents completing joint crop/livestock version. In this study we focus on only responses to the crop and livestock versions and drop the joint crop/livestock version to avoid confusion about which expendable items the respondent may have been referring to.

Method

The cluster analysis was conducted four times, once for each of the four expendable products: seed, crop protection chemicals, animal health, and feed. The method follows the approach of Gloy and Akridge (1999), Alexander, Wilson and Foley (2005), and Roucan-Kane et al. (2010). The first step is selecting clustering variables for the four expendable products. Instead of using demographics, we used responses to behavioral questions because behavioral data is more descriptive of a customer's basic reasons for purchase (Assael, 1981). The key survey question asked respondents to weigh the influence of five factors they may use to choose their supplier of the four expandable products. For example, for seed products, the respondents assigned weights to the factors on a force sum scale according to the following question: *When you choose a supplier for seed products, how is your decision influenced by the following factors? Assign a percentage value to each factor based on its importance in the decision. The percentages should add to 100% in each column.* The five factors included: convenience/location, customer service/information, price, product performance, and support services. The crop version of the sur-

vey also asked the same question for crop protection products while the livestock version asked the same question for animal health and feed products.

Before the clustering analysis began, the total set of observations needed to be reduced to appropriate samples. Observations for the seed and crop protection cluster analysis were restricted to those 980 respondents who completed only the crop version of the survey. Likewise, observations for the animal health and feed cluster analysis were restricted to those 378 respondents who completed only the livestock version of the survey. Further data cleaning consisted of deleting 136 observations that had a farm size less than the lower bound of the mid-size farm definition as defined by Alexander et al. (2009). In addition, observations that allocated the full 100% to any single decision factor were removed as this result suggests response bias likely due to the difficulty of answering the question; we deleted 84 observations for seed and crop protection, and 86 observations for feed and animal health products. After data cleaning was complete the final sample sizes for the cluster analyses were 855 observations each for seed and crop protection products, 283 observations for animal health products, and 281 observations for feed.

Clustering provides a method for classifying a large number of observations across many variables, but potentially describes random connections if a theoretical basis for relationships or triangulation with other studies is not used to augment researchers' judgments about what the classifications mean (Ketchen Jr. and Shook, 1996). For this analysis, the same clustering algorithm was used as Gloy and Akridge (1999), Alexander, Wilson and Foley (2005), Roucan-Kane et al. (2010) and Roucan-Kane et al. (2011) which is a two-step process. We first used a hierarchical clustering algorithm (Ward's Minimum Variance) to identify the appropriate number of clusters and obtain seed values for a subsequent non-hierarchical clustering algorithm (k-means). Both estimation procedures were conducted in SAS (1989).

Results

Based on the hierarchical clustering step and using the pseudo F-statistic, we identified four clusters for seed and crop protection products, and three clusters for animal health and feed products. While the pseudo-F statistic is one criterion for choosing the optimal number of clusters, researchers also need to confirm that the resulting clusters are measurable, actionable and significant. Tables 1-4 present the sample means for the clustering variables and the cluster names based on the largest factor for seed, crop protection, animal health, and feed products, respectively. For example, the price segment is composed of respondents who consider price to be the major criterion in their purchase decision. To validate the cluster results, we used cross-tabulations with chi-square test for significant segment differences on non-clustering variables such as demographics, farm characteristics, influences on purchasing decisions, and brand preferences and attitudes.

The cluster analysis identified four market segments for seed and crop protection chemicals, and three market segments for animal health and feed. This initial result suggests producers' purchasing decisions for expendable inputs vary based on whether they are crop-specific or livestock-specific. Also within a specific product, e.g. seed, the market segments vary with respect to the influence a specific factor has on a producer's purchasing decision.

Table 1. Relative Importance by Segment of each Factor for Seed Products

	Market Segments for Seed Products			
Factor	Balance	Price	Performance	Convenience
Convenience/Location	18	15	6	**52**
Customer Service	21	17	9	25
Price	21	**47**	17	13
Performance	**25**	16	**61**	6
Support Service	16	5	7	4
Percent of Sample	58.2%	13.8%	17.9%	10.1%

Table 2. Relative Importance by Segment of each Factor for Crop Protection Products

	Market Segments for Crop Protection Chemicals			
Factor	Balance	Price	Performance	Convenience
Convenience/Location	17	11	7	**42**
Customer Service	21	13	9	27
Price	23	**47**	16	18
Performance	**24**	23	**62**	9
Support Service	16	5	7	4
Percent of Sample	57.0%	18.0%	14.4%	10.6%

Table 3. Relative Importance by Segment of each Factor for Animal Health Products

	Market Segments for Animal Health Products		
Factor	Balance	Price	Performance
Convenience/Location	**28**	24	10
Customer Service	24	11	13
Price	19	**50**	22
Performance	16	10	**43**
Support Service	14	6	12
Percent of Sample	57.6%	17.7%	24.7%

Table 4. Relative Importance by Segment of each Factor for Feed Products

	Market Segments for Feed		
Factor	Balance	Price	Performance
Convenience/Location	**25**	23	10
Customer Service	23	16	10
Price	19	**49**	30
Performance	17	8	**40**
Support Service	17	4	10
Percent of Sample	58.4%	19.9%	21.7%

Segments' Characteristics

Balance. For all four products, the Balance segment is the largest, representing between 57% and 58.4% of the farms (Tables 1-4). Buyers in the Balance segment consider all of the input supplier's criteria (convenience/ location, customer service, price, performance, and support service) to be equally important. That said, the relative weighting of these factors depends on the product. For the seed Balance segment, the most important factor is product performance (shown in bold in Table 1, with the most important factors for each segment bolded similarly in Tables 2-4), with price and customer service tied for second most important. For the crop protection chemicals Balance segment, the most important factor is also performance with price being ranked a close second. For both the animal health products and feed Balance segments, the most important factor is convenience/location followed by customer service.

Price. Producers in the Price segment placed a large emphasis (47-50%) on product price. The price segment is the second-largest segment for crop protection chemicals at 18% of farms; and the third-largest segment for seed at 13.8% of farms, animal health at 17.7% of farms, and feed at 19.9% of farms. For the seed Price segment, price buyers rank customer service, performance and convenience/location about equally, while for the chemicals Price segment product performance is clearly the second most important factor. For the livestock inputs Price segment, convenience/location is the second most important factor for price buyers.

Performance. Producers in the Performance segment placed a large emphasis on product performance, at 61-62% for crop inputs and at 40-43% for livestock inputs. The performance segment is the second-largest segment for seed at 17.9% of farms, animal health products at 24.7% of farms, and feed at 21.7% of farms; and third-largest segment for chemicals at 14.4% of farms. For all four products, performance buyers rank price as the second most important factor.

Convenience. The Convenience segment is only present for crop inputs (seed and crop protection chemicals) and it was the smallest segment with roughly 10% of the farms. This segment placed a large emphasis on convenience/location at 52% for seed and 42% for chemicals. Customer service/information was the second most important factor to the Convenience segment.

Characterizing these segments enables suppliers to identify groups of producers and develop a marketing strategy that best creates value for that group. Gloy and Akridge (1999) contend that, for any reasonably sized market segment, a supplier can design a product/service mix to profitably serve that target segment. The designation of a reasonably-sized market segment depends on the supplier and the sales generated by that target market, i.e. a combination of the number of farms in the segment, the size of those farms, and the price they are willing to pay for the product. For crop input suppliers, the Convenience segment is the smallest and these suppliers will need to decide whether it would be more profitable for them to design a marketing program targeted to this segment or to passively serve this segment. Passively serving this market segment means that suppliers offer the Convenience buyers a marketing campaign that is targeted at other segments. This strategy will only partially satisfy the Convenience segment but will also require the smallest investment. Consistent with characteristics described by Gloy and Akridge (1999), the rest of the discussion regarding the market segments for the four expendable items is organized into the following sections: demographics, outside influences on the farm purchasing deci-

sions, brand preferences, loyalty, and price. Lastly, we compare market segments for crop production products, seed and chemical protection products, and for livestock production products, animal health and feed.

Demographics and Farm Characteristics

We focus on the three main demographics of farm size as measured by gross sales, education, and age. As noted by Assael (1981), demographic variables are less accurate in predicting which market segment a producer will belong to than behaviors are, demographic characteristics are easily observable and usable by suppliers to identify market segment membership. Table 5 presents cross tabulations of members in each segment by each demographic variable. The Pearson chi-square statistic is used to test for statistical significance of the distributions by market segment. The F-test is used to test for the statistical significance of the mean age by market segment.

With the exception of animal health product market segments, farm size and age characteristics were found to be significantly different across the segments. For all products, Performance buyers tended to operate the largest farms while for crop inputs Convenience buyers clearly operate the smallest farms. While there was no significant difference in the education levels of members across the segments, there tended to be a higher percentage of college graduates in the Price and Performance segments which is consistent with Gloy and Akridge (1999) and Alexander, Wilson and Foley (2005).

Influences of the Purchase Decision

It is common in production agriculture for producers to seek advice from others within or outside the operation. A simple example is demonstrated by agronomic consultants -- their advice has large impacts on the specific crop protection products used by producers (Gloy and Akridge, 1999). It is important for input suppliers to understand which on- or off-farm parties have the most influence on purchasing decisions. Marketing strategies can be built around this knowledge that includes educating and advertising to those parties that have influence on purchasing decisions about their products.

Two sets of questions in the survey were used to determine if purchasing decision influences exist or not. The first was the use of consultants, specifically independent crop, environmental, and management consultants for crop producers and independent nutritionists, environmental, management, and veterinarian consultants for livestock producers. Of the producers using these various types of consultants, the only significant difference was for the use of environmental consultants by the crop protection chemical market segments (Table 6). While not statistically significant, Performance buyers across all product categories tended to be more likely to hire consultants than other segments.

Table 5. Farm Demographics and Characteristics Organized by Input

Demographic	Total Sample	Balance	Price	Performance	Convenience	Prob of No Assoc.[1]
Seed						
Sales < $500,000	39%	40%	40%	29%	52%	
Sales $500,000 - $1M	28%	27%	28%	29%	30%	18.96***
Sales > $1M	33%	34%	32%	43%	17%	
College Graduate	33%	32%	36%	33%	30%	1.09
Age < 35	4%	5%	2%	2%	8%	
Age 35 – 44	15%	13%	20%	17%	14%	
Age 45 – 54	37%	35%	39%	42%	30%	22.43**
Age 55 – 64	28%	28%	31%	25%	24%	
Age > 65	16%	18%	9%	14%	23%	
Mean Age	53.4	53.7	52.4	52.9	53.9	0.59
Crop Protection						
Sales < $500,000	39%	39%	34%	33%	55%	
Sales $500,000 - $1M	28%	27%	33%	29%	22%	14.62**
Sales > $1M	33%	34%	33%	38%	23%	
College Graduate	33%	32%	36%	32%	33%	0.94
Age < 35	4%	5%	6%	1%	4%	
Age 35 – 44	15%	13%	20%	13%	17%	
Age 45 – 54	36%	36%	34%	48%	26%	22.41**
Age 55 – 64	28%	29%	25%	23%	28%	
Age > 65	17%	16%	14%	16%	25%	
Mean Age	53.4	53.4	52.0	53.8	55.0	1.52
Animal Health						
Sales < $500,000	38%	42%	36%	30%		
Sales $500,000 - $1M	24%	25%	24%	21%		5.72
Sales > $1M	38%	33%	40%	49%		
College Graduate	25%	21%	26%	33%		3.84
Age < 35	5%	4%	10%	3%		
Age 35 – 44	14%	14%	16%	16%		
Age 45 – 54	36%	36%	38%	33%		8.46
Age 55 – 64	29%	27%	22%	37%		
Age > 65	16%	19%	14%	11%		
Mean Age	53.8	54.6	51.1	53.8		1.88
Feed						
Sales < $500,000	38%	45%	36%	20%		
Sales $500,000 - $1M	23%	22%	21%	26%		12.68**
Sales > $1M	40%	34%	43%	54%		
College Graduate	24%	20%	34%	26%		4.51
Age < 35	5%	6%	5%	3%		
Age 35 – 44	14%	12%	27%	10%		
Age 45 – 54	35%	32%	36%	39%		19.48**
Age 55 – 64	28%	26%	25%	36%		
Age > 65	18%	24%	7%	12%		
Mean Age	54.2	55.5	50.0	54.7		5.00***

[1]Probability of no association represents the Pearson chi-square in the case of the chi-square test of cross tabulation or the F statistic in the case of the Anova table.
*, **, and *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

Table 6. Use of Consultants by Product and Market Segment

Purchasing Decision Influences	Balance	Price	Performance	Convenience	χ^2 Statistic[1]
		Seed			
Independent Crop Consultant	31.6%	29.7%	40.9%	34.5%	5.30
Environmental Consultant	5.2%	5.1%	3.9%	5.8%	0.54[a]
Management Consultant	9.2%	7.6%	9.8%	8.1%	0.50
		Crop Protection			
Independent Crop Consultant	32.3%	34.9%	38.3%	32.6%	1.72
Environmental Consultant	4.1%	6.5%	3.3%	9.9%	6.87*[a]
Management Consultant	10.3%	6.5%	6.5%	9.9%	3.16
		Animal Health			
Independent Nutritionist	51.0%	52.1%	53.1%		0.08
Environmental Consultant	23.9%	24.0%	28.6%		0.60
Management Consultant	14.7%	12.0%	15.7%		0.34
Veterinarians	83.2%	72.9%	85.9%		3.51
		Feed			
Independent Nutritionist	54.0%	51.9%	63.6%		1.90
Environmental Consultant	26.2%	21.4%	32.8%		1.97
Management Consultant	13.4%	17.9%	16.4%		0.78
Veterinarians	83.3%	83.3%	83.6%		0.00

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.
[a] For the Pearson Chi-Square test, one cell had an expected call count less than 5.

In a second set of questions, respondents were asked about their decision-making process. For each of the expendable items, respondents were instructed to select how purchase decisions are made from five response answers: made by me with very little input, made by me after discussion with family and/or employees, made by the person responsible for using the item after discussion with others on the farm, made by the person responsible for the item with little input from others, or made by a purchasing agent hired by our farm (Table 7). Of the four expendable items only seed was found to have significant differences between the segments. Specifically, Price buyers were more likely to make decisions with little input from others whereas the Performance segment relies on purchasing agents more than other segments. The Balance segment relies on family more than others. While not statistically significant, Price buyers in the other product categories also tended to make their decisions with little input from others.

Brand Preferences and Loyalty

Product branding and its effects on purchase decisions can be integrated into a personalized marketing strategy. Practically, all input products are branded by quality characteristics and pricing. A producer evaluates the quality and price combination to determine the appropriate purchase decision (Gloy and Akridge, 1999). To assess whether or not branding characteristics vary across market segments, respondents were instructed to respond to a series of statements about brands and brand loyalty on a five-point Likert scale with 1 representing strongly disagree and 5 representing strongly agree. To test for differences across segments participants that responded either 4 or 5 on the Likert scale were grouped and their percentage of all the total respondents reported in Table 8. The Pearson chi-square test statistic for no association is also reported.

Table 7. Relative Influence of Family, Employees, and Agents on Purchasing Decisions

Purchasing Decision Influences	Balance	Price	Performance	Convenience	χ^2 Statitic[1]
Seed					
Made by me with very little input from family members and/or employees	57.0%	61.9%	58.8%	53.5%	
Made by me after extensive discussions with other family members and/or employees	28.1%	20.3%	22.9%	26.7%	
Made by the person responsible for using the item after extensive discussion with others on the farm	7.2%	7.6%	5.9%	4.7%	
Made by the person responsible for the item with little input from anyone else	6.2%	9.3%	6.5%	12.8%	21.42**
Made by a purchasing agent hired by our farm	1.4%	0.8%	5.9%	2.3%	
Crop Protection					
Made by me with very little input from family members and/or employees	49.5%	51.3%	43.1%	52.7%	
Made by me after extensive discussions with other family members and/or employees	27.9 %	26.6%	29.3%	27.5%	
Made by the person responsible for using the item after extensive discussion with others on the farm	8.6%	9.7%	9.8%	7.7%	6.04
Made by the person responsible for the item with little input from anyone else	9.9%	9.7%	10.6%	8.8%	
Made by a purchasing agent hired by our farm	4.1%	2.6%	7.3%	3.3%	
Animal Health					
Made by me with very little input from family members and/or employees	54.0%	60.0%	47.1%		
Made by me after extensive discussions with other family members and/or employees	25.2%	18.0%	31.4%		
Made by the person responsible for using the item after extensive discussion with others on the farm	6.7%	12.0%	12.9%		
Made by the person responsible for the item with little input from anyone else	4.3%	2.0%	7.1%		11.95
Made by a purchasing agent hired by our farm	9.8%	8.0%	1.4%		
Feed					
Made by me with very little input from family members and/or employees	51.2%	60.7%	47.5%		
Made by me after extensive discussions with other family members and/or employees	29.3%	23.2%	36.1%		
Made by the person responsible for using the item after extensive discussion with others on the farm	7.3%	5.4%	8.2%		
Made by the person responsible for the item with little input from anyone else	4.3%	5.4%	4.9%		4.79
Made by a purchasing agent hired by our farm	7.9%	5.4%	3.3%		

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

Table 8. Respondent Attitudes towards Brands by Product by Market Segment

Purchasing Decision Influences	Balance	Price	Performance	Convenience	χ^2 Statistic[1]
Seed					
For the seed I buy, most brands are more or less the same	21.5%	27.1%	11.1%	29.1%	15.02***
I consider myself loyal to the brands of seeds I buy	52.4%	41.5%	41.8%	47.7%	8.09**
Crop Protection Chemicals					
For the crop protection chemicals I buy, most brands are more or less the same	36.1%	35.7%	25.2%	34.1%	5.39
I consider myself loyal to the brands of crop protection chemicals I buy	39.2%	27.3%	29.3%	38.5%	9.92**
Animal Health					
For the animal health products I buy, most brands are more or less the same	33.7%	32.0%	27.1%		0.98
I consider myself loyal to the brands of animal health products I buy	48.5%	30.0%	42.9%		5.34*

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

The segments have significantly different views of Brands (Table 8). Specifically for seed, only 11.1% of Performance buyers agreed that most brands are more or less the same, compared to 29.1% of Convenience buyers. For chemicals and animal health products, Performance buyers were the least likely to agree that brands are more or less the same, though this difference was not statistically significant. Brand loyalty also differed by segment and by product. The Price segment was the least likely to be loyal to a specific brand for seed, chemicals and animal health products (this question was not asked for feed), and these differences were statistically significant. For the crop inputs, Performance buyers also tended to be less brand loyal than Balance and Convenience buyers. Respondents were also asked a series of questions comparing branded and generic products. While none of the answers were statistically significant, again Price buyers tended to be more favorable towards generic products compared with other segments. We did not ask the brand questions for feed; assuming that in the commercial agriculture sector feed is primarily a commodity.

Distribution and Loyalty to Local Suppliers

Producers can have strong preferences about the types of suppliers and differing levels of loyalty to those suppliers. To assess whether or not loyalty to local suppliers varies across market segments, respondents evaluated a series of statements about local suppliers on a five-point Likert scale with 1 representing strongly disagree and 5 representing strongly agree. To test for differences across segments, participants that responded either 4 or 5 on the Likert scale were grouped and their percentage of all the total respondents was reported in Table 9. The Pearson chi-square test statistic for no association is also reported.

Table 9. Respondent Attitudes towards Local Suppliers and Distribution by Product by Market Segment

Purchasing Decision Influences	Balance	Price	Performance	Convenience	χ^2 Statistic[1]
Seed					
I consider myself loyal to my primary local supplier of seed	58.0%	44.1%	60.8%	65.1%	11.46***
In the next five years, I want a more direct relationship with seed companies	34.5%	40.7%	43.8%	39.5%	5.11
I prefer to buy most of the expendable items from one supplier	34.3%	33.1%	28.1%	38.4%	3.08
I am willing to pay slightly more to buy my inputs from locally owned suppliers	61.4%	52.5%	54.2%	64.0%	5.56
I often know more about many inputs products than my local supplier	31.5%	38.1%	37.9%	32.6%	3.36
Crop Protection Chemicals					
I consider myself loyal to my primary local supplier of crop protection chemicals	58.7%	40.9%	50.4%	71.4%	25.98***
In the next five years, I want a more direct relationship with manufacturers of crop protection chemicals	33.1%	38.3%	36.6%	36.3%	1.74
I prefer to buy most of the expendable items from one supplier	35.9%	25.3%	28.5%	45.1%	12.63***
I am willing to pay slightly more to buy my inputs from locally owned suppliers	62.0%	53.9%	52.8%	63.7%	6.21
I often know more about many inputs products than my local supplier	33.5%	37.0%	30.9%	30.8%	1.53
Animal Health					
I consider myself loyal to my primary local supplier of animal health products	55.8%	50.0%	60.0%		1.18
I prefer to buy most of the expendable items I need from one supplier	41.1%	30.0%	35.7%		2.18
I am willing to pay slightly more to buy my inputs from locally owned suppliers	58.3%	50.0%	61.4%		1.63
I often know more about many inputs products than my local supplier	36.2%	48.0%	47.1%		3.66
Feed					
I prefer to buy most of the expendable items I need from one supplier	34.8%	32.1%	45.9%		2.99
I am willing to pay slightly more to buy my inputs from locally owned suppliers	60.4%	51.8%	55.7%		1.38
I often know more about many inputs products than my local supplier	37.2%	48.2%	59.0%		9.06***

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

For both seed and chemicals, there were significant differences between market segments in loyalty to local suppliers. Convenience buyers were the most loyal to their local supplier and Price buyers were the least loyal to local suppliers. Balance buyers were also loyal to local suppliers for both seed and chemicals. Performance buyers were somewhat loyal and were more loyal to local suppliers of seed than local suppliers of chemicals. For animal health products, while there were no significant differences between market segments, Price buyers were, again,

the least loyal to local suppliers and Performance buyers were the most loyal. We did not ask this question for feed.

Crop producers were asked if they wanted a more direct relationship with seed companies and chemical companies. Overall interest in a direct relationship with seed and chemical companies was relatively low with between 33% and 44% of the producers in a market segment reporting that they were somewhat or definitely interested in a more direct relationship and there were no significant differences between market segments. That said, Price and Performance buyers were slightly more likely to want a direct relationship with seed and chemical companies.

For chemicals, Convenience and Balance buyers were significantly more likely than Price and Performance buyers to prefer to buy all of their chemicals from one supplier. For feed, Performance buyers were significantly more likely to say that they know more about the inputs they purchase than their local supplier than were other segments. We did not ask the supplier loyalty question for feed.

Price

To assess producers' price sensitivity, respondents were instructed to respond whether they tend to purchase the lowest priced products on a five-point Likert scale with 1 representing *strongly disagree* and 5 representing *strongly agree*. To test for differences across segments, participants that responded either 4 or 5 on the Likert scale were grouped and their percentage of all the total respondents is reported in Table 10. The Pearson chi-square test statistic for no association is also reported.

Overall, producers were the least price sensitive with regards to purchasing seed relative to chemicals and animal health products. For seed, chemicals, and animal health products, there were significant differences between market segments in terms of their price sensitivity. For seed, Convenience buyers (20.9%), followed by Price buyers (17.8%) were the most likely to report they purchased the lowest priced seed, while Performance buyers (6.5%) were the least likely. For both chemicals and animal health products, Price buyers (40.9% and 40.0%) were the most likely to agree they usually purchase the lowest priced products, followed by Performance buyers (23.6% and 27.1%) who were noticeably less price sensitive.

Producers may have different views of prices when it comes to the suppliers of products. For both seed and chemicals, there are statistically significant differences in producers' perceptions of the differences in prices among local suppliers. Performance buyers are the most likely to notice significant price differences, followed by Price buyers, with Balance and Convenience buyers being less likely to notice price differences. For both animal health and feed, while the differences between market segments are not statistically significant, Price buyers for both animal health products and feed, as well as Performance buyers for animal health products, are very likely to notice price differences between suppliers. One explanation for the price sensitivity of Performance buyers is that they tend to purchase more expensive products so they may expend more effort to find the least cost supplier of these products.

Table 10. Respondent Attitudes towards Price by Product by Market Segment

Price Sensitivity	Balance	Price	Performance	Convenience	χ^2 Statistic[1]
Seed					
When buying seed, I usually purchase the lowest priced products	9.8%	17.8%	6.5%	20.9%	17.21***
For expendable items, there are often significant price differences for similar products from one local supplier to another	38.2%	45.8%	49%	34.9%	8.17**
Crop Protection Chemicals					
When buying crop protection chemicals, I usually purchase the lowest price products	19.1%	40.9%	23.6%	16.5%	33.81***
For expendable items there are often significant price differences for similar products from one local supplier to another	39.4%	46.1%	48.0%	29.7 %	9.46**
Animal Health					
When buying animal health items, I usually purchase the lowest priced products	23.9%	40.0%	27.1%		4.96*
For expendable items, there are often significant price differences for similar products from one local supplier to another	34.4%	44.0%	44.3%		2.81
Feed					
For expendable items, there are often significant price differences for similar products from one local supplier to another	35.4%	42.9%	36.1%		1.04

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

Market Segment Comparisons

Input suppliers often sell multiple products. Since it is costly to develop product-specific marketing plans, one obvious question is how much overlap is there between market segments for these expendable products? Overall, 72.0% of crop producers have the same buying behavior for both seeds and chemicals and 70.1% of livestock producers have the same buying behavior for animal health and feed products. Furthermore, the Pearson chi-square test for no association showed very strong correlations between product categories in both the crop and the livestock input market segments, which suggests that suppliers can leverage their market strategies across product categories. For crop input suppliers, Table 11 presents producers' membership in chemical market segments given their buying behavior for seeds. For livestock input suppliers, Table 12 presents producers' membership in animal health market segments given their buying behavior for feed.

For crop input suppliers, there is a strong overlap in buying behaviors between seed and chemicals. If a producer is a Balance buyer for seed, then there is an 80.4% likelihood he or she is also a Balance buyer for chemicals. If a producer is a Price buyer for seed, then there is a 60.0% likelihood he or she is also a Price buyer for chemicals and a 27% likelihood of being a Balance buyer. If a producer is a Performance buyer for seed, then there is a 59.6% likelihood of also being a Performance buyer for chemicals, with 19.9% likelihood of being a Balance buyer and 17.2% chance of being a Price buyer. If a producer is a Convenience buyer for seed, there is a

60.2% likelihood of also being a Convenience buyer for chemicals with a 27.7% chance of being a Balance buyer.

Table 11. Overlap in Membership Seed and Crop Protection Market Segments

	Seed Market Segments				
Crop Protection Market Segments	**Balance**	**Price**	**Performance**	**Convenience**	**χ^2 Statistic[1]**
Balance	**80.4%**	27%	19.9%	27.7%	
Price	9.7%	**60.0**%	17.2%	10.8%	729.87***
Performance	4.6%	7.0%	**59.6**%	1.2%	
Convenience	5.2%	6.1%	3.3%	**60.2**%	

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

For livestock input suppliers, there is a strong relationship between membership in a feed market segment and the equivalent animal health market segment. Again, the strongest relationship is for the Balance segment. If a producer is a Balance buyer for feed, then there is a 77.9% likelihood he or she is also a Balance buyer for animal health. If a producer is a Price buyer for feed, then there is a 54.7% likelihood he or she is also a Price buyer for animal health and a 26.4% likelihood of being a Balance buyer. If a producer is a Performance buyer for feed, then there is a 63.2% likelihood of also being a Performance buyer for animal health, with 26.3% likelihood of being a Balance buyer.

Table 12. Overlap in Membership in Animal Health and Feed Market Segments

	Feed Market Segments			**χ^2 Statistic[1]**
Animal Health Market Segments	**Balance**	**Price**	**Performance**	
Balance	**77.9**%	26.4%	26.3%	
Price	7.8%	**54.7**%	10.5%	120.95***
Performance	14.3%	18.9%	**63.2**%	

[1]Pearson chi-square statistic and its significance where *, **, *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

Conclusion

The market place for expendable agricultural inputs is rapidly changing. With fewer farms making larger purchases, acquiring and retaining customers is of the utmost importance to agricultural input suppliers. This paper conducted a segmentation study on U.S. commercial producers for four expendable items: seed, crop protection, animal health products, and feed. For crop protection products and seed, four markets segments were identified: Balance, Price, Performance, and Convenience segments. For animal health and feed products, three market segments were identified: Balance, Price, and Performance segments. Each of these segments were examined for differences in demographic and attitudinal characteristics.

For all four expendable products, the Balance segment defined the typical producer that considered all of the input supplier criteria (convenience/ location, customer service, price, peformance, and support service) to be equally important. Since the Balance segment is the largest market segment, input suppliers and retailers must serve this segment. To compete for the Balance segment's business, the supplier must be competitive with other suppliers on convenience/location, customer service, price, performance, and support service. The default assumption is that all customers are Balance buyers until they demonstrate a strong interest in convenience, product performance or price.

The Convenience segment, for crop protection products and seed, was comprised of older producers who generally were more loyal to local suppliers and specific brands. The Convenience segment is the smallest segment and so input suppliers should consider whether they should develop a marketing program targeted to this segment, or alternatively offer the Convenience segment the marketing program developed for the Balance segment. Future research might consider whether there is a relationship between membership in the Convenience segment and purchase of services like application that would make this segment more attractive to serve.

The Performance segment, which is most interested in product effectiveness, was the least convinced that different brands for expendable items are more or less the same. They were also much more skeptical of generic labeled brands than some of the other segments. Understanding the trade-offs between brand loyalty and willingness to pay, given various information sources in the decision process, is an important area for future study of this segment and others.

The Price segment generally thought the trade-off between price and performance was good for expendable items. Price segment members were also much more involved in the decision making process as they preferred to make more decisions with little input from others than the other market segments. Using these and other characteristics input suppliers can begin to customize their marketing strategy to the various market segments.

There are several implications for managers that are clear from this analysis. First, for seed and crop protection sellers, it is worth noting that the large number of Balance buyers makes this segment an attractive opportunity. One aspect of this segment that is unique compared to others, is that this segment still places some value on support services. Marketers who wish to target that segment may want to be sure that those services are part of their offering. For example, in support of a strategy that targets Balance buyers, agronomy oriented retailers may wish to empha-

size their expertise in crop planning and analysis by including these capabilities in advertising and mailings.

Next, there is clearly a segment of buyers who prioritize performance over almost everything else, and performance is also the most valued aspect of the offering for Balance buyers. As marketers develop messages for the value they create, performance should take a prominent role unless there are other compelling reasons to emphasize other company strengths. For example, milk replacement marketers who target dairies who are Balance buyers may want their messages to emphasize recognizable high performing products while demonstrating how their expertise of matching those products to the needs of the operator results in higher production outputs.

Third, marketers may find efficiencies in marketing seed and crop protection together. While combining these products into a single package may not be attractive to all buyers, the buying differences between the two products are similar enough between the products, that a common segmentation strategy should be considered. Organizing supplier marketing efforts around segments of customers, rather than product lines, may provide a more efficient and effective means of allocating resources.

Finally, it is worth noting that many buyers consider themselves to be loyal to local retailers, and that translates into willingness to pay more for expendables. Local managers should not underestimate the value they create for seed and crop protection products. Neither should they rest in their effort to innovate services, which are valued less by some buyers. Marketers should leverage the strength of the relationship, by training sales and support staff to excel at matching seed and crop protection products with customer needs.

In some ways the livestock industry leads the crop industry in terms of consolidating segments. While the Convenience segment is small within crop input markets, this segment does not exist within the livestock industry. That said, convenience still weighs heavily for Balance buyers, who make up the largest segment. Marketers who don't possess a product or price advantage still have opportunities to emphasize a service component of their offering. Feed marketers in particular should consider enhancing the knowledge of staff in the field. This is an area where Performance buyers feel they often know more than the people who call on them. There may be an opportunity to capture market share with the Performance segment if firms emphasize this issue. Feed marketers who seek to market high performance feeds should be aware of this weakness as they build strategies for these product offerings.

Marketers of all expendable products should be cautious about creating a purely balanced approach to messaging across all buying motivations (price, product performance, service, and convenience). Particularly in areas where competition is stiff, suppliers risk losing their identity by trying to be all things to all buyers. It may be preferable to focus marketing messages on areas that are competitive strengths and then to tailor value propositions with individual customers to a more balanced value proposition through sales efforts. This may be most critical for suppliers who sell products like crop protection, which have potential for use across broad geographies and therefore have many competitors. Suppliers of products like seed, which may have limited suitability because of differing regional growing conditions, may benefit from emphasizing product performance. Future research may wish to consider the causal relationships between

cognitive perceptions of the value bundle and segment membership or decision making processes, particularly as it relates to mediating influences like veterinarians and agronomists.

One major contribution of the 2008 version of CAB's large commercial producer survey was that it enabled us to examine how market segments vary between expendable inputs. There was strong correlation found between memberships for animal health products and feed, and an even stronger correlation for crop protection products and seed. Market segment membership is relatively consistent across expendable items suggesting that an input retailer can develop buying behavior-based marketing strategies, rather than product-specific marketing strategies. Input suppliers need to recognize that while the majority of customers have a defined buying behavior regardless of the product, a sizeable number shift their buying behavior depending on the product.

This paper is a companion to Roucan-Kane et al. (2011) which used the 2008 Large Commercial Producer survey to identify market segments for capital equipment. In their review of the literature, Roucan-Kane et al. (2011) highlighted that the focus of the industrial marketing management literature is on how to segment markets and then once the market segments have been identified, how firms can use these segments to improve their marketing efforts. They also commented that the market segmentation literature in general does not offer insight as to why customers choose a particular buying behavior, which is a major shortcoming of the literature. One future direction for the Large Commercial Producer project is to examine the causal factors for producers' buying behaviors.

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An Institutional Approach to the Examination of Food Safety

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Abstract

Food safety is an inherently complex agribusiness problem. Food safety is a result of the collective efforts of various members of the food supply chain in which each member's production, handling, processing and retailing practices jointly determine the safety of the consumed product. Although agency explanations have been offered as one potential solution to this research challenge, food safety also operates within a greater institutional setting. A theoretical framework that draws on an institutional approach is developed in which two sets of propositions are offered to explain the coordination and economic organization of food safety. Such a framework offers four contributions / implications to organizational economic and food safety research.

Keywords: food safety, institutions, separating equilibrium.

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Introduction

Food safety is an inherently complex agribusiness problem (e.g. Berg et al. 2005; Loader and Hobbs 1999; Ménard and Valceschini 2005). Food safety is a result of the collective efforts of various members of the food supply chain in which each member's production, handling, processing and retailing practices jointly determine the safety of the consumed product (Weiss 1995). Yet, despite its importance to society, there is no definitive system of food safety that food supply chain members can agree on. This is because firms seek their own food safety technologies and standards as a means to differentiate from others. Specifically, while firms have a public responsibility to provide safe food to the consumer, they have a private incentive to profit from such responsibilities by investing in specialized assets that differentiate them from others (Loader and Hobbs 1999; Ménard and Valceschini 2005; Sporleder and Goldsmith 2001). For instance, as the largest food service supplier in the U.S., Sysco Inc. has differentiated its services through investments in its food quality assurance programs that are specialized to this firm's food safety needs. This specialization provides a source of competitive differentiation because it "signals" to potential customers as well as to competitors its commitment to food safety. Many other firms are also involved in such competitive differentiation, such as Walmart's efforts to implement and coordinate a Global Food Safety Initiative (GFSI). Yet, since food safety is the result of the collective efforts of many, the research problem is: how does management coordinate the specialized and thus divergent interests of firms in a food system in a way that not only satisfies their private interests for competitive differentiation, but also organized to meeting the needs for public safety?

Agency explanations have been offered as one potential solution to this research problem (e.g. Fearne and Hornibrook 2001; King, Backus, and Van der Gaag 2007: Resende-Filho and Buhr 2008; Starbird 2005; Starbird, Amanor-Boadu, and Roberts 2008; Weiss 1995). The goal of agency theory is to demonstrate how divergent interests can be coordinated by organizing economic exchanges through a contractual arrangement. By "getting incentives right", an optimal contract coordinates the divergent interests of a principal-agent relationship in which incentives modify an agent's actions towards the interests of its principal (Eisenhardt 1989; Hill and Jones, 1992; Jensen and Meckling 1976). In a food safety context, a principal firm that has made investments in food safety assets, such as Sysco, may design a contract to pay its supplier or agent (i.e. food processor) a premium to produce food products that meet a specific pathogen reduction goal. Such incentive inducements have been manifested in various forms. For instance, Starbird (2005) conceived that changes to sampling conduct in inspection could lead to analogous results to incentives in the structuring of principal-agent relationships (see also Starbird et al., 2008). Furthermore, King et al. (2007) demonstrate that payment mechanisms based on safety routines can align the safety interests of the agent with those of its principal.

Yet, despite its general appeal, agency theory rests on an assumption that incentive contracts are governed by efficient markets (Barney and Ouchi 1986; Fama 1980; Fama and Jensen 1983; Hill and Jones 1992; Jensen 1983). With efficient markets, the principal and agent have the freedom to enter and exit contractual relationships (Hill and Jones 1992). In the long run, such free entry / exit yields a competitive market situation in which an agent can voluntarily enter into those contractual arrangements that are mutually compatible with the interests of its principal. And if such contractual arrangements are not agreeable, competitive market conditions ensure that agents or

principles "can always seek better alternatives" (Hill and Jones1992, 135). Contracts – as a means of economic organization- are thereby inherently efficient because in the long run, competitive market forces will not only select out the most inefficient forms, but will reveal contracts that mutually coordinate the divergent interests of the agent to its principal (Hill and Jones, 1992).

However, institutional theorists argue markets do not always subscribe to the efficient premises of agency theory (e.g. Coase, 1937, 1960; Hayek, 1960; Hill and Jones, 1992; Ménard and Valceschini, 2005). A long tradition in industrial organizational economics contend that markets are subject to barriers to entry / exit that contribute to concentrated market conditions (e.g. Caves and Porter, 1977; Carleton and Perloff, 2005; Porter, 1980). Market concentration introduces market power influences that limit an agent / principals' ability to voluntarily enter / exit a contractual arrangement (Hill and Jones, 1992). For instance, as U.S. and European food markets have transitioned towards increasing concentration (e.g. Boehlje, 1995, 1996; 1999; Cook and Chaddad, 2000; Loader and Hobbs, 1999; Ng, 2008), concentration yields market power influences in which "chain captains" (Boehlje, 1996) can pressure supply chain members to conform to a food safety standard (Ménard and Valceschini, 2005). This market power undermines agency explanations because market power precludes an agent the freedom to voluntarily enter or exit mutually beneficial contractual exchanges.

In addition, agency theory lacks consideration for the role of specialized assets in coordinating the divergent interests of the market (Lajili and Mahoney, 2006). This is because due to its assumptions of free entry / exit, agency theory assumes that firms in the long run will eventually possess similar assets (Carlton and Perloff, 2005). Yet, various institutional economists contend that asset specificity is important to coordinating less than efficient markets because specialized assets can "signal" the quality / safety of the product (e.g. Allen, 1984; Kirmani and Rao, 2000; Landon and Smith, 1998; Shapiro, 1983). Institutional theorists argue that specialized assets can yield a "small numbers" situation in which contracts can no longer benefit from the "large number" efficiencies of a competitive market (e.g. Lajili and Mahoney, 2006; Williamson, 1975). This is because agents not only face fewer contractual alternatives in coordinating their food safety activities, but these remaining alternatives face a greater potential for hold up.

Although not directly examined in agency theory, the efficient premise of agency theory is also predicated on a well-defined set of property rights (e.g. Asher, Mahoney and Mahoney, 2005; Coase, 1960; Hayek, 1960; Kim and Mahoney, 2005; Rothbard, 1982). This is because property rights enable parties to coordinate mutually beneficial exchanges by profiting from the ownership / use of specialized assets (e.g. Asher et al., 2005; Hayek, 1960; Rothbard, 1982). Yet, the assignment of property rights, in terms of food safety liability, is often difficult to determine (e.g. Brewster and Goldsmith, 2007; Loader and Hobbs, 1999). When property rights cannot be fully defined, contracts are incomplete and the parties to an exchange become vulnerable to the liable actions of their connected partners (Brewster and Goldsmith, 2007). When contracts are incomplete, contracts are thereby not likely to be sufficient in coordinating food safety because in the absence of punitive action, contractual members can shirk on their food safety commitments.

Lastly, as the efficient market processes play a primary role in coordinating economic exchanges, an agency theory does not account for the role of institutional norms in coordinating private-

collective interests. In that, while competitive markets can yield an efficient contract that coordinates food safety, this coordination cannot be attributed to financial incentives alone. It may also depend on a firm's social or normative obligations to the consuming public. For instance, studies have shown that consumers do not have the objective nor scientific expertise to assess the safe handling practices of food firms (Berg et al., 2005). Thus, in the absence of such expertise, food firms have a normative obligation or duty that they can be counted on or trusted in producing food that is safe (Berg et al., 2005; Sapp et al., 2009). Hence unlike the efficient premises of agency theory, the coordination of food safety cannot be attributed to financial incentives alone, but may also depend on a firm's social or normative obligations to their consuming public.

As a result, although agency theory offers a potential means to explain the coordination and economic organization of food safety, the efficient premises of agency theory operates within competitive market setting that cannot account for these various institutional considerations. That is, agency theory is principally concerned with the alignment of divergent interests, but such an alignment operates within a greater institutional context that is not accounted for in the efficiency tenets of agency theory. As a result of this "gap" in agency explanations of food safety, the objective is to draw on an institutional approach to addressing this study's aforementioned research problem. Namely, how does management coordinate the specialized and thus divergent interests of firms in a food system in a way that not only satisfies their private interests for competitive differentiation, but also organized to meeting the needs for public safety?

To address this research problem, this study argues that as food safety fundamentally involves the coordination of public and private interests, an institutional approach offers a framework that serves to coordinate an individual's self-interests towards a pattern of economic organization that advances the interests of a social collective (Coase, 1937, 1960; Hill and Jones, 1992; Nelson and Sampat, 2001; Pfeffer and Salancik, 1978). While undoubtedly there are variety of possible institutional factors to consider, a conceptual framework is developed that focuses on five factors that influence the coordination and economic organization of food safety activities: 1) market concentration (e.g. Boehlje, 1999), 2) specialized assets (e.g. Ménard and Valceschini, 2005), 3) small numbers situation (e.g. Ménard and Valceschini, 2005), 4) property rights (e.g. Ménard and Valceschini, 2005) and 5) trust (e.g. Berg et al., 2005; Freudenburg, 1993; Loader and Hobbs, 1999; Sapp et al., 2009). By accounting for these institutional factors, this framework not only underscores departures from the efficient premises of agency theory, but it extends agency's focus on contracts to consider other forms of economic organization that include vertical integration and social networks (e.g. Boehlje, 1995; Loader and Hobbs, 1999; Sporleder, 1992).

To organize the development of this institutional framework, the concept of an agribusiness institution is first outlined. The five institutional factors surrounding this concept of an agribusiness institution are then examined by drawing on insights from institutional research that include industrial organization economics (Carleton and Perloff, 2005; Caves and Porter, 1977; Porter, 1980), Signaling theory (Shapiro, 1983; Sporleder and Goldsmith, 2001), Transaction cost economics (Williamson, 1975), Property rights (Coase, 1960), and Trust (Berg et al., 2005; Freudenburg, 1993; Granovetter, 1983; Sapp et al., 2009). Insights from these five institutional areas are then integrated to yield propositions that explain the coordination and economic organization of food safety. This study then concludes with its contributions to institutional economics and draws implications to food safety research.

Conceptual Development

Defining the Concept of an Agribusiness Institution

Although there are varied meanings of institutions, one primary function of an institution is to coordinate human exchanges towards a pattern of economic organization (e.g. Coase, 1960; Hayek, 1960; Nelson and Sampat, 2001; Scott, 1995). For instance, Nelson and Sampat (2001) describe that a common focus of institutions is "achieving agreement in contexts where there is a collective interest in channeling and controlling self-interested behaviors and achieving a pattern of action that is in the collective interest" (p. 38). However, as such coordination tends to be influenced by the context in which it is studied (Nelson and Sampat, 2001); this study argues the institutional context surrounding the coordination of food safety is particularly influenced by: market concentration, asset specificity, small number situations, property rights and trust. Furthermore, as institutions coordinate activities towards a pattern of economic organization, various agribusiness researchers contend that exchange relationships are organized not only through contracts, as ascribed by agency theory, but also through vertical integration and social networks (Boehlje, 1995; Loader and Hobbs, 1999; Sporleder, 1992). This study thereby defines an agribusiness institution by a pattern of economic organization – contracts, vertical integration, social networks- in which an agribusiness firm is subject to institutional factors – market power, asset specificity, property rights and trust- that influence the coordination of its food safety activities. While such a definition may appear to be similar to "mainstream" definitions of agribusiness, mainstream definitions of agribusiness however tend to focus on the interdependencies among connected supply chain members but do not explain the institutional factors impacting such interdependence (e.g. Boehlje, 1999; Cook and Chaddad, 2000; King et al., 2010; Sporleder, 1992). Hence, this study's definition differs from mainstream treatments in its attention on those institutional factors that impact the coordination and economic organization of food safety in the agribusiness supply chain[1]. The institutional factors shaping this coordination are explained as follows:

Institutional Factors of Coordination

Concentration: As U.S. and European agricultural markets have evolved towards increasing concentration (Boehlje, 1996, 1999, Cook and Chaddad, 2000; Ménard and Valceschini, 2005; Ng, 2008), such changes in market structure are increasingly characterized by a small number of large and specialized agribusiness operations (e.g. Hardesty and Kusunose, 2009). While there are numerous factors influencing concentration, economies of scale is an important factor because they form a barrier to entry that limits the number of firms that can enter the market (e.g. Carleton and Perloff, 2005; Porter, 1980). Specifically, as economies of scale are based upon an investment of fixed and often specialized assets, reductions in average costs stem from spreading these specialized assets over increasing quantities. This yields barriers to entry because such scale economies favor a minimum efficient scale that can only support a small number of larger players in the market (Porter, 1980). For instance, the U.S. pork production industry is strongly characterized by such concentrated market structures in which the minimum efficient scale has

[1] Hence, this definition limits the scope of those inter-dependencies between members of a given supply chain and not members across different supply chains. Although cross industry / supply chain externalities are important, it is beyond the scope of this study. Future research is thus called upon to examine such interdependencies.

increased tremendously such that small scale operations have been virtually replaced by specialized large scale feeding and feeder-pig operations (Babcock, 2005; Babcock and Clemens, 2005). This push for an increasing scale of operations has led to an industry wide concentration in which a small number of large scaled pork producers and packers control 80% of the U.S. markets (Babcock, 2005; Babcock and Clemens, 2005).

Although such a characterization of market concentration need not reflect all agricultural industries, there is nevertheless a general recognition that modern agricultural industries- in both the U.S. and European markets- favor "structural changes" towards a small number of large and specialized agribusinesses (e.g. Banterle and Stranieri, 2008; Boehlje, 1999; Codron, Giraud-Heraud and Soler, 2005). This type of market concentration yields two implications to food safety. First, a consequence of concentration is it yields a form of "market power" (Hill and Jones, 1992; Pfeffer and Salancik, 1978; Scott, 1995) in which large firms are placed in a position of influence that can directly shape the coordination of food safety standards (e.g. Ménard and Valceschini, 2005). This is because by virtue of their success and their overall role in society, larger firms have greater "legitimacy" to members of society to which yields them normative or institutional powers to enforce standards and practices that protect their self-interests (Hill and Jones, 1992; Pfeffer and Salancik, 1978; Porter, 1980; Scott, 1995). This is consistent with Porter's 5 (1980) forces framework in which he argues increases in concentration at one stage of a supply chain can yield a "threat of buyer / supplier power" over other stages of the supply chain (see also Hill and Jones, 1992). Such a threat of buyer / supplier power however involves more than the market price abuses described in industrial organizational economics (Carleton and Perloff, 2005), but includes the enforcement of standards that support those who are in power (Hill and Jones, 1992; Porter, 1980).

For instance, Wal-Mart had adopted a Global Food Safety Initiative Standard (GFSI) for its private label products. Under such a food safety standard, all producers of Wal-Mart and Sam's Club private label food products must be audited and be fully certified in accordance with Wal-Mart's food safety requirements (A.N.S.I., 2008). Due to the overall increasing concentration of the food retailing sector (Anders, 2008; Loader and Hobbs, 1999; Ménard and Valceschini, 2005), food producers and processors face little choice but to accept this food safety standard. While such food safety initiatives have originated from the downstream segments of the food supply chain, food safety initiatives can also be influenced by the supplier power of upstream members. For instance, the Leafy Greens Marketing Agreement has been a successful government-private partnership program that originated from the food safety initiatives of California produce farmers. The success of this food safety initiative has led to its adoption throughout the downstream stages of the fresh produce supply chain and has been a model for other states.

As a second consequence, industrial organizational economists argue concentrated markets can also yield larger than average market returns (e.g. Anders, 2008; Carleton and Perloff, 2005; G.A.O, 1999). These above normal returns are important to supporting investments in food safety related assets because they tend to involve specialized investments that are costly to reverse (e.g. Ménard and Valceschini, 2005; Sporleder and Goldsmith, 2001). For instance, as the largest food service supplier in the U.S. market, Sysco Corporation has differentiated its services through specialized investments in its food quality assurance programs. Such investments in a firm's food safety reputation and other supporting assets requires a long term commitment that is

costly to reverse because such investments tend to be highly specialized to a firm's food safety needs (e.g. Sporleder and Goldsmith, 2001).

More generally speaking, since concentration is influenced by underlying scale economies, studies have shown that large firms are better able to absorb the fixed cost of such specialized investments over that of smaller firms (Codron et al., 2005; Hardesty and Kusunose, 2009). While smaller firms in competitive industries have sought to differentiate themselves through marketing safe products that involve claims such as "local", "organic, "rBst- Free", such monopolistic competitive market conditions are not likely to generate a level of sustainable returns that will support the level of investment in specialized assets made by larger firms. Hence, with concentrated market conditions, scale economies yield above normal returns that provide the financial means to invest in costly to reverse specialized assets that would not be possible in the limited return settings of a monopolistic competitive market.

Specialized Assets: As concentration promotes an investment of specialized assets (e.g. Hill and Jones, 1992; Montgomery, 1994), it is important to thereby outline the nature of such specialized assets. In the context of food safety research, specialized food safety assets include investments in a firm's food safety reputation and those assets that support a firm's reputation (e.g. Banterle and Stranieri, 2008; Sporleder and Goldsmith, 2001). With respect to a firm's brand reputation, a food companies branding efforts include food traceability traits (Banterle and Stranieri, 2008; Pouliot and Sumner, 2008). For instance, due to the *E.coli* outbreak in the U.K, regulation 1760/2000 in the EU of the meat supply chain obligates members of the beef supply chain to be able to include in their labels the country of origin of the animal, a traceability code linking the meat to the animal, and the country and registration number of the slaughterhouse and culling of the traced animal (Banterle and Stranieri, 2008). Such EU regulations also permit voluntary labeling in which beef supply chain members can include additional information beyond these mandatory requirements, such as a system of cattle breeding, cattle feeding, breed, date of slaughtering, name of slaughter house (Banterle and Stranieri, 2008). Such branding efforts are specialized because it create a "national" identity that distinguishes the safety of meat from other regions (i.e. meat originating from non-U.K. origins) (Banterle and Stranieri, 2008). Such branding efforts also require other specialized investments that involve the costs of planning the system, consulting and training the personal, and the design of the data management and control system that support the traceability requirements of the food label (Banterle and Stranieri, 2008). As another example, California leafy greens producers have also made similar investments in such specialized assets. Due to the 2006 *E.coli* outbreak in U.S. spinach, California leafy green producers undertook specialized investments in the production; marketing and handling of leafy greens (Hardesty and Kusunose, 2009). In the spring of 2007, a group of California handlers established the Leafy Greens Product Handlers marketing Agreement (LGMA). Through government certification, this agreement required that handlers source from growers who are in compliance to the food safety practices of this agreement. Growers who are in compliance are distinguished by a "service mark" brand label which was carried on sales documents throughout the produce supply chain. As such branding efforts are specialized to the good agricultural practices (GAPs) described in the LGMA, other specialized investments were also required in implementing this food safety standard. In particular, Hardesty and Kusunose (2009) study found that in order to support the best practices of the "service market label", specialized investments involving additional training in field monitoring, procedures documentation, water testing and overall

personnel training were needed. Food safety specialists were also identified as another required investment to which the total cost for compliance to LGMA was estimated at $84.36/ acre. There are also other specialized investments involving "one time modification costs" such as additional fencing at $17.2/ acre, modification of compost storage area at $0.8 / acre) and other modifications including air cannon to scare off wild life at $5.4 /acre[2].

In explaining the incentives to invest in such specialized assets, food safety researchers have drawn on the price signaling literature that argues firms make such investments because there is a basic market failure (i.e. inefficient markets) in "signaling" the safety attributes of a firm's products (Ménard and Valceschini, 2005; Sporleder and Goldsmith, 2001). This market failure stems from the "experience good characteristics" of food safety whereby food hazards are either difficult to detect or are detectable only after its consumption[3] (Loader and Hobbs, 1999). With this experience good characteristic, markets fail to coordinate the production of high quality / safe products. This is because in the presence of such market failure, producing firms have an incentive to sell unsafe food products as safe to which buyers respond by paying lower prices. This reduces incentives for firms to produce high quality / safe products (Loader and Hobbs, 1999) and thus low quality / unsafe food products will drive out the production of high quality/ safe products (e.g. Akerlof, 1970; Sporleder and Goldsmith, 2001).

More generally speaking, to overcome this market failure problem, signaling research finds that firms have an incentive to invest in specialized assets because they yield a "separating equilibrium" outcome that differentiates the quality of their products from others. A "separating equilibrium" refers to an outcome where high quality / safe firms have in their economic self-interest to signal the quality of their products, while lower quality / unsafe firms do better by not signaling (Kirmani and Rao, 2000; Sporleder and Goldsmith, 2001). That is in the context of food safety, because the production of safe quality products requires a greater investment of specialized assets, a separating equilibrium involves two types of food firms: large and small food businesses. In such a separating equilibrium, large food companies have in their self-interest to engage in a "separating equilibrium" in which their investments in specialized food assets serve to signal the safety of their product offerings from that of smaller food companies.

Large companies engage in such a separating equilibrium because the specialization of food safety assets exhibit scale advantages in food safety and they provide a means of competitive differentiation. With such scale economies, larger firms are in a better position to signal the safety of their products than smaller growers because small producers cannot absorb the higher cost that is associated with the investment of specialized assets. For instance, in the case of LGMA, large firms face greater economies of scale than smaller producers whereby the cost of LGMA compliance for growers with sales over $10 million was estimated at $8.29 /acre, while for growers with revenue between $1 and $10 million, LGMA compliance costs was estimated at $18.05 / acre (Hardesty and Kusunose, 2009). Furthermore, due to such scale economies, large firms have an incentive to "signal" their food safety because it provides a source of competitive differentia-

[2] In the U.S. beef supply chain, food safety assets in meat packing such as Frigoscandia's beef steam pasteurization system used in Excel's plant in Fort Morgan, Colorado is also highly specialized asset. Because food safety protocols, such as HACCP, involve a strong systems orientation, the integration of food safety prevention assets need to be integrated within the processing conditions and constraints of the plant (see Golan et al.(2004))

[3] Readers are noted, this definition does not exclude consideration that food safety can also include credence attributes.

tion. For instance, Codron et al.'s study (2005) found that large agribusinesses, such as Carrefour, have made specialized investments that meet the strict quality standards of their premium private label, "Filière Qualité Carrefour" (see also Label Rouge Program[4]). This specialization exceeded publicly mandated food safety standards and thus yielded a source of competitive differentiation in which Carrefour commanded a price premium of 10 to 20%. While, as smaller firms lack the specialization of assets that is associated with a large firm's scale economies, small firms thereby lack the competitive differentiation of large producers. Hence, in a separating equilibrium, smaller firms are better off with not signaling the quality of their products by remaining "anonymous" (e.g. Cordon et al., 2005; Hardesty and Kusunose, 2009).

Small Number Exchanges: However, the challenge facing this "separating equilibrium" outcome is that such "signaling" efforts are often cast between a single seller and buyer and thus do not speak to the coordination that is required in the multiple agent settings of an agribusiness institution. Yet, since concentrated markets consist of large firms that have market power, such market power can institutionalize the investment of specialized assets in their upstream or downstream partners (e.g. Hill and Jones, 1992). This investment of specialized assets can subsequently create a sequence of "bilateral monopolies or small number situations" (Williamson, 1975) in the agribusiness supply chain. In particular, through such asset specific investments, each large firm member of this small number exchange "signals" to their adjacent buyer their quality differentiating efforts. This not only yields a "separating equilibrium" amongst the various members of the supply chain, but such a "separating equilibrium" rewards each member a higher price premium for their investments made in food safety (see also Pouliot and Sumner, 2008). As a result, through market concentration, a large firm with market power can institutionalize or enforce upstream and downstream members to invest in specialized food safety assets that serve the firm's food safety goals. This yields a separating equilibrium in which there is a sequence of small numbers exchange relationships in which large food companies align and coordinate the interests of the various members of the agribusiness food system.

For instance, in following the U.K. BSE crisis, the giant retailer Carrefour, second largest worldwide, created its own label for beef (Filière Qualité Carrefour) that involved tight quality control requirements on cattle farmers and slaughterhouses (Ménard and Valceschini, 2005) involving complete traceability and organoleptic quality of the meat (Codron et al., 2005). As each value chain member conformed to the food safety standards and investment requirements of their "chain captain", such pressures for conformance coordinated the collective activities of the beef supply chain. Such coordination in turn differentiated the food safety attributes of this supply chain. This coordination is supported by the arguments of a "separating equilibrium" whereby higher price premiums are commanded by the quality investments and standards made by the small number exchange members of this beef supply chain. The following is thus proposed:

1a. Market concentration positively affects a firm's incentives to making specialized investments in their firm's food safety assets
1b. Specialized investments in a firm's food safety assets positively influences a "separating equilibrium" amongst small number exchange members of a food supply chain system.

[4] Westgren's (1999) discussion of the Label Rouge Poultry system exhibits similar parallels.

Property Rights: A consequence of this "separating equilibrium" is that investments in specialized assets yield property right considerations that can also influence the coordination of food safety activities in an agribusiness institution. Institutional researchers have long recognized the importance of property rights in coordinating exchange activities (e.g. Coase, 1960; Hayek, 1960; Ménard and Valceschini, 2005; Rothbard, 1982). Property rights involve a right of exclusivity in which owners can exclude exchange partners from the benefits of asset ownership (Asher et al., 2005; Coase, 1960; Hayek, 1960; Rothbard, 1982). Acts such as violations of patents or the appropriation of returns on another's property reflect infringements to such rights (Asher et al., 2005). The right of exclusion and the assignment of liability are thereby two sides of the same coin (Coase, 1960). This is because the right to exclude non-owners from the benefits of ownership implies a right to impose liabilities on those who violate such rights.

In the context of food safety, rights of exclusivity and liability are important to coordinating the food safety activities of an agribusiness institution for two reasons. First, property rights over the ownership of specialized assets are central to the coordinating advantages of a separating equilibrium. For instance, consider a situation in which there is an absence of property rights. Under such a situation, a firm will not have an incentive to invest in their food safety assets because they will be unable to exclude small number exchange members from "free riding" on the signaling benefits of these assets. This inability to exclude others from appropriating the signaling benefits of a firm's assets introduces a "markets for lemons problem" (Akerlof, 1970) in which low quality / unsafe food products will be sold at premium prices. Hence, in the absence of a right of exclusion, a separating equilibrium is unsustainable because the market will not support price premiums that would sustain a firm's investment in specialized food safety assets.

Second, although the Coase theorem (1960) has not been examined in the context of price signaling research, a clear assignment of liability is important to the onset of a separating equilibrium. In situations where individuals do not fully bear the social costs of their actions, the Coase theorem argues that regardless of the initial assignment of liability, as long as property rights can be well defined with no transactions costs, societal resources will be allocated to their most efficient use. To illustrate, Coase uses an example in which a rancher's straying cattle creates crop damage to a neighboring farm. Coase argues that as long as property rights can be fully specified whereby liability can be assigned to the damaging party (i.e. rancher) with minimal or zero transaction costs, the liable party (rancher) can negotiate with the damaged party (farmer) to accept payments for damages (i.e. farmer has the right of exclusion) created by its straying cattle. Coase further argues that the initial assignment of liability does not affect the efficient allocation of societal resources. Coase argues if the rancher cannot be held liable (i.e. the rancher has the right of exclusion), in which liability now resides with the farmer, the farmer can provide payments to the rancher for reducing the size of its herd. In either situation, the initial assignment of liabilities does not affect the final social outcome. This is because in both situations the bargaining process introduces additional social costs that were not previously considered by the other party. Such a bargaining process, irrespective of the assignment of initial liability, leads to a greater internalization of social costs and thus promoting the coordination and efficient allocation of social resources.

In drawing from the Coase theorem, a clear assignment of food safety liability – irrespective of initial assignment- can promote the onset of a separating equilibrium. Because investments in specialized assets create a small numbers situation (Lajili and Mahoney, 2006; Williamson,

1975), each partner is vulnerable to the liable actions of their connected partner. For instance, since the detection of food pathogens is costly (Loader and Hobbs, 1999), small number exchange members can "shirk" on their commitments to food safety and thus impose social costs in the form of food safety liability to their adjacent partners. In the absence of a clear assignment of liability, there will be no incentive for a firm to invest in specialized assets because the damaging party will not internalize the social cost of their liable actions.

As a result, since a separating equilibrium is contingent on investments in food safety assets, the lack of a clear assignment of liability will undermine the onset of a separating equilibrium. This suggests that a separating equilibrium role is not only dependent on a right to exclude "small members" from appropriating excessive returns from a firm's ownership of specialized assets, but according to Coase (1960) depends on an assignment of liability that protects each member's specialized assets from the liable actions of their connected partners. For instance, the 1990 Food Safety Act in the U.K. holds each party in the value chain accountable for due diligence over the safety of the supplies that it uses (Loader and Hobbs, 1999). By creating a widely shared liability, the Act motivated the private sector to a high level of coordination and control in food safety enhancements (Holleran, Bredahl and Zaibet, 1999; Loader and Hobbs, 1999). Every contemporary analysis of the drivers of supply chain coordination in the U.K. notes the role of the legal liability system in establishing shared responsibility, and it is widely agreed that this assignment of rights spurred the coordination for safer food standards (e.g. Loader and Hobbs, 1999). The following is thus proposed:

1c. Property rights promote the coordination of food safety activities by protecting a firm's right to appropriate the returns from its specialized investments and from the liable actions of its connected parties.

Yet, although property rights are important to protecting a firm's investments in specialized assets, property rights themselves are necessary but not a sufficient condition to providing the level of food safety that is predicted by a separating equilibrium. Specifically, given the assignment of private property rights, private-public partnerships for food traceability can also facilitate the onset of a separating equilibrium outcome. Such private-public partnerships can involve the development of voluntary food safety standards that exceed minimum public standards. For instance, in the case of the EU meat supply chain, EU regulation 1760/2000 permits voluntary labeling in which beef supply chain members can include additional information beyond that of government mandated requirements (Codron et al., 2005). This private-public partnership promotes a greater transparency about the food safety practices of supply chain members. This transparency not only facilitates the detection and thus subsequent assignment of liability to infracting parties, but it can also promote the realization of a separating equilibrium outcome.

To explain within this private-public partnership, large firms have an interest to signal their food safety by engaging in voluntary standards that exceed a publicly mandated standard. This is because by virtue of their larger size, lapses in food safety by these large members can incur significant liabilities to its financial position. For instance, in the case of *E. coli* contamination in hamburger patties, court costs and lost sales to Jack in the Box restaurant have been estimated of up to $100 million (Martin, 1998). Hence, large firms have an incentive to signal a higher level of food safety that exceeds government mandated standards because it minimizes their exposure to

such financial liabilities and risks. In contrast, a small producer's signaling strategy is to choose a publicly mandated requirement because they do not have the financial resources to cover the financial liabilities in failing to conform to the higher food safety requirements of a voluntary standard. Furthermore, as smaller food firms do not possess specialized assets in food safety, they lack the expertise that is required to meeting the additional food safety requirements of a voluntary system. As a result, through this private-public partnership, a separating equilibrium can arise in which large firms have in their self-interest to signal a commitment to a "voluntary standard", while the self-interests of the small firm is to signal a commitment to a publicly mandated standard. The following is thus proposed:

1d.Given well defined property rights, private-public partnerships involving voluntary and mandatory food safety standards positively influence the onset of a separating equilibrium.

Trust: Yet, while such private-public partnership are helpful in realizing a separating equilibrium outcome, institutional researchers contend that "trust" in food producers and regulatory bodies is also important to the provision of food safety (Berg et al., 2005; Sapp et al., 2009). According to a theory of recreance, an increasing specialization of tasks yields a highly interdependent society which renders the public increasingly vulnerable to the risks posed by each specialized member. As Sapp et al. (2009) note, a theory of recreance,

"recognizes that risk is socially constructed, wherein contemporary citizens are "dependent not just on the technologies [of a modern society], but also on the social relations that bring them into being, involving whole army of specialists, most of whom have areas of expertise that we may not be competent to judge, and many of whom we will never even meet, let alone have the ability to control" (Alario and Freudenberg, 2003: 2000). Institutional actors must therefore be perceived as both competent and reasonably responsive to citizens" (pg. 529).

In particular, since food safety risks cannot be fully understood by the concerns of the consuming public, theoretical and empirical studies have found that there are normative expectations on food companies that they are increasingly "counted on" by the public "to follow through on a duty or trust" in producing goods that are safe (Freudenburg, 1993, pg. 916; Sapp et al., 2009). For instance, Sapp et al.'s (2009) study found that consumers' trust in the U.S. food system is based on a normative expectation that agribusiness food companies are expected to demonstrate "competency" in their handling of safe food and that the production of food is conducted in a "fiduciary responsible" manner. Food companies have an obligation to fulfill such normative expectations because when food companies fail to behave in accordance to such expectations, they are deemed "miscreants" (Freudenberg, 1993, p 917) and will fail to receive the "trust" and support from the public. Such trust places normative obligations on firms to produce food that is safe even when their risks cannot be fully identified.

To elaborate, while the stochastic and complex nature of food safety risk renders it difficult to fully detect safety infractions (Brewster and Goldsmith, 2007), trust can yield a "separating equilibrium" in which large firms face a greater normative obligation to producing safe food over that of smaller firms. Consumers are more likely to place greater trust in large firms because their investment in specialized food safety assets may give them the appearance of competence. Furthermore, because of their size, they are socially more visible and thus may appear to uphold

a greater fiduciary responsibility to the public. In contrast, as smaller firms lack an investment of specialized assets, they do not possess equal "competence" of their larger counterparts and thus command less trust from the consuming public. Furthermore, small firms may prefer a signaling strategy of "anonymity" because they cannot be held liable for any food safety infractions. Such anonymity lacks accountability and thus reducing a small firm's fiduciary responsibilities to society. As a result, despite the complex and stochastic nature of food safety risks, large firms have an incentive to provide safe food even when such risks are costly to detect. This is because larger firms face a greater normative obligation to develop trust with their consumer public to which such trust serves to yield a separating equilibrium that "signals" their commitment to food safety over that of smaller firms. The following is thus proposed:

1e. Increases in the complexity or interdependency of food safety risks positively influences a separating equilibrium outcome.

Economic Organization

Since the purpose of an institution is to coordinate individual interests towards a pattern of economic organization (Nelson and Sampat, 2001), the institutional factors ascribed by this study are not only used to explain the coordination of food safety activities in a separating equilibrium outcome context, but these factors are also used to explain the economic organization of this outcome. Agribusiness researchers contend that the activities of the agribusiness system can be organized through contracts, vertical integration and social networks (e.g. Boehlje, 1995; Sporleder, 1992; Ng, 2008) to which their choice can be explained by a transaction cost minimizing logic (Williamson, 1975). While a transaction cost economics approach is well established in agribusiness research, the institutional factors surrounding the economic organization of food safety is not. As result, in drawing on the institutional factors of this study, a transaction cost minimizing logic approach is extended to explain within a separating equilibrium context the economic organization of food safety activities. This extension is explained as follows:

Contracts: Given concentrated markets, a clear delineation of property rights coupled with asset specificity and a small numbers situation is argued to favor a contractual mode of organizing the food safety activities of a separating equilibrium. This is because when property rights on food safety assets are well defined, exclusivity and the assignment of food safety liability reduces the transaction costs in the enforcement and monitoring of food safety transactions. Exclusivity minimizes opportunistic problems of hold up and thus prevents small number members from having the rents of their food safety assets being appropriated by their adjacent partners. Furthermore, the assignment of liability reduces efforts by small number members to shirk on their food safety activities. This assignment of liability mitigates problems of moral hazard which reduce the transaction costs of monitoring the food safety practices of small number partners. As a result, given concentrated markets, a well-defined system of property rights coupled with asset specificity and a small number exchange situation will reduce the transaction costs of market exchange. This would favor a contractual mode of economic organization in which food safety activities of a separating equilibrium are coordinated by a contractual arrangement that rewards small number members –consisting of large food producers- a price premium for their specialized investments in food safety assets. The economic organization of this separating equilibrium is proposed as follows:

2a. A well-defined system of property rights coupled with asset specificity and a small number situation positively influences contractual forms of economic organization.

Vertical Integration: Yet, when it is difficult to fully assign food safety liability, the assignment of property rights not only becomes costly, but it renders vertical integration – as opposed to contracts- a more viable form of economic organization.

For instance, Brewster and Goldsmith (2007) argue that courts tend to avoid imposing harsh liability to infracting firms on the basis of a type I error avoidance, an avoidance to punish the innocent. The U.S. constitutional setting protects individual rights at its core and thus individuals are deemed innocent until proven guilty. Yet, although Type I error protects individual rights, Brewster and Goldsmith (2007) argue that "proving cause, effect, and responsibility becomes difficult for regulators within a system that is most concerned about not committing a type I error" (p. 29) and "…hinders the ability of the legal system to correctly signal and enforce consequences associated with safety risks" (p. 30). The implication to the economic organization of food safety is that the inability to assign food safety liability not only renders that property rights are ill-defined, but as result introduces a transaction costs in the assignment of such rights. Specifically, consistent with Coase (1960), when there are transaction costs in the assignment of property rights or the property rights are not well defined, asset specificity and small number situations increases the transaction costs of a contractual exchange. This is because when liability cannot be fully defined –due to an avoidance of Type I errors-, ill- defined property rights opens up opportunities for small number members to shirk on their commitment to food safety without financial recourse. Furthermore, small number members cannot be excluded from appropriating or holding up the returns made by their partner's investment in specialized food safety assets. This inability to fully define property rights thereby raises the transaction costs in writing more complete contracts that mitigate such opportunistic behaviors.

Vertical integration has been argued as an alternative to this contractual mode of economic organization (Williamson, 1975). Vertical integration is distinguished by its power of authority (Coase, 1937, Williamson, 1975). Authority replaces the arms-length transactions of contracts with a single employer-employee relationship (Coase, 1937). An employer-employee relationship reduces the need for an agribusiness firm to write a complete contract, and relinquish the need to monitor and enforce the food safety practices of its contractual partners because an employee who is conducting the same food safety activity in question can be directly monitored by the employer. Such authority not only reduces the transactions costs associated with the monitoring and enforcement of food safety practices, but authority also reduces problems associated with shirking and holdup (e.g. Coase, 1937; Williamson, 1975). This is because with the power of authority, employers can instruct their employees to act in ways that reflect the safety goals of their business and thus protect the firm's specialization of food safety assets from problems of hold up and shirking. Hence, due to the transaction cost minimizing properties of authority, the logic of transaction cost economics would suggest that when property rights cannot be fully defined, conditions of asset specificity and small numbers situation would favor organizing the food safety activities of a separating equilibrium through vertical integration. Hence, to emphasize the significance of property rights to the vertical integration of food safety activities, the corollary to proposition 2a is stated as follows:

2b. Given asset specificity and small numbers situation, the absence of property rights positively influences the vertical integration of food safety activities.

In spite of the transaction cost minimizing benefits of authority, Coase (1937) however recognizes that a firm cannot vertically integrate all activities of a market. Coase argues that with increasing vertical integration, managers face an increasingly bureaucratic administrative structure that limits a firm's ability to grow. For instance, since food safety risks are complex and interdependent, efforts to increasingly vertically integrate specialized food safety assets increasingly exposes the firm to the risks of each integrated and specialized unit. This follows Durkheim's notion of "organic solidarity"[5] in which "increasingly complex social systems may increase the probability that some key portions of the system…cannot be safety counted on. Paradoxically the very division of labor [specialization] that permits many of the achievements of advanced industrial societies may also have the potential to become one of the most serious sources of risk and vulnerability." (Freudenberg, 1993, p, 914). This suggests that while the absence of well-defined property right favors organizing a separating equilibrium through vertical integration, an increasing integration of specialized food safety assets limits a firm's growth. This is because as this vertical integration increases a firm's internal complexity, it exposes the firm to various sources of specialized and interdependent risks and thus limits a firm's ability to provide safe food.

Strong tie networks: To deal with such limits, social networks involving strong ties offer another form of economic organization (e.g. Chiles and McMackin, 1996; Granovetter, 1983). Distinct from contracts and vertically integrated forms of economic organization, strong ties are defined by interactions that involve a high frequency of close and reciprocal social relationships amongst similar individuals (Granovetter, 1973, 1983; Hansen, 1999; Ng, Unterschultz, and Laate, 2006; Rowley, Behrens and Krackhardt, 2000). Due to the focus on close and reciprocal relationships, strong ties have been found to: 1) promote the exchange of detailed and / or difficult to codify knowledge (Dyer and Nobeoka, 2000; Granovetter, 1983; Kraatz, 1998; Uzzi, 1997), 2) facilitates joint problem-solving activities, and 3) provide the mutual identification of parties that enhance trust-based governance (Dyer and Nobeoka, 2000; Granovetter, 1983; Kraatz, 1998; Rowley et al., 2000; Uzzi, 1997).

In drawing on a recreance theory of trust, strong ties offer an alternative means of organizing a separating equilibrium. In this separating equilibrium, a recreance theory would suggest that even when food safety risks have become increasingly complex and interdependent, small number members with strong network ties will nevertheless face a normative obligation to produce safe food. Namely, as strong ties have been found to promote a conformance to institutionally prescribed norms (e.g. Burt, 1992; Coleman, 1988; Granovetter, 1983), strong ties increase a small number members' competence and fiduciary responsibilities to their consuming public.

To elaborate, in terms of competence, the close and reciprocal exchanges of strong ties increase members' ability to jointly solve a common set of problems (Hansen, 1999; Ng et al., 2006; Uzzi, 1997). This is because strong ties promote an in depth understanding of each small number member's food safety practices to which each member develops a unique or specialized understanding of their potential food safety hazards. For example, such detailed or specialized knowledge promotes joint solutions in identifying the Critical Control Points (CCPs) of a

[5] Readers should note that the theory of recreance is based on Durkheim's notion of organic solidarity

HACCP program. By promoting such greater joint problem solving, strong ties thereby increase small number members' competence in their handling of food safety events.

Moreover, in accordance to the normative pressures ascribed by recreance theory, strong ties create a greater social obligation to produce food in a fiduciary responsible manner. This is because as strong ties involve frequent and detailed interactions, strong ties have been found to promote a greater monitoring and governance of partner practices (see Dyer and Nobeoka, 2000; Dyer and Singh, 1998).With this greater monitoring of partner behaviors, strong ties create a greater social obligation by small number members to become accountable for their food safety actions. In that, due to their close and frequent exchanges, strong ties will render that small number members are more likely to devote resources to reducing food safety contaminants than focusing their attention to cost control efforts. Hence, in accordance to the normative obligations ascribed by a recreance theory of trust, strong ties increase trust in the small number member's food safety practices because these ties promote fiduciary responsible actions to the public.

Hence, although vertical integration offers a means to organize food safety activities, strong ties can thus become an increasingly relevant alternative when limits to such vertical integration have been reached. Specifically, strong ties not only offer an alternative means to organizing a separating equilibrium, but strong ties develop small number members' trust with its consuming public. Amongst small number members that consist of large food firms, strong ties reinforce their joint specialization of tasks to which increases their competence in their handling of food safety activities. These strong ties also increase their accountability and thus fiduciary responsibilities to the consuming public because their actions are closely monitored by their small number partners. As result, these strong ties yield a greater trust by the consuming public to which places a normative obligation on these small number members to be increasingly "counted on" in producing food that is safe (Sapp et al., 2009). As a result, while the economic organization of a separating equilibrium can be influenced by financial incentives and transaction cost reducing motivations, strong ties reflect an alternative mode of economic organization in which small number members - consisting of large firms- differentiate their food safety on institutional or normative grounds. Given that there are limits in even a large firm's ability to integrate specialized food safety assets, the normative or institutional aspects of this separating equilibrium are captured in the following proposition:

2c. Increasing vertical integration- beyond a size threshold- positively influences a strong tie mode of economic organization in which small number members – consisting of large firms- face a normative obligation to produce food that is safe.

Conclusions

As food safety has become an increasingly important attribute in consumer choice, firms differentiate their competitive position by making investments in food safety related assets (Berg et al., 2005; Loader and Hobbs, 1999; Ménard and Valceschini, 2005). Yet, the challenge facing agribusinesses is that the benefits from such investments rest on a firm's ability to coordinate and organize the diverse interests of its exchange partners. Although principal-agent explanations have been a useful approach to addressing this research problem, agency explanations rest on an implicit assumption that contracts are devised under highly efficient market settings (Barney and

Ouchi, 1986; Hill and Jones, 1992). While markets in the long run tend to exhibit the properties of an efficient market, institutional researchers contend that markets in the short run are less than efficient (e.g. Coase, 1937, 1960; Hayek, 1960; Hill and Jones, 1992; Rothbard, 1982). Such inefficiencies can stem from a variety of institutional factors that include but are not limited to market concentration, asset specificity, small numbers exchange, property rights and trust (e.g. Coase, 1960; Chiles and McMackin, 1996; Freudenburg, 1993; Hill and Jones, 1992; Ménard and Valceschini, 2005; Sporleder and Goldsmith, 2001; Williamson, 1975). Yet, in spite of a recent growth in interest about institutions (e.g. Sykuta and James, 2004), there remains a limited understanding of how these various institutional factors influence the coordination and economic organization of food safety activities in an agribusiness institution. As a result, by drawing on these varied institutional factors, this study developed an institutional approach to addressing this gap in food safety research. This institutional approach offers four contributions / implications to organizational economics and food safety research.

First, as agency theory is predicated on an efficient market premise (e.g. Fama, 1980; Fama and Jensen, 1983; Jensen, 1983), an agency perspective understates the complexities involved in the coordination and economic organization of food safety. This underscores a criticism made by Eisenhardt's (1989) review of agency theory in which she notes,

"Agency theory presents a partial view of the world that, although it is valid, also ignores a good bit of the complexity of organizations" (p.71)

This study complexifies agency explanations by recognizing that the coordination and economic organization of food safety depends on institutional considerations that have received limited treatment by the efficient premises of agency theory. Specifically as the design of an efficient contract depends on a highly competitive market outcome, this study argues and shows that food safety does not operate under such conditions. Food safety operates in concentrated markets in which the alignment of divergent interests is not just about "getting incentives right", but such an alignment is also influenced by those in power. That is, although high powered monetary incentives are crucial to the alignment of divergent interests, such an alignment need not be driven by monetary incentives alone but is also driven by the institutional demands of those in power (e.g. Hill and Jones, 1992; Pfeffer and Salancik, 1978). As a result, this study introduces a concept of power that is absent in the competitive market outcomes of agency theory (see also Hill and Jones, 1992).

Second, departures from such an efficient market premise introduce other institutional considerations that are not considered in agency theory. Concentrated markets promote an investment in specialized assets that have been largely ignored in agency theory explanations of contract design (Hill and Jones, 1992; Lajili and Mahoney, 2006). In the context of food safety, specialized investments in a firm's food safety assets addresses a basic failure of the market in valuing the experience good characteristics of food safety. A firm's investment in specialized assets not only resolves such a market failure problem, but it indicates that "getting incentives" right also requires that agents "signal" the quality of their food products. Investment in specialized assets signals a firm commitment to food safety which in turn supports price incentives that will sustain such an investment. As a result, by introducing the role of specialized assets, it underscores that

the use "ex-ante bonding costs" in agency theory (Hill and Jones, 1992) should also consider these asset characteristics of such bonding costs.

Third, as this study's institutional approach complexifies agency explanations, it yields a broader understanding of organizational economic research. Transaction cost economics argues that under conditions of asset specificity and a small numbers situation, the transaction cost minimizing properties of a firm's authority are favored over that of contracts (e.g. Williamson, 1975). In the context of food safety, this transaction cost argument is however dependent on the extent to which property rights are defined. That is, in contrast to transaction cost economics, this study argues that if property rights can be fully specified, asset specificity and small number situations will favor a contractual rather than a vertically integrated form of economic organization. This suggests that the importance of "property rights" needs to be more fully considered in transaction cost economics applications of food safety research. Furthermore, as food safety involves a complex system of partnerships, this study extends the markets and hierarchies distinctions (Williamson, 1975) of transaction cost economics to include the role of strong tie networks. Grounded in a recreance theory of trust, this study argues that strong ties differ from contractual and vertically integrated modes of economic organization because firms face normative obligations that lead them to produce food that is safe. Such normative obligations are not only absent in the incentive design explanations of agency theory but they are also not typically considered in the opportunistic premise of transaction cost economics (see also Granovetter, 1983).

Lastly, by drawing on these varied institutional considerations, this study also extends "signaling" research in two distinct ways. First, while an investment in specialized assets is widely recognized as important to realizing a separating equilibrium outcome (Kirmani and Rao, 2000), this study shows that such investments are contingent on the varied institutional factors raised by this study. Second, this study also argues that these institutional factors impact not only the coordination of food safety activities of a separating equilibrium but also that of its economic organization. Given that signaling research is a response to problems of market failure, such institutional considerations to our knowledge, have not been a subject of examination in signaling research (see Kirmani and Rao, 2000; Loader and Hobbs, 1999). Accounting for such institutional considerations are important to food safety research because institutions are widely recognized to address private-collective action problems (Nelson and Sampat, 2001).

In light of these contributions, there are nevertheless notable limitations in this study. The objective of this study was to develop an institutional theory that explains the coordination and economic organization of food safety activities in an agribusiness institution. Such theory development speaks little about its empirical aspects. As a result, future research is called upon to empirically examine the propositions proposed by this study. In particular, with the recent approval in the U.S. Congress of the FDA Food Safety Modernization Act, this legislation places greater responsibilities on farmers and food companies to prevent food contamination. This legislation also changes food safety oversight for U.S. imports. As food safety concerns over fresh produce (i.e. *E.coli.* spinach outbreak in 2006) have become an increasing public concern and given that a significant portion of produce is imported into U.S., the U.S. produce industry will be one setting to empirically examine this study's propositions.

To conduct such a study, future research should develop empirical measures that capture the varied institutional elements described in this study. Concentration can be measured through standard measures used in Industrial organization research, such as CR4 ratios and / or the Herfindahl Index (Carleton and Perloff, 2005). Asset specificity can be measured by variables used in Montgomery's (1994) study. As small number exchanges involve a bilateral monopoly exchange relationship, a small number exchange relationship can be measured by "exclusive" marketing or producing agreements amongst large firms. With regards to property rights, especially in regards to the assignment of food safety liability, property rights can be measured through contract provisions that stipulate penalties associated with food safety infractions. Lastly, as trust arises from strong tie networks, strong ties can be measured by the frequency and proximity of social exchange relationships (see Bian, 1997; Fischer, 1982; Friedkin, 1982). Survey methods that elicit the degree of friendship and frequency of exchanges can be used to elicit such a construct (e.g. Fischer, 1982). Furthermore, as these institutional factors favor the onset of a separating equilibrium outcome, such an outcome can be measured by differences in food safety recall between that of small and large food companies. Measures of food safety recall can be obtained by Food Safety Inspection Service (F.S.I.S) of the U.S.D.A. and FDA, to assess differences in food safety recall of small and large producers. Joy (2010) study offers one such approach. Through these proposed measures, this study offers an initial basis to advancing an institutional approach to food safety and offers a future research agenda for researchers in food safety.

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Enhancing the Design and Management of a Local Organic Food Supply Chain with Soft Systems Methodology

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Abstract

Supply chain partners for local organic food face uncertainties such as poor collaboration and communication that cannot be reduced through the application of traditional supply chain design and management techniques. Such techniques are known to improve supply chain coordination, but they do not adequately consider major aspects of local organic food supply chains such as ethics, sustainability and human values. Supply chain design and management approaches suitable to small-scale, local organic food enterprises are lacking and need to be developed.

The aim of this paper is to suggest Soft Systems Methodology (SSM) as a new and suitable approach to design and manage local organic food supply chains. We illustrate how SSM can be used to reduce uncertainties within local organic food supply chains based on a German case. This illustration serves to identify the benefits of using SSM, compared with ad hoc, pragmatic and less structured approaches. The major benefits are of thought, intervention and change, as well as action-oriented, meaningful and participatory decision making.

Keywords: supply chain management, supply chain design, organic food, Soft Systems Methodology

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Introduction

Designing and managing local organic food supply chains (LOFSCs) is complex, and it faces socially bound uncertainties such as poor collaboration, communication and information sharing (Kottila et al. 2005; Strauch and Schaer 2005, 21; Stolze et al. 2007; Hindborg 2008, 347; Kledal and Meldgaard 2008, 309-315). Such complexity cannot be reduced through quantitative supply chain design and management techniques. Quantitative techniques have been found useful to improve supply chain coordination and efficiency, but they are inadequate for considering key aspects of LOFSCs such as ethics, sustainability and human values (Milestad et al. 2010) that influence decision making and supply chain activities. LOFSCs are mainly composed of small-scale enterprises (Milestad et al. 2010) that face limitations to implementing complex mathematical models and sophisticated software used in quantitative supply chain design and management (Dutta and Evrard 1999; OECD 2000; Celuch et al. 2007; Ahumada and Villalobos 2009). Viable and well established approaches to reduce the inherent uncertainty, design and manage LOFSCs are lacking and need to be developed (Marsden et al. 2000; Kledal and Meldgaard 2008, 309-315).

In practice, LOFSC partners mainly manage their relationships *ad hoc*, through personal communication, and reach agreement through hand-shaking (Marsden et al. 2000; Morgan and Murdoch 2000; Sage 2003; Stevenson 2009, 7). Organized and facilitated approaches such as workshops and information meetings, however, have been found to be more successful, especially in a long-term perspective (Marsden et al. 2000; Strauch and Schaer 2005, 4-28; Hindborg 2008, 345-350). Some successful implementations of facilitated approaches have been documented, but there is still a need to develop and explore systemic, structured, flexible, and practically 'softer' approaches to design and manage LOFSCs.

The objective of this paper is to suggest Soft Systems Methodology (SSM) (Checkland 1981; Checkland and Scholes 1990) as a new approach to tackle uncertainties within, and to design and manage LOFSCs. SSM is useful in facilitating common understanding and sense making of unstructured problem situations, as well as achieving agreement on actions to alleviate them (Checkland and Scholes 1990; Rosenhead and Mingers 2001). This understanding, sense making and agreement may help LOFSC partners reduce uncertainties, support supply chain coordination, and enhance supply chain efficiency. As a well-established problem structuring method (PSM) (Rosenhead 1996), SSM is a participatory approach to intervene in problem situations, and enhance collaboration, communication and information sharing within multi-organizational groups (Huxham 1991; White and Taket 1997; Gregory and Midgley 2000; Taket and White 2000; Franco 2008, 2009). Besides, SSM enables problem solving through dialogue and qualitative methods, and it explicitly considers aspects such as ethics, sustainability, and human values (Wilson and Morren 1990, 73-106; Kunsch et al. 2009; Mingers 2011). This paper illustrates and discusses how SSM may be used to tackle problem situations within LOFSCs. The illustration and discussion is based on a case within the German organic cereal sector (Bahrdt et al. 2002) and serves to highlight the benefits of using SSM compared with less 'systemic' and structured approaches (e.g. expert interviews, telephone surveys and workshops that are not based on the application of a specific intervention methodology). We use the information provided in the case report to illustrate the stages of SSM. Drawing on SSM literature we show how the process of

SSM could have been applied within the case to better understand and structure the problem situation, support the participants in making decisions and reaching agreement on action plans.

A new contribution to the literature is achieved because SSM is here presented as a new problem solving approach which is useful to the local organic food sector. Within this paper, we provide a guideline for LOFSC partners to intervene and act in problem situations. This guideline shows how SSM is applied in practice, answers why it may be useful and emphasises the benefits of using it.

Local Organic Food Production

In the developed world, since the Second World War, food has mainly been produced through conventional, industrialized and resource intensive practices, which has caused environmental degradation, resource depletion, health scares and consumer anxiety concerning food safety. Farmers, consumers, policy makers and researchers recognized the need for environmental and human protection, and thus started to support alternative food systems such as organic agriculture (Sage 2003; King 2008). The International Federation of Organic Agriculture Movement (IFOAM 2005) defines organic agriculture as, "a production system that sustains the health of soils, ecosystems and people...Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved".

The organic area in the EU has been estimated to amount to 7.6 million ha with an increase by 7.4% per year (from 2000 to 2008) and 197.000 holdings (in 2008). The household expenses for organic food correspond to 1.9% of total food expenses implying difficulties for producers to sell their products and a consumers' limited purchasing power. Although, the sales of organic food in Italy, Germany and France have been increasing between 2000 and 2009 (average increase in Italy of 8.7%, in Germany of 14%, and France of 18.1%) (European Commission 2010, 1, 40-42).

Compared to conventional produce, organic food has to be produced, processed and marketed according to strict regulations and national legislation and it is often produced and sold within local food supply chains (Milestad et al. 2010). LOFSCs are mainly composed of small-scale enterprises that aim to maintain short distances between each other and to end-consumers. Enterprises are diverse and they focus on holistic production practices and often sell their products through alternative food purchasing venues (e.g. farmers' markets and box schemes). Supply chain partners and end-consumers are committed to sustainable, ethical food production, distribution and consumption, whilst they appreciate trust, respect and values (Hinrichs 2000; Marsden et al. 2000; Sage 2003; King 2008; Björklund et al. 2009).

Local Organic Food Supply Chains – Problem Situation

In general, agri-food supply chains are more complex to design and manage than most other supply chains (Ahumada and Villalobos 2009). Supply chain partners, for example may face uncertainties that mainly result from a lack of information and knowledge about markets; isolation of supply chain partners; different perceptions, attitudes, values and motivation among supply chain

partners; and the limited size of enterprises (Bahrdt et al. 2002; Kottila et al. 2005; Milestad et al. 2010). These uncertainties need to be controlled and reduced in order to design and manage supply chains, ensure supply chain coordination and achieve competitiveness and customer service (Stadtler 2005). In addition, reviewing the LOFSC-related literature, the following types of uncertainties are identified:

- Difficulty in choosing the right supply chain partners (Kledal and Meldgaard 2008, 309-315);
- Difficulty in finding skilled supply chain partners (who have specific knowledge concerning organic food production and processing and management and economics) (Middendorf 2007; Kledal and Meldgaard 2008, 309-315);
- Difficulty in establishing contacts and dialogue with buyers (Hindborg 2008, 347);
- Inefficient and a lack of information sharing between supply chain partners (Kottila et al. 2005; Strauch and Schaer 2005, 21; Stolze et al. 2007);
- Difficulty in communicating differences between organic and conventional products to end-consumers (Kledal and Meldgaard 2008, 309-315);
- A lack of agreement among supply chain partners (Stolze et al. 2007; Kledal and Meldgaard 2008, 309-315; Naspetti et al. 2009);
- A lack of cooperation among suppliers causing shifts in raw-material quantities and quality (Kledal and Meldgaard 2008, 309-315);
- Barriers to accessing supermarkets for small-scale enterprises (Bahrdt et al. 2002, 28).

Such types of uncertainties are typically found in unstructured, complex problem situations (Rosenhead and Mingers 2001), as well as multi-organizational and collaborative groups (Gray 1989; Huxham and Vangen 2004). Stakeholders facing such uncertainties need to collaboratively engage in dialogue in order to understand, make sense of and structure the problem situation. Dialogue facilitates negotiation, accommodation of diverging interests and shared agreement on feasible actions to reduce the uncertainties (Rosenhead 1996; Franco 2009).

Compared to conventional producers, LOFSC partners have different needs concerning supply chain design and management (Marsden et al. 2000; Morgan and Murdoch 2000). The local distribution of organic food, for example through alternative food purchasing venues, is based on supply chain relationships which are different from conventional food distribution which occurs through global, larger companies. Local organic food suppliers, furthermore, require flexibility in supply chain activities as they may be distributing food through different channels ranging from farmer stands to restaurants and supermarkets. The presence of different channels opens up the opportunity to approach a broader range of customers and find a suitable niche for organic products. This, however, requires food suppliers to adapt to the customers' specific conditions: price setting by supermarkets (Milestad et al. 2010) and food demand in schools, kindergartens and restaurants differing from the seasonality of local produce are some of the challenges.

The next section defines supply chain design and management and reviews how uncertainties are traditionally controlled and reduced.

Supply Chain Design and Management

Supply chains are networks of organisations that are connected with each other with the aim of processing and selling products to end-consumers. Supply chains include suppliers, producers, customers, and end-consumers, but also transporters, warehouses, and retailers, depending on the specific supply chain configuration. Agri-food supply chains are networks of organisations that produce and sell fresh or processed products from vegetables, crops or animals (van der Vorst et al. 2007). In order to ensure materials, information and financial flows between supply chain partners, supply chains must be dynamic and flexible, built on cooperation, coordination, control and trust (van der Vorst et al. 2007; Naspetti et al. 2009).

Supply chain design (SCD) is a process to build supply chains. It consists of: (a) the choice of supply chain partners; (b) the identification of customer segments; (c) the location of production and distribution facilities; and (d) the identification of facility capacity and transportation means (Stadtler 2005). Stadtler (2005, 576), moreover, presents SCD as the basis for supply chain management (SCM), which is "…the task of integrating al units along a supply chain and coordinating materials, information and financial flows in order to fulfil (ultimate) customer demands with the aim of improving competitiveness of the supply chain as a whole". Supply chain partners achieve competitiveness and customer service through enacting supply chain activities such as managing relationships, defining supply chain leadership and advanced planning (Stadtler 2005).

Quantitative techniques have been found useful for supply chain design and management, especially to control and reduce uncertainties and to make optimal decisions (examples in: Beamon 1998; Reiner and Trcka 2004; Apaiah and Hendrix 2005; Santoso et al. 2005; Wang and Shu 2007; Thanh et al. 2008; Ahumada and Villalobos 2009; Hammami et al. 2009; Schütz et al. 2009). Supply chain contracts (Cachon 2003; Simchi-Levi et al. 2008, 125-138) and inventory management (Axsäter 2003; Graves and Willems 2003) have been used to manage relationships between supply chain partners and to coordinate materials, information and financial flows. Supply chain management through supply chain contracts may be optimized through quantitative analysis of possible types of contracts that match specific supply chain configurations. Quantitative analysis identifies supply chain partner´s profit and the global profit of supply chains. Therefore it enables the implementation of optimal contracts to enhance supply chain coordination (Cachon 2003, 5). Supply chain management and decision making through inventory management, similarly, rely on quantitative analysis of different supply chain configurations (Axsäter 2003).

These techniques, however, do not adequately consider LOFSC partners´ capabilities or needs. The application of quantitative techniques to control and reduce uncertainties within LOFSCs is limited. Quantitative supply chain design and management techniques require the application of complex mathematical models and advanced software. Not only are large amounts of precise data necessary that are difficult to collect and tabulate (Simchi-Levi et al. 2008, 90; 130-131), but also financial assets, sophisticated strategies, specific skills and knowledge. Such resources are lacking within small-scale enterprises, which limits the introduction of complex mathematical models and advanced software (Dutta and Evrard 1999; OECD 2000; Celuch et al. 2007). Quantitative techniques, furthermore, do not include variables which address major uncertainties within LOFSCs such as a lack of agreement, collaboration, communication and information sharing.

Besides, decision making to reduce uncertainties and to design and manage LOFSCs also depends on ethical, moral and sustainability aspects that are not adequately considered by quantitative techniques.

Considering the nature of LOFSCs, new supply chain design and management approaches need to address: (i) the development and support of relationships between supply chain partners; (ii) the consideration of financial and intellectual capabilities; (iii) a focus on ethical, moral, and sustainability, as well as on satisficing goals; and (iv) flexibility in supply chain activities. As LOFSC partners lack information about markets and supply chain activities and face limitations in adopting complex mathematical models, it may be appropriate to focus decision making on satisficing – acceptable and rational goals (Douma and Schreuder 2008, 125-126) instead of on optimisation.

The so-called problem structuring methods (PSMs), designed to reduce complexity and uncertainty and to support group-decision making (Rosenhead 1996), provide a candidate group of methodologies which meet the identified requirements for new approaches to design and manage LOFSCs.

Problem Structuring Methods

Van der Vorst (2000) describes supply chains as systems (Ackoff and Emery 1972). Systems Thinking (ST), also defined as the inquiry into systems, is a useful conceptual framework for understanding supply chains, as well as for intervening in supply chain design and management problem situations. ST includes two complementary traditions – hard and soft ST (Checkland and Scholes 1990, 25). Hard ST relies on quantitative, mathematical methods and is based on the idea that the world is systematic (Checkland and Scholes 1990, 25) and that problems can be adjusted to fit optimisation models in order to solve them (Wilson and Morren 1990, 109). The above-mentioned traditional supply chain design and management techniques can be classified as hard ST methods. Soft ST, on the other hand, aims to make sense of problem situations in order to understand, improve and change them (Checkland and Holwell 1998, 48). Goals of inquiry are considered to change constantly and to be conflicting (Wilson and Morren 1990, 111) so that problem situations need to be grasped from different points of view (Checkland and Holwell 1998, 48). Soft ST relies on qualitative approaches and human activity systems models that comprise human perceptions, behaviour, values, ethics and sustainability (Wilson and Morren 1990, 73-106; Kunsch et al. 2009; White and Lee 2009; Mingers 2011). Moreover, soft ST is based on facilitated processes of inquiry within a group of stakeholders (Checkland and Scholes 1990, 25) that are known as Problem Structuring Methods (PSMs). PSMs enable participatory problem definition, structuring, understanding and solving in complex situations of common interest (Rosenhead 1996; Taket and White 2000; Rosenhead and Mingers 2001). PSMs have not only been successfully applied to business redesign, strategic development, strategic change and innovation (Ormerod 1999) within individual organisations (Rosenhead 1996), but also within multi-organizational groups to strengthen cooperation, communication, negotiation and agreement (White and Taket 1997; Gregory and Midgley 2000; Taket and White 2000; Franco 2008, 2009).

The suite of PSMs covers a range of methodologies (Rosenhead 1996) such as Interactive Planning (Ackoff 1999), Strategic Choice Approach (SCA; Friend and Hickling 1987), Strategic Options Development and Analysis (SODA; Eden 1989), and Soft Systems Methodology (SSM; Checkland 1981; Checkland and Scholes 1990), which we suggest to design and manage LOFSCs.

Soft Systems Methodology

The main reason for suggesting SSM lies in its potential to enable stakeholders to define problems logically and in detail, and to systematically take action for improvement (Checkland 1981). In particular, SSM addresses the four requirements for new approaches to design and manage LOFSCs listed above. As a PSM, SSM addresses the requirement (i) to develop and support relationships between LOFSC partners. The use of SSM enhances stakeholders´ participation and group-decision making, whilst it also supports inter-organizational cooperation, communication, negotiation and agreement. Concerning requirement (ii), SSM is a learning process that is not solely reliant on a facilitator's skill as it can also be taught to the stakeholders involved (Checkland 2001, 88). Stakeholders already know the simple language to develop conceptual models as activities necessary to improve problem situations are formulated as verbs; as activities familiar from daily life (Checkland 2001, 77). Facilitators may also adapt SSM to stakeholders' needs and capabilities in such a way that all feel comfortable and can make their way through intervention (Checkland and Scholes 1990, 302). SSM fulfils requirement (iii), to focus on ethical, moral and sustainability, as well as satisficing goals, because it is based on soft ST and may also include hard methods if appropriate and necessary (Checkland and Scholes 1990, 25). Concerning requirement (iv), SSM is flexible to use and can be shaped throughout intervention (Checkland and Scholes 1990, 1-7). Therefore, it enables flexibility, not only during intervention, but also in the implementation of change and the carrying out of supply chain activities.

Soft Systems Methodology – An Illustration

In the following section, we describe how SSM is applied in practice and illustrate a possible application to local organic food supply chain management based on a German case within the organic cereal sector (Bahrdt et al. 2002). The case serves to demonstrate how SSM may be used to intervene in problem situations and deal with uncertainties within LOFSCs.

An advisory company completed a project with the aim of describing the organic cereal sector in Germany and identifying challenges, barriers and uncertainties within related supply chains. Literature studies, expert interviews and telephone surveys with stakeholders were carried out to describe the organic cereal sector and to identify problem situations. In addition, workshops were organized with stakeholders to discuss the problem situations and identify possible actions for improvement. The advisory company looked at Germany as a whole in order to get a rich description of the organic cereal sector, but then narrowed down the perspective to the federal level to better understand the problem situations. For the latter purpose, the advisors carried out interviews and workshops with a limited number of representatives (1-5) from different supply chain stages and federal states. The representatives contributed especially with information from their local, regional environment. The German organic cereal sector is unstructured and includes sup-

ply chains that are mainly based on small-scale enterprises. The project participants have identified three major problem situations: (1) poor communication between supply chain partners and end-consumers and poor communication and collaboration among supply chain partners; (2) lack of access to information about markets, supply chain partners and necessary supply chain activities; and (3) complexity of traceability and food safety requirements.

The process of SSM is a framework for facilitators to guide groups of stakeholders during intervention in problem situations. The stakeholders are here supposed to be local organic food producers and/or suppliers who aim to collaboratively reduce supply chain uncertainties in order to design and/or manage supply chains. LOFSC partners´ participation and engagement in SSM is useful, because it enables to jointly examine, understand and make sense of uncertainties, besides to agree on actions to alleviate them (Checkland and Scholes 1990; Rosenhead and Mingers 2001). It can be argued that the types of uncertainties faced by LOFSC partners correspond to those for which PSMs were developed. Of course, other PSMs may be considered as well; here we intend to present SSM as an example and a promising approach.

To provide a guideline for LOFSC partners to intervene in problem situations, we illustrate SSM as a staged process. SSM however is an iterative and a flexible process, which allows for switching between and repeating stages (Checkland and Scholes 1990, 284). The purpose of iteration is to elicit relevant knowledge and reflect it back in a structured form, and often it is the process that is most revealing. Outputs of interventions may be visible, e.g. models and action plans or invisible, e.g. a change in appreciation, learning and an improvement of relationships (Rosenhead 1996; Franco and Montibeller 2010). Successful interventions may facilitate and enhance long-term decision making and action among stakeholders.

Stage 1 — Rich Picture

The process of SSM starts with the composition of a rich picture to describe (ideally also pictorially) a problem situation of common interest (Checkland and Scholes 1990, 45). The stakeholders jointly draw the rich picture and aim to understand the problem situation from different perspectives, to emphasise structures, processes, relationships, conflicts and uncertainties (Checkland 1990, A16-A19; Wilson and Morren 1990, 106; 119-120) and to get a feeling of the situation. Stakeholders get a feeling of the situation because they express concerns, judgments and values and visualize abstract aspects through symbols (Checkland and Scholes 1990, 45) (Fig. 1).

Stage 2 — Cultural Analysis

Cultural analysis views the intervention itself as being problematic and identifies: (a) the structure of the intervention and its roles – Analysis 1, (b) connections between roles, values and norms – Analysis 2, and (c) political dimensions – Analysis 3 (Checkland and Scholes 1990, 45-51).

Within Analysis 1, stakeholders identify who is going to initiate the intervention and why it should take place, who intends to change and improve the problem situation based on what perceptions, knowledge and resources, and who may own the problem.

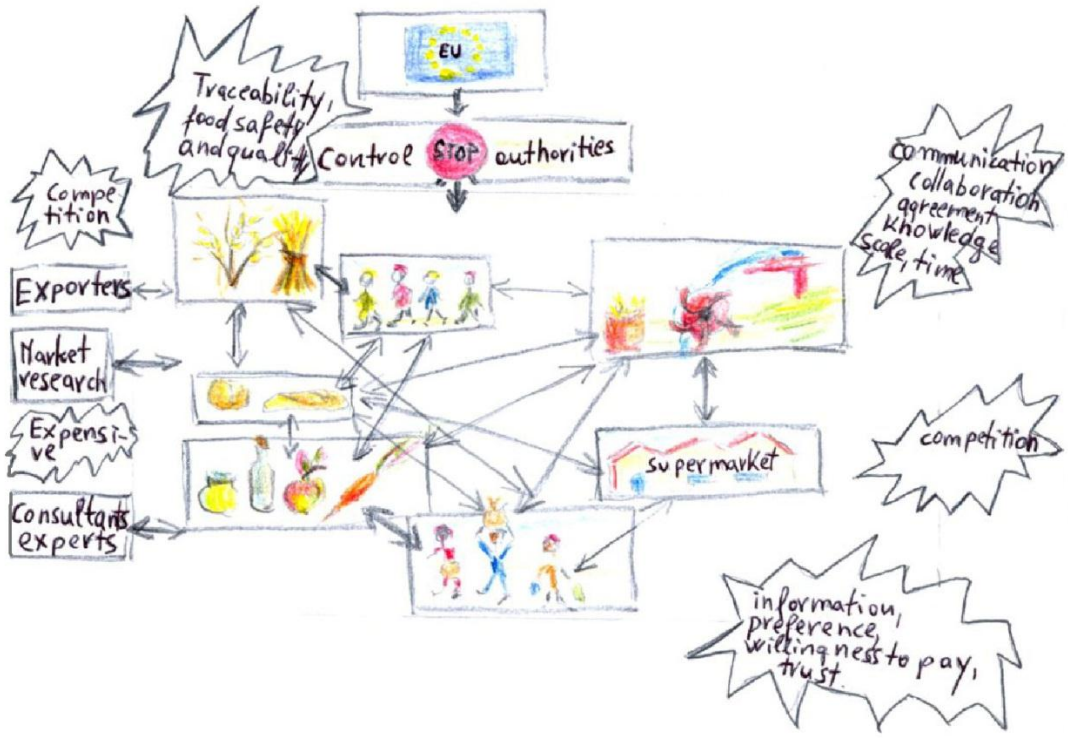

Figure 1. An example of a rich picture used as a facilitative device to support collective deliberation.

<u>Analysis 1:</u>

a) *Client*: food producers and/or suppliers participating in the German case
b) *Client´s aspiration*: improve communication and collaboration between supply chain partners and with end-consumers
c) *Problem solvers*: involved facilitator(s) (facilitators´ names), advisory company, and supply chain partners
d) *Resources available*: SSM; supply chain partners; information, knowledge and material available; duration of the project
e) *Constraints*: time; knowledge and information about LOFSCs; cultural environment
f) *Problem owners*: food producers and/or suppliers, involved supply chain partners, end-consumers, control authorities
g) *Implications of problem owner chosen*: the results of intervention must especially be useful to supply chain partners and end-consumers. Therefore, information regarding supply chain partners, as well as end-consumers, must be available. Involvement of end-consumers in a representative way is difficult to achieve. Therefore, existing empirical data about end-consumers should be analysed
h) *Reasons for regarding the problem as a problem*: loss in market opportunities; lack of product quality, supply chain coordination and efficiency
i) *Value to the problem owner*: improved communication and collaboration between supply chain partners and with end-consumers may increase supply chain coordination, efficiency and profit, whilst also supporting end-consumers' trust and decision making

Within Analysis 2, stakeholders look at the problem situation as a social system. Here stakeholders have a specific social position, which is characterized by a specific socio-cultural behaviour. Analysis 2 not only serves to identify and describe the atmosphere within the intervention, but also to judge whether it is humanly good or bad (Checkland and Scholes 1990, 49) and seek to identify the reasons for a certain atmosphere (Georgiou 2008).

Analysis 2:

Socio-cultural behaviour among supply chain partners and end-consumers is characterized by:
- Tension
- Low team spirit
- Disorganized
- Reluctance
- Desire to communicate, collaborate, and improve
- Desire to meet customer demand

Within Analysis 3, stakeholders look at political dimensions typical for situations in which humans with different interests are involved. Stakeholders identify how power is expressed, obtained, maintained and passed on (Checkland and Scholes 1990, 50-51; Georgiou 2008).

Analysis 3:

Supply chain partners have:
- Power to change
- Power to hinder collaboration and communication (e.g. lack of information and knowledge, isolation and different opinions)
- Low power in larger markets (barriers and competitors)

Consumers have:
- Power to change buying behaviour
- Power to impact supply chain profit (low demand, buying frequency and expenditures; different preferences and lack of information)
- Power to impose demand (e.g. for information and prices)

Through Analysis 3, stakeholders become aware of the contradictory issue of being responsible for poor collaboration and communication and of being capable of changing problem situations. Finding out why stakeholders are responsible for poor collaboration and communication may clarify the actions necessary to achieve improvement.

In the case of supply chain design, we suggest Analyses 1, 2, and 3 as an approach to define the first part of the design of LOFSCs. In Analyses 1 and 2, local organic food producers and/or suppliers discuss the need to find and integrate further supply chain partners, who may be involved in the intervention process. In Analysis 3, the identified and cooperating supply chain partners discuss and decide who should be in charge of chain leadership and responsible for coordinating supply chain decisions. This stage is not illustrated here because supply chain design is not included in the German case.

Stage 3 — Definition of Relevant Systems

Relevant systems, also called root definitions, describe in one or two sentences transformation processes of some entity into a new form of the same entity (Checkland and Scholes 1990, 33). Root definitions as planning statements describe the system to realize transformations, enhance change and improvement. This system should suit the problem situation of concern and its stakeholders in order to enable meaningful and innovative change. First, stakeholders identify transformations to reduce uncertainties. Second, the details of the transformations are defined through the CATWOE mnemonic. Finally, the root definitions are formulated (Georgiou 2008).

Formulations of Transformations (T):

Uncertainty 1 - example:
Difficulty in implementing marketing activities
T1: Poor marketing activities → marketing activities met

Uncertainty 2 - example:
Poor knowledge, information and expertise sharing between SC partners
T2: Poor knowledge, information and expertise sharing → knowledge, information and expertise sharing met

The same exercise is performed for each uncertainty identified within the rich picture.

CATWOE Based on T2:

C (customers – victims or beneficiaries): supply chain partners
A (actors who undertake T): supply chain partners
T: Poor knowledge, information and expertise sharing → knowledge, information and expertise sharing met
W (Weltanschauung – meaningful perspective): Knowledge, information and expertise sharing between supply chain partners supports collaboration and improves supply chain coordination. Openness benefits everybody and leads to increased financial returns
O (owners who might stop T): supply chain partners
E (environmental constraints): capabilities, culture, attitude, access to information

Root Definition:

A supply chain internal system to improve knowledge, information and expertise sharing between supply chain partners, in accordance with supply chain partners' needs and wishes, in order to support collaboration and improve supply chain coordination, by introducing new opportunities to share knowledge, information and expertise. The system operates in an environment in which supply chain partners have different capabilities, cultures, attitudes and limited access to information.

Stage 4 — Modelling Relevant Systems

Relevant systems are modelled as conceptual models (Figure 2), which are also known as purposeful human activity systems (HAS) that show the inter-linked human activities necessary to

realize transformations. Human activities formulated as verbs depend on and influence each other, thereby building a structured plan for action (Checkland and Scholes 1990, 35-36). The HAS model (Figure 2) shows human activities to carry out the transformation T, i.e. to improve knowledge, information and expertise sharing between supply chain partners.

Action plans need to be evaluated before implementation in order to ensure their maintenance under uncertain, complex and dynamic circumstances. Checkland and Scholes (1990, 38-39) suggest the logical analysis including the 5 Es' to evaluate the feasibility of transformations and related human activities:

- *Efficacy* identifies whether the means work to realize T;
- *Efficiency* identifies whether the minimum resources are used to realize T;
- *Effectiveness* identifies whether T meets long-term aims;
- *Ethicality* identifies whether T is moral;
- *Elegance* identifies whether T is aesthetically pleasing.

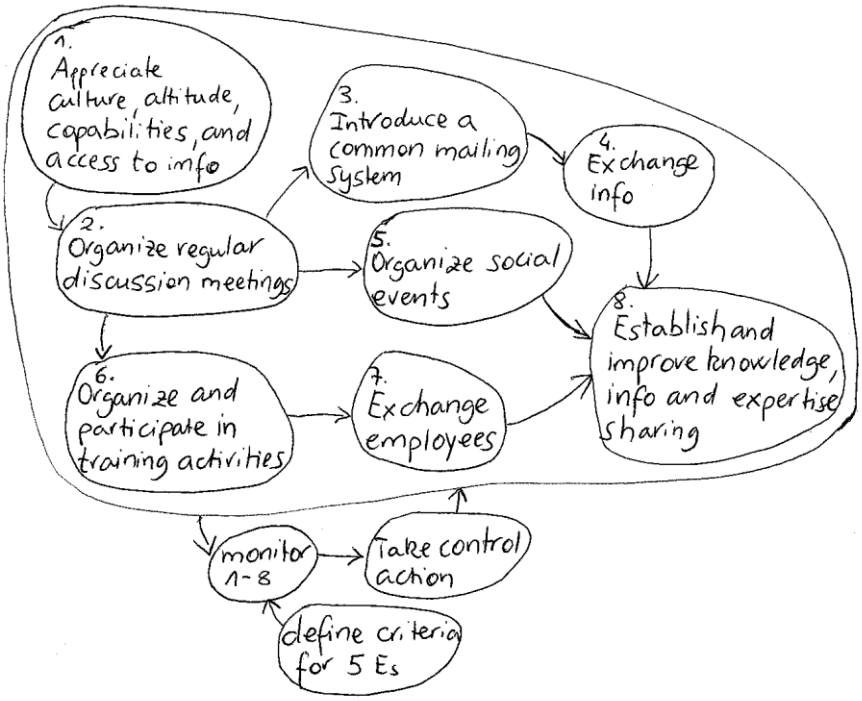

Figure 2. An example of a human activity system (HAS) used to facilitate collective design and discussion processes.

<u>Logical Analysis for HAS in Figure 2:</u>

Efficacy: Collaboration and supply chain coordination are increasing
Efficiency: Knowledge, information and expertise are shared at minimal costs
Effectiveness: Knowledge, information and expertise are shared
Ethicality: Supply chain partners act with social and moral responsibility
Elegance: Knowledge, information and expertise sharing enables obstacle free collaboration

In line with Checkland and Scholes (1990, 25; 31-32) and Wilson and Morren (1990, 107; 110), conceptual models can be completed or replaced by quantitative models. Therefore stakeholders can at this stage choose between qualitative and quantitative models depending on the uncertainty and the supply chain activity of concern.

In the case of SCD, supply chain partners design here the second part of supply chains (resulting from stage 2), i.e. identify the location of production sites and facilities, facility capacity and transportation means.

Stage 5 — Comparison of Conceptual Models with the Real World

Stakeholders compare conceptual models with the real world by answering questions such as, "Does the activity in the model exist in the real world? How is it done? By what criteria is it judged?" (Checkland 2001, 83-86) (Table 1). Comparison allows ideas for change to be debated so that new ones eventually emerge and finally agreement is achieved as to how to implement change and realize improvement (Checkland and Scholes 1990, 43-44).

Table 1. Comparison of Conceptual Models with the Real World

Activity in Model	Exists?	How?	Who?	Good or Bad?	Alternatives?
Organize regular discussion meetings	No, not regularly	Occasional discussion occurs between individual SC partners	SC partners	Current discussion is bad	Organizing regular meetings along the entire SC is a new opportunity
Introduce a common mailing system	No				Introducing a mailing system is innovative
Organize social events	No				Organizing social events is innovative
Exchange information	Yes	Information is exchanged as part of traceability requirements	SC partners	Current exchange of info concerning traceability is good	Exchange of info should also occur apart from traceability

Note. Each activity in the human activity system is to be compared with the real world. This table only provides an example.

Stage 6 — Formulation of Changes

As a result of stage 5, stakeholders formulate changes that are systematically desirable and culturally feasible; changes that are relevant, meaningful and that meet stakeholders' needs and wishes (Checkland 2001, 85-86) (Table 2).

The process of SSM may be seen as innovative compared with the research approach used within the German case because SSM relies on visual methods (e.g. rich picture and HAS) and means (e.g. boxes and tables) to provide compact, clear and easily accessible information. Visual mate-

rial allows stakeholders to share different perceptions, ideas, and issues, and to better understand complex relationships. Dialogue and debate which is based on visual material may, thus, be more efficient than purely oral dialogue and debate (White 2006). Visual material improves stakeholders´ engagement because they see how their input is considered to increase richness and take action (Franco 2006). It is also useful to define and assess milestones, see what has been addressed and identified in order to keep track of progress (Ackermann 1996), support decision making and accelerate the implementation of change.

Table 2. Formulation of Changes

How	Desirable?	Feasible?	Possible Action
Organize monthly discussion meetings	Yes	Yes	Find location; select an organizing committee; select discussion topics. Who will carry out the actions and by when?
Exchange employees	Yes	Yes	Describe employees' profiles; exchange profiles; set up a plan. Who will carry out the actions and by when?
Organize product information days	Yes	Yes	Find location; provide product descriptions; discuss production and marketing practices. Who will carry out the actions and by when?
Exchange product information	Yes	Yes	Provide product descriptions; circulate e-mails. Who will carry out the actions and by when?

Stage 7 — Take Action

Stakeholders take action to implement change and improve the problem situation through recycling the SSM process (Checkland 2001, 86).

Methodological Reflections and Conclusion

Local organic food supply chain partners face uncertainties such as poor collaboration, communication and information sharing that cannot be controlled and reduced through quantitative supply chain design and management techniques. Such techniques are expensive and complex to use and do not adequately consider major aspects of LOFSCs such as ethics, sustainability and human values. Systemic, structured, and facilitated approaches to reduce uncertainties within LOFSCs, support supply chain design and management are lacking and need to be developed.

Researchers have discussed the benefits of using systemic, structured and facilitated approaches for problem solving and decision making. Systemic and structured approaches enable stakeholders to enter problem situations from a complete, wide ranging perspective, to gain clarity in thought, will and deed. Moreover, systemic and structured approaches not only structure the process of intervention and the complex problem situation, but also structure the process of thinking and change (Mingers and Taylor 1992). These approaches also help facilitators guide stakehold-

ers during exploration with a focus on the problem situation in order to achieve progress (Ackermann 1996).

Facilitators guide stakeholders in a constructive direction, refresh them with energy (Phillips and Phillips 1993) and deal with different personal interests and dominating personalities (Ackermann 1996). Facilitators not only manage the complexity of problem situations, but also of human relations manifested during intervention (Rosenhead 1996). Their aim is to understand group life (Phillips and Phillips 1993, 541), and ensure stakeholders' free contribution and equal participation (Ackermann 1996). Free contribution and equal participation increase stakeholders´ motivation, ownership and commitment to decisions and actions for change (Ackermann 1996; Gregory and Midgley 2000).

The aim of this paper was to suggest SSM as a suitable approach to design and manage LOFSCs. Based on theory and the illustration of a German case, the paper has illustrated how SSM may be used to tackle uncertainties within organic FSCs that are mainly based on small-scale enterprises. In order to identify the benefits of using SSM, we shall consider what it might have evoked, if applied to the German case. The case mainly reports uncertainties that need to be approached through dialogue and consensus. Case participants express a need for change, improvement and innovative approaches to deal with difficulties to communicate, agree, learn and understand. The research approach used within the case enables participants to better understand the problem situations and uncertainties. The case report, however, does not mention any increase in communication and agreement as a result of the research approach. Participants come up with innovative ideas about how to improve the problem situations, but these are only formulated as suggestions (Bahrdt et al. 2002, 67-69) and not as agreed and planned actions.

Soft Systems Methodology is a structured learning approach that enables stakeholders to better understand and structure problem situations, evolve strengths, agree on action plans for improvement, and engage for intended change and innovation (Checkland and Scholes 1990, 3). The process of SSM is just about purposeful, every-day thinking, but it provides better organisation and structure. Stakeholders explicitly formulate ideas, follow a path towards results and may share, trace and recall ideas at any time (Checkland and Scholes 1990, 300-302).

The case report is more a detailed description of the German organic cereal sector than a plan to take action, but it can be seen as an input for future activities. From our point of view, SSM and the identification of who is going to do what and how, would have added an action-oriented perspective to the suggestions to improve problem situations. SSM might have supported the participants in agreeing on actions to tackle the problem situation and carrying out the suggestions they made. The participants formulated suggestions using verbs such as "could" or "should", whereas the use of SSM would have generated feasible and desirable options for change based on active verbs. Through SSM, stakeholders get ready to act for change and improvement because Analysis 1, CATWOE, root definitions and conceptual models clarify who does *what* (T in CATWOE), *how* (activities in HAS), *under what constraints* (E in CATWOE), *with what resources* (point d in Analysis 1), and *why* (points h and i in Analysis 1; W in CATWOE). Knowing why in particular and clarifying the meaning and value of ideas motivate stakeholders to decide, take purposeful action and engage for improvement (Checkland 1990, A39).

The use of SSM implies further benefits: rich pictures and Analyses 1, 2, and 3 extract tacit knowledge from stakeholders, which is valuable for improving problem situations (Georgiou 2008). Within Analysis 2, stakeholders identify and discuss the atmosphere of intervention and abstract aspects that *a priori* might not be obvious. Stakeholders become aware of emotional relations between each other that not only help explain and structure uncertainties, but also enhance motivation to act for improvement. Analysis 3 supports stakeholders in identifying their power and competences. Awareness of being able to change problem situations, but also to hinder change – which might not be obvious to all stakeholders – may enhance further engagement and motivation. The identification of power may also increase learning among stakeholders because learning is considered to be especially productive when it is done by those who have the power to act (De Geus 1988).

Checkland (1990, A14) points out that the formulation of ideas is not enough to enable action, but that "debate structured by questioning perceptions of the real situation by means of purposeful activity models" enables action. A comparison of models with the real world enhances discussion about which activities already exist, which need to be expanded, and which to be introduced. Additionally, comparison identifies different stakeholders' attitudes to actions and aims at achieving conciliation between conflicting stakeholders (Checkland 1985). Conciliation leads stakeholders to agree upon how to act, formulate and implement changes that are systematically desirable and culturally feasible. Changes to improve problem situations need to be desirable and feasible, and to meet supply chain partners' needs and wishes. Only desirability and feasibility will enable and motivate supply chain partners to engage in the implementation of and benefit from change.

Decision making, change and innovation within LOFSCs need to consider ethics, sustainability and human values. The use of SSM enables intervention with a focus on sustainability, ethics and human values: action starts from the problem situation of concern, builds on related characteristics and leads to desirable, feasible, ethical and elegant change (5 Es'). Besides, Analysis 1 identifies values for intervening in problem situations; Analyses 2 and 3 look at human relations and behaviour; root definitions clarify human needs and wishes, whilst they also consider human aspects such as capabilities, culture and attitudes. The importance of human aspects within LOFSCs is also expressed through socially embedded relationships and personal communication between suppliers (Hinrichs 2000; Marsden et al. 2000; Sage 2003). Personal communication can be improved through the participatory and facilitated conversational processes adopted in the use of SSM. Conversation enables stakeholders to share knowledge and different perspectives, thus to enhance learning and collaborative efforts. Collective learning has been found useful to strengthen organizational identities, as well as power to manage resources and relationships among suppliers (Hinrichs 2000; Marsden et al. 2000).

Drawing on the illustration of the use of SSM in the German case and the preceding discussion, it can be argued that SSM is a promising approach to tackle uncertainties within LOFSCs. We recognize the findings reported here are based on a conceptual study, which poses limitations to their generalizability and transfer to practice. Based on a thorough literature study we have, however, attempted to provide insight into the potential of SSM and its use in LOFSC management. Empirical work in this area is needed and practical applications of SSM in LOFSCs are to be encouraged. Practical applications would not only be of value to further investigating the potential

of SSM to design and manage LOFSCs, but also to attract more researchers and practitioners to access this area. Moreover, the use of SSM as an intervention tool could be considered for other types of food supply chains as well, in which 'intangible' uncertainties dominate. Overall, it can be argued that SSM is also a suitable approach to intervene in other 'ill-defined' supply chain situations, but here it is the particular nature of LOFSCs – socially embedded relations, personal communication, and the focus on sustainability and ethical values – which supports our suggestion.

Can we be sure that SSM will trigger better results? As Checkland (1990, A12) emphasizes, "…any methodology which will be used by human beings cannot, as methodology, be proved to be useful". Successful use of SSM does not necessarily mean that results are quantifiable or objectively evaluable. Success may also result from the potential of SSM to identify problem situations, change stakeholders´ perceptions, increase stakeholder involvement, build and strengthen relationships, share values and enable change (Mingers and Taylor 1992; Rosenhead 1996; Connell 2001; White 2006).

This paper has illustrated how SSM may be used to tackle problem situations, and to design and manage LOFSCs. It has, furthermore, attempted to identify the benefits of using SSM compared with less 'systemic' and structured approaches. SSM is a promising approach to enable stakeholders to reduce uncertainties within LOFSCs, support coordination and enhance efficiency.

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Modal FDI Strategies in Asia-Pacific Region

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Abstract

This paper utilized a Binomial Logistic model to study the world's 60 largest food and beverage multinational firms' (MNE) decisions on the forms of ownership for their foreign subsidiaries in the Asia-Pacific Rim region during the early- to mid-1990s. Both firm- and country-specific factors are used to explain the MNEs' investment strategy. The model found that the firm's past investment patterns, product type, the operations risk index in the host nation, and the geographic distance between investing firm's home nation and the host nation all had significant impact on the bi-modal investment choice by the MNEs.

Keywords: FDI, MNE, Ownership, Asia-Pacific Region

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Introduction

Multinational enterprises (MNE) look to foreign direct investment (FDI) as a potential way to secure success in the world market for a variety of reasons. They may use FDI to accrue rents associated with a first-mover advantage, i.e., economies of scale, technologies, marketing, transportation, distribution, reputation, and brand development. They may use FDI to avoid excessive import tariffs or to receive preferential tax treatment or investment incentives by producing and marketing goods in a host nation. They may also use FDI to have influence in the political arena of a host nation or to seek stable access and internal pricing of hard-to-attain raw inputs (Stiegert and Schultz 2002).

During the early- and mid-1990s, FDI in all industries was increasing rapidly in the Asia-Pacific region. From 1990 to 1996, the total FDI inflow in the Asia-Pacific Rim nearly tripled, and the region became the world's second largest FDI inflow area (after the EU) (UNCTAD 1999). The rapid growth of FDI in the Asia-Pacific region was partly due to the high GDP growth rate, dynamic demographic trends and low labor cost in many of the developing countries (Tozanli 2005). Specifically in the food and agribusiness industry, from 1987 to 1996, Asia-Pacific Rim region appeared to have become a newly emerging region for hosting the world's largest agribusiness MNEs. The number of subsidiaries of the world's 100 largest food and beverage MNEs in this region almost doubled (Agrodata 1998).

This study seeks to develop a greater understanding of the investment strategies made by these companies. We use a unique dataset of modal FDI activity in the Asia-Pacific region by the world's largest 100 food and beverage firms from 1987 to 1996. The underlying model was structured to address the following questions: How do political and economic stability, and socio-cultural factors influence firms' modal investment decisions? Do the past investments of these firms into and within the Asia-Pacific region influence their decision about the FDI mode? How do firms' revenue growth rate and product type influence their FDI patterns? We model the firm's choice of a partial-control versus full-control mode of investment, and estimate the influence of firm- and country-specific factors that influence the choice. Results from the Binomial Logistic regression show that firm's past investment pattern, product type, the operations risk index in the host nation, and the geographic distance between investing firm's home nation and host nation all had significant impact on the probability of choosing either full ownership or partial ownership.

The rest of the paper is organized as follows. After a brief overview of related literature, the data are described. The next section contains the empirical model specification, followed by a section with results and discussions. The last section concludes.

Related Literature

Plenty of previous studies have looked at food and beverage MNEs' FDI versus their trade strategies. Reed and Ning (1996) investigated decisions regarding the type of FDI by U.S. food firms and characterized the basis for their strategies using case studies. They discovered MNE firms favor a high control mode, thus they tend to engage more in FDI rather than export or license activities. Gopinath, Pick and Vasavada (1999) analyzed the economics of FDI applied to the

U.S. food processing industry. Their results indicated that foreign sales and exports are substitutes in U.S. processed food industry and owners of capital gain more from FDI relative to owners of labor. Henderson, Voros, and Hirschberg (1996) tested the hypothesis that relates a firm's dominance in its home market, product characteristics and investments in intangible assets to export characteristics and FDI intensity. Carter and Yilmaz (1999) studied the relationship between FDI and trade in the processed food industry using the firm-level data from Turkey in the 1980s and 1990s, and found that the two choices are complementary. Goldsmith and Sporleder (1998) evaluated the firms' two-level decision making, i.e., first, remain domestic or engage in trade; and then export or make FDI. They found that smaller and LDC firms are less likely to go international, and firms that are engaged in heavy R&D and producing differentiated products are more likely to make FDI.

In addition, a number of studies have focused on the agribusiness MNEs' geographic investment decision. Ning and Reed (1995) found a positive correlation between a foreign country's GDP and U.S. food companies' FDI. Skripnitchenko and Koo (2005) studied U.S. MNEs' FDI in the processed food industry in Latin America and found that the FDI outflows are determined by numerous factors such as the wage rate, the interest rate, tax rate, real GDP, exchange rates and the demand conditions in host country. Rama (1998) showed the food MNEs' ability to innovate is a crucial factor in determining their international expansion and performance in the host nation. Filippaios and Rama (2008) studied the geographic strategies of 81 food and beverage companies and found only a few companies were adopting the global strategy. Pritchard (2000) did a case study of Nestle operations in Thailand in late 1990s and concluded that agro-food firms' dynamic geographic strategy can help them gain a financially driven competitive advantage. Multinational Agribusinesses (2005), edited by Rama, contains an excellent set of articles that focus on different perspectives of multinational agribusiness development, including the dynamic structure of the world's food industry (Tozanli 2005), FDI in U.S. food products (Pick and Worth 2005), globalization of food MNEs from Australia and New Zealand (Pritchard 2005), and the globalization of agro-food MNEs from Southeast Asia (Burch and Goss 2005).

Very little research has been done to evaluate what factors would impact the MNEs' modal FDI strategies. After the MNEs decide to invest in a foreign nation, they then face the decision of what ownership structure to select, a fully-owned subsidiary, or a partially-owned subsidiary such as partial acquisitions of stocks, joint ventures, and co-operations (Agrodata 1998). Full ownership and partial ownership each has its inherent advantages and disadvantages. Full ownership can minimize transaction cost (Buckley and Casson 1976), reduce technology spillover due to the domestic partner's moral hazard (Nakamura and Yeung 1994), and keep intangible assets such as scientific knowledge, production skills, know-how and brand names competitive (Nakamura and Xie 1998). Full ownership may not be allowed by the host government or it may be infeasible if the investing firm knows little about the host country's market, culture, customs and laws. In this case, firms may develop local partners to limit the political, societal and legal risks.

Partial ownership is often sought by firms that are unfamiliar with the host country and need resources possessed by the foreign local partners such as specific technology or capital, knowledge of local markets, or good relations with the host government. With partial ownership, firms can spread the risk and the financial burden, and minimize the risks of being cut off from a single supplier (Caves 1996). However, partial ownership has significant disadvantages such as possi-

ble technology spillovers (Nakamura and Xie 1998), high transaction costs associated with coordination and cultural differences.

Selecting an optimal modal arrangement can be challenging because firms have a variety of options available that appear to suit their strategic development needs. In the literature, one study has specifically addressed the question of why certain modes of FDI were or were not selected. Stiegert, Ardalan and Marsh (2006) examined agribusiness MNEs' modes of FDI into and within the European Union, and they found that the firms' previous investment modes, language barriers and exchange rate fluctuations were the main factors that determined the firms' investment patterns. Stiegert et al. (2006) estimated a binary modal FDI model (full ownership versus partial ownership), which this study follows.

Data

The Agrodata dataset (1998) contains the modal investment strategies of the 100 largest food and beverage firms in the world for the FDIs from 1987 to 1996. For example, suppose Cargill engaged in a joint venture in Australia in 1995, one activity is recorded as a joint venture for Cargill in 1995. All these companies engaged in a total of 287 FDI activities over the 10-year period. Joint ventures and mergers were the most frequent modes of investment, with 32.4 and 23.7 percent of investment activities. The top 100 food and beverage firms are based primarily in North America (32 firms) and Western Europe (53 firms).

Figure 1 shows the distribution of the world's 100 largest food and beverage MNEs' foreign subsidiaries across host-country regions for 1987 and 1996. Their subsidiaries present in Western Europe stayed the same at 46%. However, there is a rapidly increasing investment trend towards economies in the Asia-Pacific region. Over the 10 years, the percentage of the 100 MNEs' subsidiaries present in the Asia-Pacific region nearly doubled from 10% to18%. Although Western Europe was still the number one market in terms of attracting foreign investment, food MNEs began to move their FDI activities towards emerging economies due to the increasing consumer disposable income, positive demographic trends (Tozanli 2005) and relatively low cost of production in the developing countries in Asia (Burch and Goss 2005).

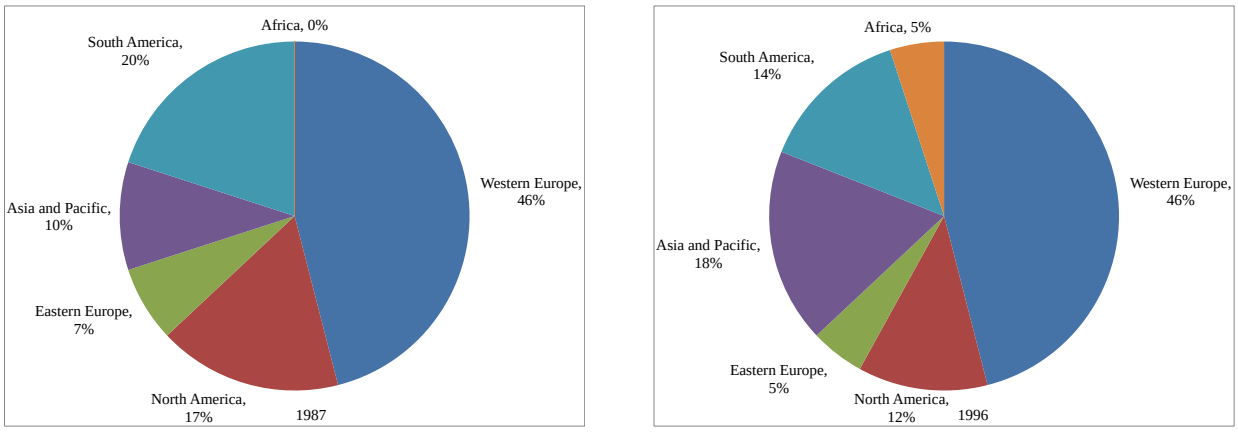

Figure 1. Distribution of Foreign Subsidiaries of 100 Largest Multinational Food and Beverage Firms
Source. Agrodata 1998

Among the 100 food and beverage MNEs in Agrodata (1998), 60 companies made a total of 287 direct investments into and within the Asia-Pacific region during 1987 and 1996. The 60 agribusiness MNEs are from 13 countries, and made investments in 18 countries, as shown in Table 1. Investments into the Asia-Pacific region were dominated by U.S. and Canadian firms (88 investments, or 31 percent, shown in the last two rows of Table 1), while U.K. and French firms made 19 and 14 percent of investments, respectively. Japanese firms accounted for 15%. Table 1 also shows the distribution of investments among host countries. Australia had the most (58 investments, or 20 percent, shown in last two columns of Table 1), with China, Japan, and New Zealand each accounting for more than 10 percent of the FDIs that occurred. The numbers in the main part of Table 1 indicate the percent of the host country's FDIs originating in different home countries (for instance, 29 percent of FDI into China were made by Japanese firms). Rather than all investments coming from a single home country, most countries host investments from several home countries.

Table 1. Home and Host Countries of FDI Occurring in Asia-Pacific Region (1987-1996)

	Home Country									Host % of Total	Host Total
Host Country	Australia	Canada	France	G. Britain	Japan	Netherlands	Switzerland	USA	Other		
	percent of host country's total									%	#
Australia		5%	9%	22%	19%	3%	7%	33%	2%	20%	58
China		2%	24%	12%	29%	2%	2%	17%	10%	14%	41
Hong Kong		15%	15%	23%	8%	8%	8%	23%		5%	13
India			19%	24%		19%		38%		7%	21
Indonesia			17%	8%	17%		8%	42%	8%	4%	12
Japan		3%	18%	38%	3%	6%	9%	24%		12%	34
Kazakhstan						100%				1%	2
Malaysia			33%	17%		17%	17%	17%		2%	6
New Zealand	16%	3%	16%	16%	13%	10%		26%		11%	31
Pakistan					33%	67%				1%	3
Philippines		17%		17%		17%	17%	17%	17%	2%	6
Russia			20%	13%	7%			60%		5%	15
Singapore	40%			20%	20%	10%		10%		3%	10
South Korea				8%	8%		17%	58%	8%	4%	12
Taiwan			13%		38%	38%	13%			3%	8
Thailand			9%	18%	45%			18%	9%	4%	11
Vietnam						100%				1%	4
% of Total	3%	3%	14%	19%	15%	9%	5%	28%	3%	100%	287
Total Home	9	9	41	54	44	27	15	79	9		287

Key for shading: percent of FDI activities that are Partial Control (PC)

0-39%	60-79%	80-99%	40-59%	100%

Source. Agrodata 1998

The 60 MNEs are active in a variety of food and agribusiness industries. Table 2 shows the distribution of these MNEs' types of businesses. About 40.42% of the investments were made by companies specialized in multiple products (e.g., Nestle, Unilever, Proctor & Gamble), 18.12% by wine and spirit companies (e.g., Guiness, Pernod Ricard), 12.20% by soft drink companies (e.g., Coco Cola, Pepsico), 10.80% by beer companies (e.g., Asahi, Heineken), and 4.88% by dairy companies (e.g., Friesland, Sodiaal).

Table 2. Food and Beverage MNEs' Business Type (1987-1996)

Food Industry	Number of Investments	Percent of Total
Fruits and Vegetables processing	4	1.39%
Dairy Products	14	4.88%
Soft Drinks	35	12.20%
Beer	31	10.80%
Meat Processing	8	2.79%
Fish, Fish Processing	1	0.35%
Multiple Products	116	40.42%
Grain Milling, Baking	11	3.83%
Sugar and Sugar Products	2	0.70%
Highly Processed Food	1	0.35%
Grain Milling	4	1.39%
Wine and Spirits	52	18.12%
Food Trading	1	0.35%
Breakfast Cereals	2	0.70%
Sugar, Sweeteners	1	0.35%
Biscuits, Baking and Pasta Products	1	0.35%
Confectionary	1	0.35%
Animal Feeds	1	0.35%
Baking Products, Biscuits	1	0.35%
Total	287	100%

Source. Agrodata 1998

There are over 90 specific modal investment possibilities in the data set, making it impossible to structure a model that could address so many modal patterns. Therefore, we grouped the investments into two categories depending on the degree of control the parent firm maintained. The first grouping is considered to be full ownership (full-control activities, referred to as FC below). Activities in this grouping consist of acquisitions, plant construction, subsidiaries, mergers, and all investment activities containing purchases over 90% of the invested firm. The second grouping, is considered to be partial control (PC) activities that include co-enterprise agreements, partnerships, joint ventures and minority interest (10% or under), all forms of licensing, contractual arrangements and franchising. The least integrated investment patterns are licensing, contractual agreement and franchising.

The shadings of cells in Table 1 indicate the percent of FDIs in a particular host-home combination that were of the partial control type, with darker shades of gray indicate a higher share of partial control FDI modes. Notably, most home and host countries have a mix of PC and FC modes. Further, a majority of the host-home combinations use a mix of modes, suggesting that firm characteristics as well as country characteristics influence modal investment decisions.

The Empirical Model of Modal Investment

Many firm- and target country-factors influence the decision of investment mode. Different economic and political policies regarding investment in target countries provide inducements or deterrents for potential investing firms. Other factors such as potential market growth, changing consumer preferences and economic uncertainty all impact the investment style chosen. Our empirical analysis is built upon the theoretical work done by Pan and Tse (2000) who modeled the firms' modal investment decision as a function of firm strength, industry characteristics and country factors, i.e., $M = f(F, I, C)$. Following Pan and Tse (2000) and Stiegert et al. (2006), we include firm-specific characteristics and host country-specific characteristics in the empirical model. Industry characteristics are excluded because all investments are for the same industry.

A Binomial Logistic regression model is chosen because the investment patterns have been classified into 2 categories: full ownership investment (FC) and partial ownership investment (PC). The model derives the choice probability of a partial ownership investment mode, represented by the following equation:

$$(1) \quad \text{Prob}(\text{PC}_\text{i} = 1 | x_i) = \frac{1}{1 + \exp(-x_i \beta)} = F(\alpha + x_i \beta)$$

where PC_i is the ith observation of the firm's investment mode, which takes value 1 if a partial-control investment pattern is chosen and 0 otherwise, and β is a vector of parameters that link the ith observation of x_i to the ith observation of PC_i. The marginal effect of an explanatory variable is computed by taking the partial derivative of equation (1) with respect to x_i:

$$(2) \quad \frac{\partial \Pr(PC_i = 1 | x_i)}{\partial x_{ij}} = \frac{\exp(x_i \beta)}{[1 + \exp(x_i \beta)]^2} \beta_j = \Pr(PC_i = 1 | x_i)[1 - \Pr(PC_i = 1 | x_i)]\beta_j$$

The Binomial Logistic structure contains the linear relationship of a group of explanatory variables as follows:

$$(3) \quad Ln\left(\frac{\Pr(PC_i = 1 | x_i)}{\Pr(PC_i = 0 | x_i)}\right) = \beta_0 + \beta_1 FINVEST_i + \beta_2 FGROWTH_i + \beta_3 PRODUCER_i + \beta_4 DISTANCE_i + \beta_5 LANGUAGE_i + \beta_6 ORI_i + \varepsilon_i$$

i.e., the log odds ratio is a linear function of explanatory variables, and ε_i is the error term. The explanatory variables are defined in Table 3, summarized in Table 4, and discussed below.

Table 3. Description of the Model Variables

Dependent Variable	
PC	Investment type of FDI made in the Asia-Pacific Rim Region. =1 if partial control (PC) =0 if the firm had full ownership
Independent Variables (and anticipated sign of estimated coefficient)	
FINVEST (–)	Firm's number of full investments into the region over the past three years
FGROWTH (+)	Firm's sales growth rate over the past three years
PRODUCER (+)	= 1 if company produces producer products; 0 if produces consumer products
DISTANCE (+)	Distance between the investing firm's home country and the host country
LANGUAGE (+)	= 1 if the language spoken in the investor's home country is the same as the host nation; 0 otherwise
ORI (+)	Host country's operations risk index calculated by BERI Larger number indicates a less risky political, financial, and economic environment

Table 4. Descriptive Statistics of the Model Variables

	Minimum	**Maximum**	**Mean**	**Std. Deviation**
FINVEST	0	13	3.41	3.07
FGROWTH (%)	-0.08	0.25	0.05	0.05
PRODUCER	0	1	0.89	0.31
DISTANCE(1,000km)	1.13	19.2	10.17	4.18
LANGUAGE	0	1	0.21	0.41
ORI	30	84	56.54	12.04

Total observations: n = 185

$FINVEST_i$ is the number of full investments into and within the region over the past three years by the investing firm. It is a proxy for how experienced the firm is in doing full-control FDI in the region. It is anticipated that the more experience the firm has, the more likely it is to engage in more integrated investment modes. Thus, the probability of engaging in a type PC investment is expected to be negatively related to *FINVEST*, and we expect a negative coefficient.

$FGROWTH_i$ is the investing firm's sales growth rate over the previous 3 years.[1] As a firm's growth rate increases, the probability of that firm engaging in partially owned FDI is expected to increase. Complete control activities normally require larger amounts of capital and managerial

[1] For example, *FGROWTH* for year 1996 = $(Sales_{95}/Sales_{93})^{1/3}$-1.

talent. Increasing growth rate of a firm implies that managerial and financial assets are likely to be thin and spread out, thus the firm is more likely to seek partial-style investment modes. External growth through mergers and acquisitions, and strategic partnership could help MNEs to attract cash from local partners, gain market share quickly, and reduce market risks in the host nation (Tonzanli 2005). Therefore, the probability of making a PC investment is expected to be higher for fast-growing firms and we expect a positive *FGROWTH* coefficient.

$PRODUCER_i$ is a dummy variable that equals 1 if the firm's activity is focused on a producer good (such as food processing machinery) and 0 if the investing firm's activity is focused on consumer good. Usually, corporate buyers require specialized or customized products. The investing firm (e.g., Nippon Meat Packers, Ito Ham Foods) might find a local partner helpful because it may better understand local firms' needs, and may have established marketing and distribution channels in the host country. Thus, PC investments are expected to be more likely for companies whose customers are producers. However, to prevent technology spillovers and maintain the value of their brand names, MNEs focused on consumer products (e.g., Pepsi, Unilever) are more likely to engage in wholly owned FDI. Therefore, we expect *PRODUCER* to be positively related to PC investment activities, and a positive coefficient is anticipated.

Spatial and cultural connections can affect a MNE's choice of investment mode (Stiegert et al. 2006). $DISTANCE_i$ is the distance in 1,000km between the investing firm's home country and its FDI host country. If the investing firm is far from its FDI host nation, the international transportation and communication costs are higher. Firms are more likely to be less involved and the probability of them seeking a PC investment mode is larger; therefore, we expect a positive coefficient for the *DISTANCE* variable.

$LANGUAGE_i$ is used as a proxy for cultural similarity. It is a dummy variable that equals 1 if the language spoken in the investing firm's home country is the same as its host country. If the language spoken in the investing firm's home country is the same as host country, then finding and working with a foreign partner is easier and the probability of adopting a PC investment mode might increase. So we expect a positive *LANGUAGE* coefficient.

Economic, societal and political stability play an important role in MNEs' decision on FDI mode. Any unexpected changes in foreign market and/or government policy in the host nation can harm investing firms' operating businesses. ORI_i is an operations risk index estimated by BERI to indicate the socio-economic and political stability in a given country. [2] The ORI index is calculated for over 140 countries using the BERI model which is based on 15 country criteria.[3] It is an integrated index of political, financial and economic risks that affect the business environment. The ORI indices for all the countries and areas in our analysis were obtained from BERI HRRP package.

[2] BERI stands for Business Environment Risk Intelligence (http://www.beri.com/), it is a private source for providing MNEs and commercial banks risk ratings, analyses and forecasts for a large number of countries.

[3] The 15 factors include: policy continuity, attitude towards foreign investors and profits, degree of privatization, monetary inflation, balance of payments, bureaucracy, economic growth, currency convertibility, enforcement of contracts, labor cost and productivity, professional services and contracts, communications and transportation, local management and partners, short-term credit, long-term loans and venture capital.

A high ORI indicates a better socio-economic and political environment for foreign MNEs (i.e., less risky for the investing firms), and a higher probability of choosing partial investment activities is expected. There are several reasons. First, healthy and fast economic growth in the host nation could make it a profitable market for a potential investing firm's goods and services. When engaging in a joint-venture, purchasing minority interest or arranging some type of contractual or licensing agreement, the investing firm's risks associated with these activities are shared with the local partners. Second, when the host nation has a professional and effective system of contract development and enforcement, the legal risks are low and so firms looking to invest are expected to opt for PC investment. Third, a high index value signals the availability of local human capital resources. A MNE's external growth through partnership is more likely to occur because finding good partnership can help the firm to reduce market risks, avoid sunk costs on the brand new facility or project in the host nation, and achieve higher profitability (Tozanli 2005).

Empirical Results

The earliest dates of investments available via Agrodata (1998) started in 1987, hence the number of full investments in the region over the past three years didn't commence until 1990. We estimated the model using the data from 1990 to 1996 with a total of 185 observations. Parameter estimates for each variable and the associated standard errors are given in Table 5.

The model's overall significance was tested using the null hypothesis that all explanatory variables have no effect on the FDI mode chosen (i.e., H_o: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$). The test statistic has a chi-squared distribution with a log likelihood ratio of 16.18. Because its p-value is 0.01, we reject the null hypothesis, and conclude that the model variables jointly explain modal investment patterns.

Of the six explanatory variables, four were statistically significant and all but *FINVEST* maintained the anticipated sign. As expected, the probability of choosing a partial-control mode of investment increased as the distance between the home and host countries increased and as the *ORI* index increased. It was also higher for investing firms who provide capital products. The investing firm's sales growth rate and whether the investing firm's home country and host country share the common language were statistically insignificant.

While a higher number of recent FC investments made by the company in the host country (*FINVEST*) was expected to decrease the likelihood of a PC investment mode, the estimated coefficient was actually positive and statistically significant at the 10 level of significance. This result also differs from the study of FDI into and within EU countries (Stiegert et al., 2006). Most host nations in our analysis are in Asia. Comparing to the food and beverage industry in EU, firms in this industry in Asia are more vertically integrated and more tied to the government and political systems (Burch and Goss 2005). Because the industry is less market-driven in Asia, the investing firms may find that switching to the partial investment activities can be more beneficial and less risky.

Table 5. Model Coefficients and Marginal Effects

Variable	Coefficient	Std. Err.	Marginal Effect on P(PC=1)
INTERCEPT	-4.16***	1.13	-
FINVEST	0.10*	0.05	0.03*
FROWTH	3.64	3.42	0.90
PRODUCER	1.21**	0.56	0.26**
DISTANCE	0.07*	0.04	0.02*
ORI	0.03**	0.01	0.01**
LANGUAGE	0.24	0.42	0.06

*** P < 0.01 ** P < 0.05 * P < 0.1

The marginal effects from changes in the explanatory variables on the probability of selecting certain investment modes are also presented in Table 5. These results are best evaluated based on our earlier discussions about the expected signs of each individual variable. One more FC investment made over the past three years (i.e., an incremental increase in *FINVEST*) will increase the firm's possibility of choosing partial-type investment by 3% point. Every 1,000km increase in the distance between the investing firm's home nation and host nation will increase the probability of shared FDI modes by 2% point. We also find that an incremental increase in the *ORI* index can increase the probability of a PC investment mode by a small but statistically significant 0.7 percent point.

Table 6 summarizes predictions of PC and FC investments derived from the estimated model. The model correctly predicted 71 out of 107 (66%) full-control investments. This can be partially attributed to the high level of significance for the *FINVEST, PRODUCER, DISTANCE* and *ORI* variables. The model was also fairly accurate in predicting partial-control investment modes, with 47 out of 78 investment activities were predicted to be of this type (60% correct). Partial-control investment modes such as franchising, licensing, and contracting can involve varying degrees of investment; this variation is more difficult to capture in the independent variables, which accounts for the model's slightly lower ability to predict the PC strategies. Overall, the model correctly predicted 64% of the data points included.

Table 6. Prediction Table

	Predicted			
	Degree of Control			
Observed	Full	Partial	Total	Percentage Correct
Full	71	36	107	66.36
Partial	31	47	78	60.26
Total	102	83	185	63.78

To better understand whether the explanatory variables in the Binomial Logistic model are statistically different between the whole-ownership and shared-ownership investment patterns, we did the t-tests for the variable means in the two groups and reported the results in Table 7. Of the six independent variables, four of them are statistically different between the two types of investment. Most firms that made type 1 investments focus on producer goods. Firms that made type 1 investments appear to have a longer geographic distance to the host nation. Nations that have a higher ORI index are more appealing for partial investment. Firms tend to make type 1

investments if the language spoken in their home country is the same as host nation. The average numbers of full investments made over the previous three years and the average revenue growth rates are statistically the same between the firms that select different modes of investment.

Table 7. Mean Difference Tests

Variable	Difference	Std. Err.
FINVEST	-0.36	0.46
FROWTH	-0.009	0.007
PRODUCER	-0.06*	0.04
DISTANCE	-1.24**	0.61
ORI	-4.03***	1.74
LANGUAGE	-0.09*	0.06

*** P < 0.01 ** P < 0.05 * P < 0.1

Conclusions

From 1987 to 1996, the world's largest food and beverage MNEs extended their investment activities beyond the traditional triad, i.e., EU, U.S. , and Japan (Tozanli 2005). Their FDI into and within the Asia and Pacific Rim region almost doubled. Based on their world famous brands, they adopted the external growth strategy through multiple investment modes. In this study, a Binomial Logistic regression model was utilized to analyze how firm and country characteristics explain food and beverage MNEs' FDI modes between full ownership and partial ownership. We find that investing MNEs' previous investment pattern, product type, the hosting nation's general economic and political stability, and the distance between the investing firm's home country and host country all have statistically significant effects on MNEs' investment mode choice.

Different from a similar study for EU (Stiegert et al. 2006) where firms were found to follow the same investment pattern, in our analysis, firms that made more full investment activities over the past three years in the Asia-Pacific region are more likely to adopt the partial investment mode. All other results are consistent with current FDI theories. Investing firms tend to choose the partial investment mode if it is focusing on producer products. Increased political, societal and economic stability in the host nation leads to a higher likelihood of partial investment activities. A larger geographical distance between the investing firm's home country and host nation results in more shared ownership investment modes. Different from prior research (Stiegert et al. 2006), whether the language spoken in the investing firm's home nation is the same as its host nation does not impact the investment mode choice in the Asia-Pacific region.

The food and agribusiness MNEs' choice of investment pattern can be very complex. Firms have a variety of options for investing to meet their specific development needs and implement their long-run strategic plans. The important implication for the food and agribusiness firms from this study is that the socio-economic and geographic factors along with the firm-specific characteristics all play a crucial role in selecting the modal investment pattern. Besides the importance of the amounts and allocation of the firm's own managerial and capital assets and its strategic development plans, certain macroeconomic and locational advantages (embedded in the ORI index) are critical as well, such as the cost of transportation and delivery, host nation's

economic growth, availability and cost of resources (i.e., management, labor and capital), market stability, political risks and government policies.

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Adoption of Mechanical Harvesting for Sweet Orange Trees in Florida: Addressing Grower Concerns on Long-Term Impacts

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Abstract

The purpose of this article is to examine the impact of mechanical harvesting of juice oranges on future productivity of the orange trees. Yield data from several growers were analyzed over a ten-year-period to estimate a statistical relationship between annual fruit yields and harvest method. Results indicated that mechanical harvesting did not create an adverse near-term nor long-term effect on yields.

Keywords: citrus; mechanical harvesting; citrus yields

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The Florida Citrus Industry contributes more than $9 billion annually to the Florida economy (Hodges and Rahmani 2009). More than 67% of the United States citrus supply, including grapefruit, comes from Florida and more than 95% of the Florida orange crop is used for juicing (NASS 2009). In Florida, 30 of the 67 counties grow citrus and more than 80% of the citrus grown is within 10 counties in the southern portion of Florida (Figure 1). In the late 1990s, Florida citrus growers produced fruit from 845,000 acres and produced a record 244 million boxes of oranges in 1997. Citrus acreage was adversely affected by several events, including a mandatory canker eradication program that removed nearly 87,500 acres of commercial groves between 1998 and 2007 (FDACS-DPI 2011); a dramatic run-up on land values between 2004 and 2007 that led to numerous citrus operations being sold to real estate developers; hurricanes in 2004 and 2005 that moved across every citrus production region in Florida; and the onset of citrus greening, or HLB, in 2006 that to-date has no cure other than eradication of infected trees. By 2010, the number of bearing citrus acres had decreased to 569,000 and orange production had fallen, fluctuating between 129 million boxes in 2006 and 170 million boxes in 2007 (Table 1). Even with the significant loss in acreage and number of trees, citrus remains Florida's top horticultural crop (FDACS 2010). Florida is the number one producer of citrus in the United States, and ranks second only to Brazil as the world's leading producer of juice oranges (Roka et al. 2009).

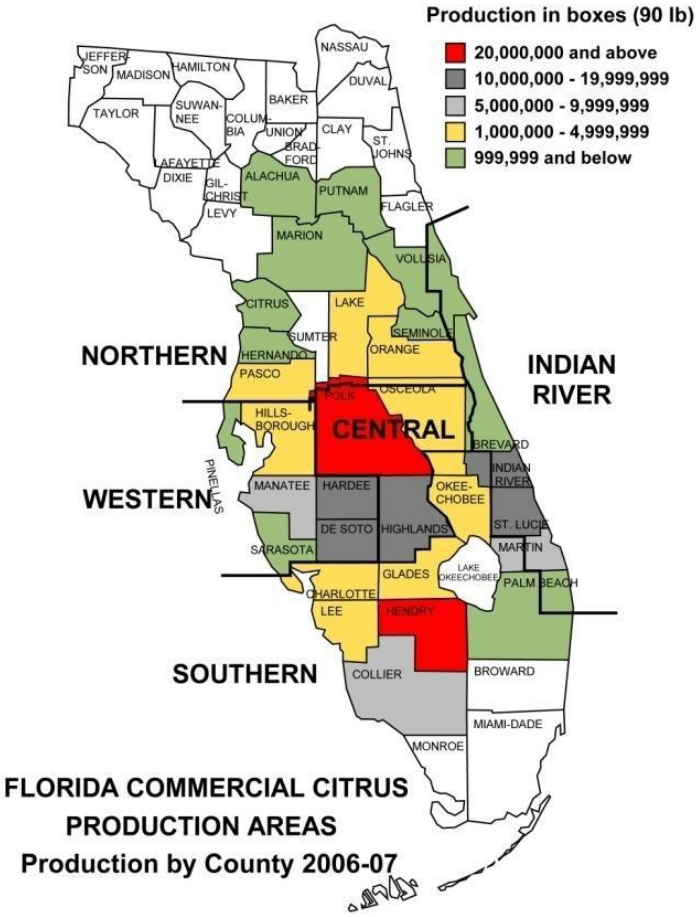

Figure 1. Florida Citrus Producing Regions and Counties, 2006–2007
Source: Roka et al. 2009

Table 1. Orange Production in Florida from 1996 through 2009 Harvest Seasons

Season	Total Orange Production (MM boxes)	Total Orange Processed (MM boxes)	Proportion of Total Orange Production – Processed (%)	Total Orange Value ($MM)
1996	226.2	215.5	96%	$801.3
1997	244.0	233.0	95%	$900.8
1998	186.0	175.1	94%	$900.0
1999	233.0	223.6	96%	$856.1
2000	223.3	213.6	96%	$716.1
2001	230.0	220.6	96%	$797.6
2002	203.0	193.3	95%	$643.8
2003	242.0	232.1	96%	$699.9
2004	149.8	142.4	95%	$522.9
2005	147.7	140.4	95%	$813.3
2006	129.0	122.6	95%	$1,325.7
2007	170.2	164.3	96%	$1,125.3
2008	162.5	155.6	96%	$937.1
2009	133.6	127.8	96%	$856.4

Source. NASS (2009; 2010).

Florida's citrus growers face significant economic threats, primarily from diseases, labor costs, and global competition. Since 2005, when citrus greening (HLB) was discovered in Florida, the cost of growing oranges has increased from $800 to more than $1,500 per acre (Muraro 2009). Most of these costs are from increased chemical usage to control the Asian citrus psyllid, which vectors the greening bacteria, and grove labor because harvesting fruit relies mainly on manual labor. The minimum wage in Florida increased from $5.15 in 2005 to $7.31 per hour in 2011. In addition, the new health care law, which will provide new health benefits to farm workers, will likely push labor and harvesting costs higher. While Brazilian citrus growers face similar disease threats and social taxes as do Florida growers, overall costs of citrus production in Brazil are significantly lower than in Florida (Muraro et al. 2003). Lower labor and land costs are important factors behind the Brazilian competitive advantage. If the Florida citrus production and juice processing industry is to remain economically sustainable into the future, new technologies must be developed and adopted to increase fruit production efficiencies and decrease harvesting costs.

One possible technology is mechanical harvesting of juice oranges. Mechanical harvesting systems were being developed in Florida as early as the 1950s. At that time, citrus acreage and production were increasing rapidly and the question over whether there would be a shortage of harvest labor motivated the research into mechanical harvesting systems. Unfortunately, these early systems did not provide a sufficiently strong economic justification for commercial investment. In addition, USDA policies discouraged public funds to research "labor-saving" technologies. Ultimately a series of devastating freezes during the 1980s drastically reduced the volume of Florida's citrus crop. Concern about labor availability waned and mechanical harvesting research came to a halt by 1985. Then came the 1990s when citrus acreage and production were again rapidly expanding across the state, particularly in southwest Florida, which renewed the interest in mechanical harvesting. Concerns over labor availability, however, were augmented by con-

cerns with low fruit prices and competition with the increasing world supply of Brazilian orange juice. The goal of the new mechanical harvesting program was focused on lowering harvesting costs.

Mechanical harvesting has the potential to dramatically reduce a grower's harvesting cost. Field observations documented that trunk and canopy shakers with catch frames could improve harvest labor productivity by ten-fold (Roka and Hyman 2004). If the economies of scale from the existing equipment could be realized, then harvesting costs could feasibly be reduced by as much as 50% and grower returns increased by between $100 and $200 per acre (Roka, et al. 2009). Achieving these economies of scale, however, required that growers adopt the new mechanical harvesting equipment and aggressively push the physical capabilities of these systems.

At the beginning of the 1999 harvest season, several commercial harvesting companies invested in mechanical systems and began to sell their services as an option to harvest juice oranges. Over the next seven years, demand for mechanical harvesting systems increased steadily from 6,500 acres in 1999–2000 to more than 35,000 acres by 2008 (Figure 2). More importantly, those growers who were able to effectively and efficiently use harvesting equipment reported a reduction of between 20 and 30 cents per box ($80 to $150 per acre) in their net harvesting costs (Personal Communication 2011). Looking at the issue of economies of scale, harvesting equipment is a large initial investment if purchased by the grower, hence mechanical harvesting would only be adopted by growers with acreage large enough to spread the cost of such an investment.

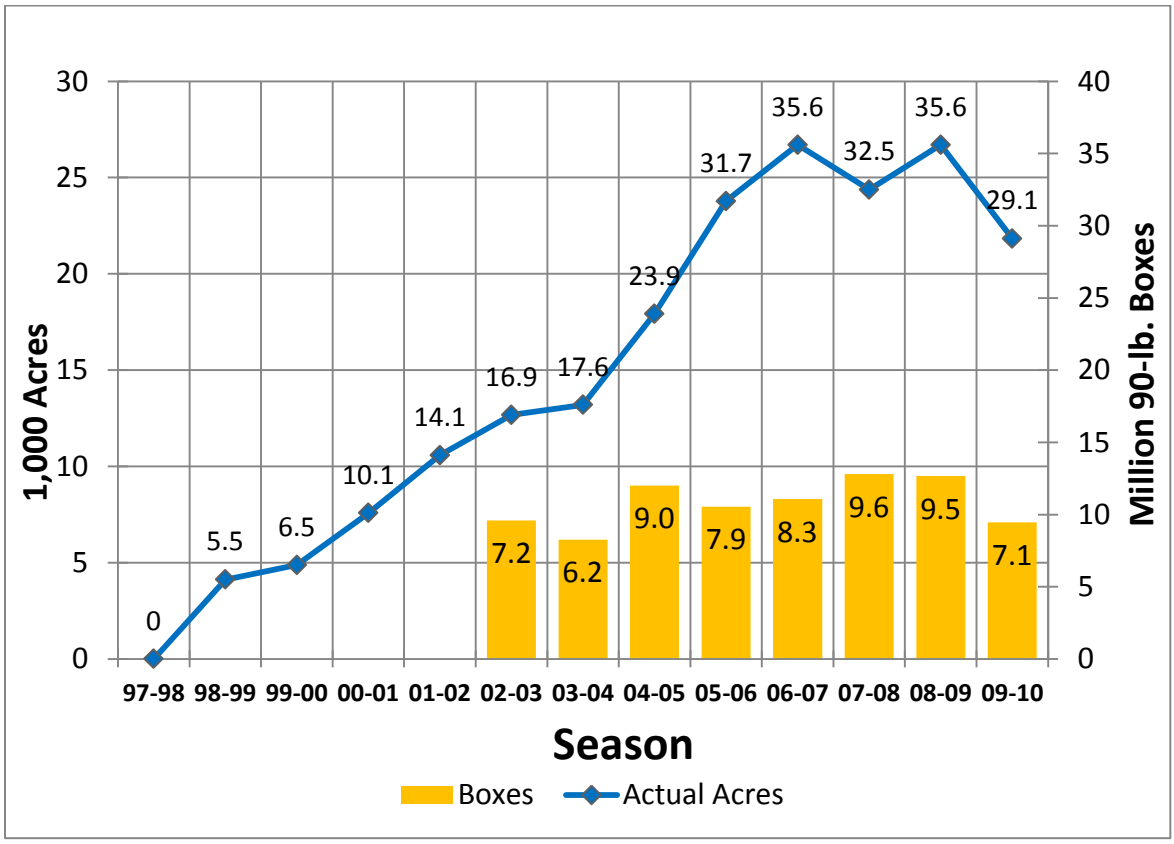

Figure 2. Total Acreage and Boxes Mechanically Harvested in Florida, 1997–2010 (FDOC 2010).

Despite some initial success, mechanically harvested acreage has not expanded since 2008, and in fact, may be on a downward trend. Technical barriers, tree health issues, and grower perceptions about the impact of mechanical harvesting on tree health are some of the major reasons explaining the slow adoption of mechanical harvesting equipment by Florida growers. The registration and use of an abscission compound is one example of a technical barrier without which prevents current mechanical systems from harvesting nearly 40% of the 'Valencia' orange crop.[1] Improvements in catch-frame design are another technological opportunity that would increase overall fruit recovery while at the same time removing all unwanted debris from the fruit load. These technological barriers can be overcome so long as growers commit to mechanical harvesting and thereby provide the financial incentive for equipment manufacturers and commercial harvesting companies to continue their investment into harvesting equipment. Currently, grower commitment to mechanical harvesting systems is in question in large part to their concerns about tree health and their perception that mechanical harvesting equipment has a direct and negative effect on tree health.

Harvesting, even by hand, adds a physiological stress to a tree. Growers have been particularly concerned about mechanical systems because of the visible scars they leave on trees and in the grove. These injuries include the removal of leaves, flowers, and young fruit, broken branches, exposed roots, and bark scuffs (see Figure 3). The question becomes whether the visible damage observed after mechanical harvesting translates to economic losses. Complicating this question is a strong and widespread consensus among Florida citrus growers that overall tree health has declined significantly since 2004. A combination of four hurricanes, a persistent drought, and the spread of citrus greening have imposed considerable physiological stress to trees independent of any harvesting method.

The purpose of this research is to analyze fruit yield data collected from commercial production operations, which have employed both mechanical systems and hand harvesting crews to harvest oranges and determine if there is in fact a negative effect from mechanical harvesting on short or long term production. Results from this study should be useful to commercial growers in helping decide their adoption strategies with respect to mechanical harvesting. In addition, results from this study should provide insights into how Florida citrus growers can achieve the dual goals of maintaining tree health while significantly reducing net harvest costs through mechanical systems.

Previous Research

Several multi-year studies dating back to the 1960s and 1970s were conducted by University of Florida and USDA-ARS horticultural and engineering scientists to investigate whether the visible damage left by mechanical harvesting equipment imparted long-term and adverse impacts on fruit production and tree mortality. These studies consistently found no connection between mechanical harvesting and lower fruit yields nor with higher tree mortality (Whitney 2003; Hedden, Churchill, and Whitney 1988; Whitney and Wheaton 1987; Whitney, Churchill, and Hedden 1986). More recently, experiments have studied the impacts of mechanical harvesting on various aspects of tree physiology. For example, water status and leaf gas exchange within mature trees have not suffered prolonged negative effects following mechanical harvesting (Li and Syvertsen

[1] 'Valencia' orange trees are harvested from March to June. During the entire harvest period, these trees carry two

2005). Further, defoliation caused by trunk or canopy shakers should not significantly reduce canopy light interception in well-developed citrus trees. In fact, healthy trees were shown to sustain up to 25% defoliation without causing any reduction in fruit yield the following season (Li, Burns, and Syvertsen 2006). In general, "well-nourished" citrus trees are very hardy and can withstand the stresses imposed by properly operated harvesting equipment. Trees mechanically harvested should be able to recover from the typical physical injuries to the same health status as hand harvested trees (Roka et al. 2009).

Figure 3. Post-mechanical Harvesting Visible Damage

The one issue where mechanical harvesting may have an adverse impact on fruit yield is when 'Valencia' oranges are harvested late in the season. 'Valencia' oranges complicate mechanical harvesting because this variety is a fifteen-month crop, and thus two crops hang on a tree throughout the harvest season, this year's mature fruit and next year's immature fruitlets. When 'Valencia' oranges are mechanically harvested the young fruitlets are small, the reduction in fruit yields the following year is insignificant. However, if mechanical harvesting occurs latter in the harvesting period, there could be more than a 30% reduction in yields the following season (Coppock 1972; Roka, Burns, and Buker 2005). This late period of 'Valencia' harvest occurs typically after May 1 and is defined by the size of the green fruitlets. Early experiments with limb shakers concluded that Valencia oranges could be harvested until the young maturing fruit is approximately 0.85 inches in diameter, without significant reduction in subsequent yields (Coppock 1972; Burns et.al. 2006).

Despite a body of scientific evidence showing no adverse effects from mechanical harvesting, growers remain unconvinced. They see the physical injuries to their trees and conclude that mechanical harvesting equipment seriously jeopardizes next year's fruit production and the long-term health of trees. Informal discussions with growers suggest two reasons for why they have yet to accept the published research on mechanical harvesting and the lack of negative effects on tree yield and health. The reasons given for lack of acceptance of the published research are from two main factors. First, all the previous studies were small-plot field trials conducted under relatively controlled conditions which, from a grower's perspective, may not reflect commercial

production conditions. Growers may be reluctant to extend results from six to ten trees per plot to commercial blocks involving hundreds of acres and thousands of trees. Second, the previous field trials lasted at most four seasons. Growers expect their trees to produce for at least twenty years and the production during the latter years of a trees life cycle that are considered to be the most economically valuable. The fact that trees may tolerate four or five years of mechanical harvesting does not allay grower uncertainty over how well trees will respond to mechanical harvesting for ten to fifteen years.

The objective of the research reported in this paper was to address grower concerns about mechanical harvesting and negative impacts on tree health and fruit production from a different angle. Instead of designing a horticultural field experiment, data were collected directly from the production records of commercial groves where both mechanical and hand crews were utilized to harvest oranges. Annual average yields of individual blocks, a grower's management unit, were analyzed as to the extent they were influenced by harvest method, hand versus mechanical. Data were included specifically from growers who had at least five years of mechanical harvesting experience and still harvested some blocks by hand. The study period spanned ten years, from 1999 through 2008. The specific research questions of this study dealt with whether there was an immediate or lagged effect on fruit yields and whether cumulative years of mechanical harvesting adversely affected tree health as measured by declining annual yields.

Data

Data were collected from four citrus operations in Hendry and Collier Counties located in southwest Florida. Each farm used both mechanical and hand harvesting at some point within the past ten years. All operations used mechanical harvesting equipment for at least five years. In three of the four operations there were blocks that were harvested mechanically for the entire time frame. Yield data, harvest method, tree age, tree density, variety, and rootstock data from commercial citrus blocks were collected from 1999 to 2008. A total of 572 observations were recorded, with 25,553 net tree acres represented. From 1999 to 2008, over 11 million boxes were both mechanically and hand harvested from the blocks analyzed in this study. A total of 44% of all blocks harvested between 1999 and 2008 were mechanically harvested. Eight blocks throughout the study were mechanically harvested each of the ten years and fourteen blocks were never mechanically harvested. Tree density ranged from 121 to 141.8 per block. There were four rootstocks and five varieties total (Table 2).

Table 2. Number of Blocks in Data by Variety/Rootstock Combinations

Rootstock Variety	Swingle	Carrizo	Cleo	Cleo-Carrizo	Total by Variety
Hamlin	111	135	10	20	276
Valencia	80	64	0	0	144
Parson Brown	0	10	0	0	10
Pineapple	0	20	10	0	30
Rhode Red Valencia	120	0	0	0	120
Total by Rootstock	311	229	20	20	580

Average yield was measured in boxes[2] per acre, per year (Figure 4). Tree age was calculated by taking the data collection year and subtracting plant date. Citrus trees were generally not harvest-

[2] One box of oranges weighs 90 pounds (41 kilograms).

ed until they were at least three years of age. The majority of the trees in this data set were between the ages of twelve and twenty-one years (Figure 5). Because new trees can be planted at different times within a block, blocks were separated into multiple observations and yields were allocated based on tree age. For the purpose of this research, percentage of production by age was a weighted average adjusted due to the range of tree ages we encountered. Based on research conducted by Albrigo and Burani-Arouca (2010), who investigated tree yields over a 37-year period, any trees ages ten or older were considered to be at 100% production. Production for younger trees was at a lower percentage of full production as they grow to maturity.

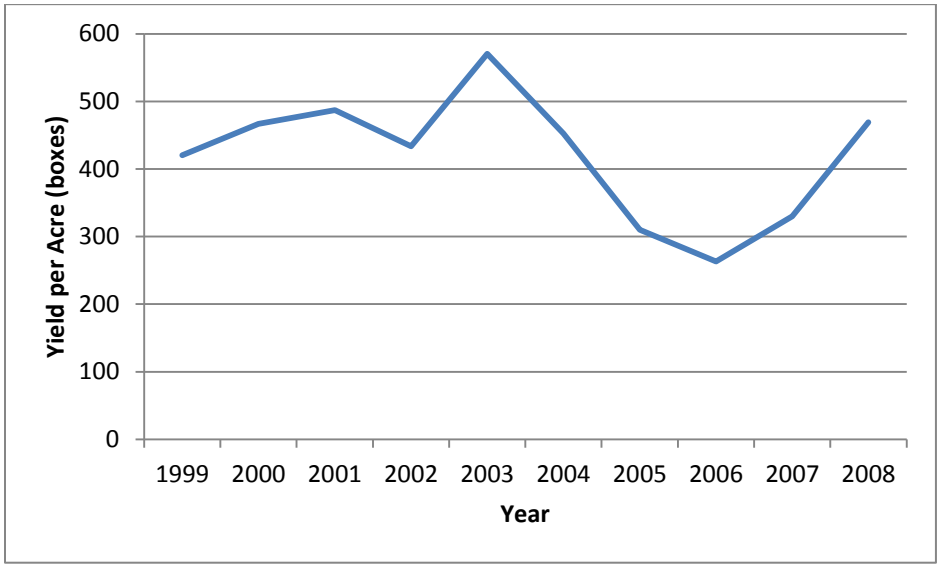

Figure 4. Average Grower Yield in Boxes Per Acre, Per Year

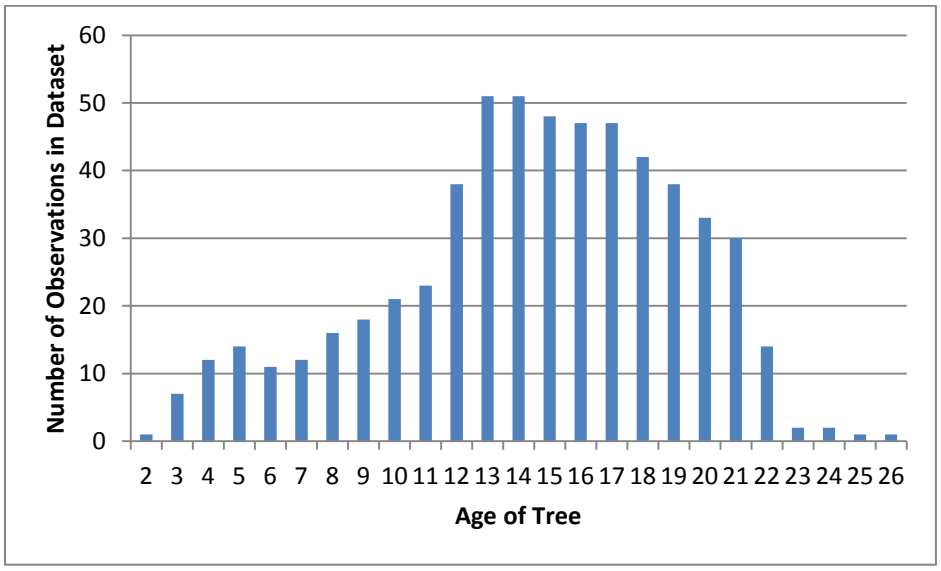

Figure 5. Tree Age Frequency

In addition to data collected from the citrus growers, the annual county average yields were collected from the annual Citrus Summary, published by the NASS Florida Field Office, which provided an estimate of season average yields (boxes per acre), by county, for all orange varieties,

and for early, mid, and late season varieties. Valencia oranges were listed in their own category due to being a late-season variety, typically exhibiting lower yields than the early/mid-season varieties. Figure 6 shows both Collier and Hendry County yields in boxes per acre, per year differentiating between early/mid varieties and late varieties. Both counties showed a substantial yield reduction after 2005, which coincides with Hurricane Wilma that hit southwest Florida in October 2005.

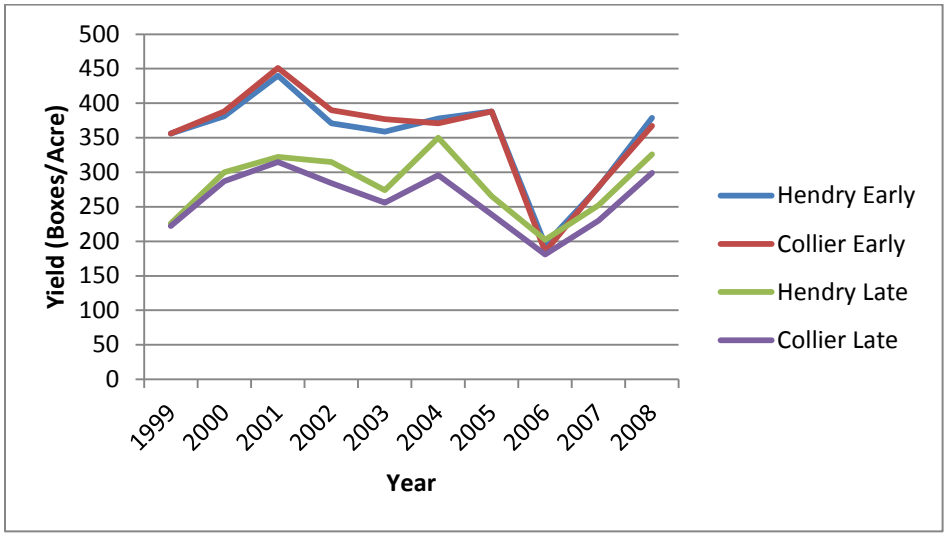

Figure 6. County Yields of Early and Late Season Oranges, Hendry and Collier Counties.

Model

The goal of this study is to use data collected from commercial orange groves to determine if harvesting method impacts current and future yields. The empirical model used to answer this question is:

Yield = *f* (harvest method, past harvest methods, variety, rootstock, tree age, tree density, county yield, grower, and hurricane)

where the dependent variable is yield, measured in boxes per acre. The independent variables include the current year's harvest method, the previous years' harvest methods, variety of citrus, type of rootstock, age of trees, density of tree plantings, county yield, and a dummy variable for years 2006 and beyond to measure the impact of Hurricane Wilma, which directly impacted southwest Florida in 2005 and had carryover effects on yields in 2006. (Three hurricanes struck the peninsula of Florida in 2004, causing significant damage in the east coastal, central, and northern production regions, with minimal effects in southwest Florida.) Variable definitions are provided in Table 3.

Table 3. Variable Definitions

Variable Name	Definition
Harvest Method	= 1 if block was mechanically harvested, 0 if hand harvested
Lagged harvest	Harvest method of prior year (=1 for mechanical, 0 for hand)
Total Mechanical	Sum of times block was mechanically harvested (minimum 0, maximum 10)
Early	= 1 if block contained Hamlin or Parson Brown varieties (early varieties)
Mid	= 1 if block contained Pineapple variety (mid-season)
Late	= 1 if block contained Rhode Red Valencia and Valencia varieties (late season)
Swingle	= 1 if rootstock was Swingle
Cleo	= 1 if rootstock was Cleo
Cleo-Carrizo	= 1 if rootstock was a mixture of Cleo and Carrizo
Carrizo	= 1 if rootstock was Carrizo
Tree Age	Year of yield data minus year tree was planted
Tree Density	Number of trees per block divided by block size (in acres)
County Yield	County yield for Hendry and Collier Counties, in boxes per acre, by type of orange (early, mid, or late season)
Grower	Dummy variable representing four growers in the study.
Hurricane	Dummy variable = 1 for seasons after Hurricane Wilma (2005)

The harvest method during the current year was included to determine if there was a significant yield difference between hand harvesting and mechanical harvesting for the current year. The null hypothesis was that harvest method should not affect yield in the current year. If harvest method were to have a significant effect on fruit yield, that impact would be evident in the following year. Lag harvest method captures the harvesting method of the year prior to the current year being studied. In addition, a variable was created to capture the total number of years during the study period that a particular block was mechanically harvested. This variable was designed to measure whether mechanical harvesting had a cumulative or long-term impact on fruit yield. This is used to address the industry concern that the impact from mechanical harvesting might not be an immediate problem, but that the long-term stress created by mechanical harvesting is a problem. The null hypotheses for the lag and cumulative variables were that their parameter values would be zero. A rejection of the null hypothesis for either variable would support the growers' contention of adverse impacts from mechanical harvesting.

Variety and rootstock combinations were included to account for general differences in fruit yield that are typical among early and late season varieties and among the common rootstocks (i.e., Swingle, Carrizo, and Cleo). Production increases as a tree ages up to the point where individual tree canopies form a hedgerow. After that point, production per acre levels off. Therefore, we must take into account how the age of the trees possibly affects crop yields. Tree density was included to reflect differences in the number of bearing trees per net tree acre among the study blocks. Average annual county yields were included to help account for general differences in growing and weather conditions among regions and across time. Counties may vary in a number of environmental ways and this variable was used to ensure that the locations of the groves were captured in the regression. The county yield variable used was specific to the county, as well as the type of citrus (early versus late season). Individual growers were included as explanatory var-

iables to capture any significant differences in overall grove management practices. Lastly, a hurricane variable was incorporated into the regression to distinguish between those years of harvest prior to Hurricane Wilma and her effect on subsequent crop yields.

Results and Discussion

This model was estimated using ordinary least squares regression methods in SAS and results are presented in Table 4. The most important finding from this model is that the coefficients for harvest method, lagged harvest method, and total mechanical harvest method were not statistically significant. Additional models were estimated including each harvest method individually, but results did not change. This indicates there are no significant yield differences per acre for mechanical harvesting versus hand harvesting, whether the mechanical harvesting happened in the current or immediately past season. The coefficient for total mechanical, which measured the number of times a block was mechanically harvested before the current year, dating back to 1999, was also insignificant, indicating that there was not cumulative damage from mechanical harvesting that impacted fruit yields.

Table 4. Regression Results

Variable	Coefficient	Error	Pr > |t|
Intercept	511.65	89.48	< .0001
Harvest Method	-10.45	20.73	0.61
Lagged Harvest	9.67	23.73	0.68
Total Mechanical	-2.04	4.31	0.64
Early	133.52	17.16	< .0001
Mid	86.77	39.50	0.03
Swingle	108.75	18.11	< .0001
Cleo	-84.70	42.52	0.047
Carrizo-Cleo	-120.28	68.68	0.08
Tree Age	11.30	1.65	< .0001
Tree Density	-3.03	0.53	< .0001
County Yield	0.49	0.12	< .0001
Grower 1	-29.73	24.72	0.23
Grower 2	-46.70	56.37	0.41
Grower 3	-99.54	19.98	< .0001
Hurricane	-134.66	18.15	< .0001

Results from our regression are confirmed with prior research and published data. Parameter estimates for orange varieties were significant, as would be expected. Early varieties, which included Hamlin and Parson Brown, yielded 134 more boxes per acre than did the late varieties (Valencia and the Rhode Red Valencia). Mid-season Pineapple oranges produced on average 87 more boxes per acre than the late season varieties. These results match yield differences reported in the annual Citrus Summary (NASS 2010)

Swingle, Cleo, and Carrizo-Cleo (groves that are a mix of Carrizo and Cleo rootstocks), were three rootstocks included as independent variables in the regression. Carrizo was included as part of the model's intercepts term and becomes the reference point around which to compare yield

effects from other rootstocks. Parameter estimates for Swingle and Cleo rootstocks were statistically significant and suggested that Swingle rootstock produced on average 109 more boxes per acre than those trees with a Carrizo rootstock, while Cleo rootstock produced 85 fewer boxes per acre as compared to Carrizo. The coefficient for the Cleo-Carrizo mixture was not statistically different when compared with trees on a Carrizo rootstock. Carrizo is generally known as being a vigorous rootstock and growers typically expect trees on Carrizo to yield more than trees on Swingle (Castle 2003). However, as trees age and canopies begin to hedge together, yield of orange trees on Carrizo rootstock tends to decline. This conclusion is supported by a long-term study of yields in southwest Florida, which indicates that Carrizo is a more vigorous rootstock and provides higher production during the first ten years of production. Afterward, however, production from trees with Swingle rootstocks outperforms the same varieties but on Carrizo rootstock (Roka 2009).

The coefficient of tree age was positive and statistically significant, implying that as trees increase in age by one year, production increases by an average of eleven boxes. The coefficient of tree density was negative, indicating that for each additional tree per acre (within the range we studied), yield decreased by three boxes per acre. This estimate closely approximates production data from southwest Florida orange groves (NASS 2010). Of the four growers, grower three had statistically significant lower yields than grower four (yields from growers one and two were not different from grower four yields). One possible explanation for this significant difference could be related to grove management practices.

County yield, which is a variable used to help incorporate countywide trends such as weather, soil, and other environmental factors, had a positive coefficient of 0.49. This indicates there is more variation in yield at the block level than at the county level. County yield captures overall growing conditions and the value of yield in any given year should vary directly with general growing conditions. Finally, a variable was included to capture the impact of Hurricane Wilma (October 2005) on overall tree productivity. The coefficient for the hurricane variable was negative and statistically significant, indicating that after the hurricane, yield decreased by 135 boxes per acre, per year. This is important as it gives evidence that the hurricane did cause long-term damage to grove health in this region.

Conclusions

The data collected for this study were from four commercial grove operations in southwest Florida. More than 90% of citrus mechanical harvesting occurs with the southwest Florida region (Roka and Hyman 2004). Data were collected from a ten-year time period in order to determine if lag effects exist in addition to short-term impacts. These research findings support earlier conclusions that mechanical harvesting does not negatively impact productivity of sweet orange trees. Variables testing harvest method, a one-year lagged harvest method, and total number of times a grove was mechanical harvested were not significant. As found in the study conducted by Whitney and Wheaton (1987), yields were very similar between hand harvesting and mechanical harvesting. Results from this study suggest the same conclusion but for a ten-year period of time and based on commercial production data. Another interesting finding was the apparent long-term impact of Hurricane Wilma on the productivity of citrus trees (yield per acre) in this region of Florida.

Previous research based on replicated small trial plots concluded that mechanical harvesting had no adverse effect on yield or productive life of an orange tree. An important caveat of those results was that trees were "well-nourished" before and after mechanical harvesting. Further research by Li and Syvertsen (2005) indicated that citrus trees are very resilient to leaf loss, drought stress, and root damage. A limitation of our research was the absence of data that quantified the health status of the study blocks and how health status changed over the study period. Consequently, we cannot say definitively that the blocks included in this analysis were representative of tree health status across the study region. If one argues that the sample blocks were biased towards unhealthy trees, the results of this study are magnified by the fact that mechanical harvesting had no adverse effect even on unhealthy trees. If, on the other hand, the study blocks were biased to only harvesting healthy trees, one could argue that purposely selected "healthier" blocks to be mechanical harvested and could mask adverse effects from mechanical harvesting equipment when yields were compared to presumably inferior hand-picked blocks.

Long-term sustainability of the Florida citrus industry rests on the assumption, perhaps requirement, that tree health must be restored and average production across the citrus industry return to at least its historic levels of between 400 and 500 boxes per acre. Once that happens, the contribution of this paper will be to reinforce and reiterate previous research findings that growers can mechanically harvest "healthy" trees without worrying about adversely affecting short- and long-term tree health.

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A Doubled Haploid Laboratory for Kansas Wheat Breeding: An Economic Analysis of Biotechnology Adoption

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Abstract

This research evaluates the use of doubled haploid lines (DHs) to accelerate breeding and gene discovery in wheat breeding. The DH biotechnology greatly accelerates time to market for new wheat varieties and speeds genetic gains in wheat yields. An economic model was built based on previous literature, knowledge of the wheat industry, and information gleaned from wheat breeder interviews. Results show that DH methods would provide large economic gains to Kansas wheat producers and global wheat consumers. The results are robust to a wide variety of scenarios.

Keywords: biotechnology adoption, bost-benefit analysis, doubled haploids, time-to-market, wheat breeding

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Introduction

In recent years, biotechnology has resulted in large increases in corn and soybean production, through the development of varieties that are resistant to herbicides, diseases, and drought. In 2010, over 90 percent of the acres planted to corn and soybeans in Kansas were varieties produced using biotechnology methods (KAS 2010). Adoption of these varieties, together with increased demand for biofuels, has led to a shift of acreage in the United States (US) out of wheat and into corn and soybeans since 2000 (KAS 2010). Recently, historically high wheat prices resulting from smaller acreages and weather events have resulted in increased interest and investment in wheat variety development by both private firms and public wheat breeders (USDA/ERS 2011). The creation of a new wheat variety is a lengthy and costly process. Traditional methods require up to 12 years. Economists have noted that any innovation that reduces the variety development time span, or "time to market (TTM)," could have large economic benefits, due to lower costs and earlier adoption of economically significant wheat varieties.

Doubled haploid (DH) technology is a method of using biotechnology to reduce variety development time. Doubled haploids are genetically pure inbred plants, now produced in a single year. Traditional wheat selection techniques typically require six to eight generations to stabilize desired traits, or fix the desired characteristics of higher yield, quality characteristics, disease resistance, or agronomic features into "pure lines" of wheat varieties. Doubled haploids allow wheat breeders to stabilize desired traits in a single year, reducing the time required for new variety development by up to five years. Doubled haploid laboratories are currently used in Europe, Canada, and Australia (Bonjean and Angus, 2001). Doubled haploid production is a form of biotechnology, but is not transgenic biotechnology, and is therefore unlikely to be subject to the resistance among some wheat producers and nations.

Recently, Heartland Plant Innovations (HPI), a public/private partnership, has made plans for the construction of a doubled haploid laboratory in Manhattan, Kansas to be used by public and private wheat breeders. This research analyzed the economic impact of the adoption and use of biotechnology in wheat variety development. A careful study of economic costs and benefits of the new laboratory was conducted, with several measures of financial return estimated. This analysis of the impact of doubled haploids on wheat markets was estimated to find the economic benefits and costs to wheat producers and consumers in Kansas, the United States, and the rest of the world. Doubled haploid methods do not replace traditional wheat breeding programs. Rather, they enhance one component of variety development: propagation of a new variety.

The use of doubled haploids in wheat variety development is timely, interesting, and important for a number of reasons. First, the potential economic benefits of a shortened variety development process are large. Nalley, Barkley, and Chumley (2008) estimated genetic improvement in Kansas wheat varieties to average 0.206 bushels per acre each year. This corresponds to approximately two to three million U.S. dollars of additional revenues from wheat production in Kansas attributable to wheat breeding programs. Yield increases are permanent and cumulative, so after a short number of years, the economic benefits to higher-yielding wheat varieties are large and significant. Adoption of doubled haploid techniques would boost yields much sooner than conventional methods, resulting in immediate increases in economic benefits and large cumulative financial gains to wheat producers in Kansas and wheat consumers worldwide. Although the

genetic gains from a wheat breeding program are permanent and cumulative, they are subject to pathogens, diseases, and other challenges that require plant varieties to be constantly improved through maintenance breeding.

Second, the development and adoption of biotechnology in wheat production is likely to grow rapidly in the near future, and careful description and estimation of the economic impacts is needed to better understand the impact of large, rapid technological advance in wheat (Fuglie and Walker 2001). Third, the economics of the introduction of biotechnology in general, and a doubled haploid laboratory in particular, are timely and important. As new techniques are discovered and implemented, the application of economic principles to the technological change allows for a more rapid and efficient transition out of traditional breeding methods to the use of biotechnology in wheat variety development. It is likely that doubled haploid methods will become more efficient as wheat breeders enhance their use of doubled haploids in wheat breeding programs in the near future.

One major contribution of this study is a detailed description and model of wheat variety development, including careful consideration of the timing and costs of investments in wheat breeding. A standard financial model of discounted future costs and revenues is estimated to accurately forecast three financial measures: (1) the benefit/cost ratio, (2) net present value, and (3) internal rate of return for the construction of the double haploid laboratory. Extensive sensitivity analyses were conducted to gain a better understanding of the impact of model parameter assumptions. Although the proposed DH laboratory is likely to produce pure line wheat seeds for wheat breeders throughout the United States, the study used Kansas as the baseline geographical unit of analysis, due to data availability and to provide a conservative estimate of the potential economic impacts of a DH laboratory.

The use of biotechnology in corn and soybeans has become nearly universal, setting the stage for biotechnology in wheat to increase rapidly in the next few years. The economic impact will be large and significant, as it has been in other crops. By quantifying the dollar value of these changes, the magnitude of rapid technological change is measured and assessed. The details of doubled haploid technology are particularly interesting. Corn pollen is used to pollinate wheat, resulting in new wheat seeds that are genetically pure and stable, each retaining a unique combination of genes carried on their parents' chromosomes. A description of this process is illuminating, since it represents a major technological breakthrough in crop production. This application of biotechnology provides economists and social scientists with a broader knowledge of recent advances in biology and biotechnology and the implications.

Background and Previous Literature

Wheat Breeding Techniques

Wheat is a grass that was originally grown in Mesopotamia, and has been cultivated by humans for 10,000 years. Wheat breeding has been practiced for millennia, as summarized by Baenziger and DePauw (2009). Acquaah (2007) provided an excellent overview of the history of plant breeding and genetics. Baenziger and DePauw (2009) and Baenziger et al. (2009) described and evaluated five methods of wheat breeding: (1) pedigree selection, (2) bulk selection, (3) single-

seed descent, (4) doubled haploid (DH), and (5) the backcross method. Baenziger and DePauw (2009) concluded, "Each method has its advantages and disadvantages. Wheat breeding is remarkably flexible, and these methods are often combined in practice to take advantage of their strengths and the selection environments that occur during cultivar development" (p. 275). Wheat breeding is both a public and private sector activity, becoming more private over time. It should be emphasized that wheat breeders are best served by using a variety of breeding methods. Forster and Thomas (2005) concluded, "We do not expect DH production to replace traditional breeding methods; rather it will provide greater efficiency and new options" (p. 80). Specifically, several wheat breeders interviewed for this project indicated that DH techniques are particularly useful when used together with molecular markers (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011).

The Doubled Haploid method generates homozygous lines from haploid tissue (Baenziger and DePauw, 2009, p. 291), by doubling chromosomes, resulting in a plant that is completely homozygous and homogeneous (Guzy-Wrobelska and Szarekjo, 2003). Laurie and Bennett (1988) described the wheat-by-maize system of doubled haploidy. In this procedure, embryo rescue methods are used to propagate haploid tissue through chromosome elimination in wide crosses when the endosperm does not form. Baenziger and DePauw (2009) concluded that, "Doubled haploidy is an expensive method but requires the least amount of time to develop inbred lines, especially when breeding winter wheat, where the vernalization requirement slows single-seed descent breeding" (p. 291). Importantly, the authors go on to state, "If past history repeats itself, the methods to create doubled haploids will become less expensive and will feature fewer culture-induced variants" (p. 292).

Henry and de Buyser (1990), Picard et al. (1990), and more recently Kasha and Maluszynski (2003), provided excellent overviews of doubled haploid production, and Forster et al. (2007) described recent technological innovations that have brought about a resurgence in haploidy in higher plants. Bonjean and Angus (2001) contributed extensive evidence for doubled haploid use in wheat breeding programs throughout the world, including the United Kingdom, Poland, Denmark, Romania, Brazil, Mexico, New Zealand, Japan, Nepal, and Iran. The authors also provided a thorough technical description of DH methods.

Baenziger and DePauw (2009) emphasized the efficiency of DH wheat breeding is recovery of mutants (p. 292). Most importantly, the authors described enhanced efficiency by using DH and molecular markers in conjunction: "…using molecular markers in selection becomes more efficient because the heterozygous lines have been removed" (p. 292). Baenziger and DePauw (2009) provided a list of successful DH wheat cultivars that have been released and grown commercially (p. 292). Lastly, Forster and Thomas (2005) noted that, "Doubled haploidy has great potential in the production of transgenic crops," and “The most important considerations for [DH] breeders are: investment in good plant production facilities, tissue culture facilities and skilled technical support, and the availability of cheap, efficient, genotype independent protocols" (p. 80).

Forster and Thomas (2005) provided an excellent review of doubled haploids in plant breeding. The authors concluded that, "The rapid attainment of homozygosity at any generation is probably the most valuable feature of doubled haploidy for plant breeding" (p. 72). A second benefit is

the development of large numbers of homozygous lines. Forster and Thomas (2005) summarized the use of doubled haploidy: "Despite proven and theoretical benefits of doubled haploidy, deployment in breeding programs must be practical, cost efficient, satisfy breeding objective, and produce marketable cultivars" (p. 72). Two potential downsides of DH were also mentioned: (1) "Although doubled haploidy is useful in fixing rare alleles, overuse may reduce genetic variation in breeding germplasm in which generic diversity may be better preserved in heterozygous lines" (p. 72), and (2) "The application of doubled haploidy, even in the most responsive species, is restricted by gentotype dependency and there is a challenge to develop more genotype independent methods… care will be needed to prevent erosion of the breeder's gene pool" (Forster and Thomas, 2005, p. 80). The authors concluded that, "Doubled haploidy not only offers an opportunity to speed up traditional breeding methods, but allows greater flexibility in that it can be applied at any generation, allowing rapid response to changing market demands" (p. 74).

Because doubled haploid production methods are labor-intensive, and thus costly, recent research has focused on the attempt to make doubled haploid methods more efficient. Liu et al. (2002) aimed to develop a more efficient and effective isolated microspore culture system for generating double haploid wheat plants, and Ravi and Chan (2010) reported a method of generating double haploid seeds by manipulating a single centromere protein. The efficiency of the doubled haploid methods can overcome the potential negative characteristics of single-seed descent include time delays and competitive interactions between plants (Forster and Thomas, 2005, p. 74).

The use of DH techniques is complementary to traditional, or conventional, wheat breeding programs. The DH production methods could substitute for, or replace, the propagation component of a wheat breeding program, while other major features of a traditional wheat breeding program would remain the same. The economic analysis presented below is for the inclusion of a DH program into the longstanding wheat breeding program; the DH laboratory does not replace the entire program. In particular, a DH program will need to use new germplasm introduced from conventional selection methods to maintain genetic diversity of the wheat industry. The economic benefits of the DH program will remain with the wheat breeders, wheat producers and consumers and the distribution of the benefits between these groups is beyond the scope of the current research.

Over the past 25 years, it has become increasingly common for retail seed prices to include royalties or other license fees payable to the owners of proprietary traits or other genetic technologies that have been incorporated into the seeds' heredity Such payments have become standard for corn and soybeans, although they are just beginning to appear in wheat. Licensed, proprietary traits are just becoming available for wheat. For wheat seeds, royalties are currently being paid in many regions to public sector breeding programs in connection with the use of varieties released from those programs. Generally, these royalties are being charged for use of the base genetics of the variety, not for the proprietary traits. For the program described in this paper, no royalties are due simply for using doubled haploids in breeding a new variety, it is simply a fee-for-service technology. However, using DH lines can greatly accelerate the incorporation of proprietary traits in a new variety, which may result in a variety for which royalties are due and payable. Farmer acceptance of such royalty payments will continue to depend on the value proposition linked to the technology in question. Where farmers have seen a net financial bene-

fit, royalty payments have gladly been made. It remains to be seen how common royalty-bearing proprietary traits will become in wheat.

An Economic Model of Wheat Breeding

The measurement of the economic impact of agricultural research has a large literature, as summarized by Huffman and Evenson (1993) and Alston, Norton, and Pardey (1995). Blakeslee and Sargent (1982) and Feyerharm et al. (1984) developed an economic framework for the quantification of the economic impact of public research and extension in wheat production. Brennan (1984, 1989a) summarized and measured the impact of the Australian wheat breeding program, providing the foundation for a large literature that has continued this work, using his original research as a template. Brennan's (1989b) work in developing a schematic approach to wheat breeding is particularly important to the model developed here. Byerlee and Traxler (1995) extended Brennan's work by consideration of international wheat breeding improvements since the Green Revolution.

The Kansas wheat breeding program has been evaluated by Barkley (1997) and Nalley, Barkley, and Chumley (2006, 2008). This previous literature demonstrated a large and statistically significant positive impact of the Kansas Agricultural Experiment Station (KAES) wheat breeding program on wheat yields, and thus producer revenues, for producers who purchase and grow varieties developed by the KAES. This research uses the quantitative estimates from Nalley, Barkley, and Chumley (2008) to derive the economic implications of the proposed DH laboratory on the Kansas wheat industry. "During the 'new age' of wheat breeding (1977-2006), wheat breeding alone is found to have increased yields by 6.182 bushels per acre, or an average increase of 0.206 bushels per year" (Nalley, Barkley, and Chumley, 2008, p. 913).

One of the most important considerations in this analysis is the "time to market," (TTM) of a wheat variety, developed under two possible methods: (1) conventional, and (2) doubled haploid. Interviews with wheat breeders in both private and public programs were conducted to gain a better estimate of the development times for wheat varieties. Wheat breeder interviews (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011) provided an average number of years for development for both conventional (11 years) and doubled haploid (7 years) wheat breeding programs (Table 1).

The baseline, "Scenario One" is a representative, or "average," length of time for winter wheat variety development, from initial cross of a new variety to public release. To account for variation in wheat breeding programs, we will also consider a "long" wheat varietal development time (Scenario Two, Table 1), and a "short" development time (Scenario Three, Table 1). The development time of a new wheat variety using conventional methods requires 11 years ($t_{con} = 11$). It is assumed that there are costs for 11 years, followed by a stream of revenues earned by wheat producers after the release of the wheat variety in year 11 (Figure 1). The illustration is simplified by assuming constant costs for 11 years, followed by constant revenues for all years after the release of the wheat variety in year 11. This simple schematic diagram captures the main features of the wheat breeding program, although the real world is much more complicated, with several new varieties being developed simultaneously, and fluctuations in cost and revenue streams based on changing economic conditions.

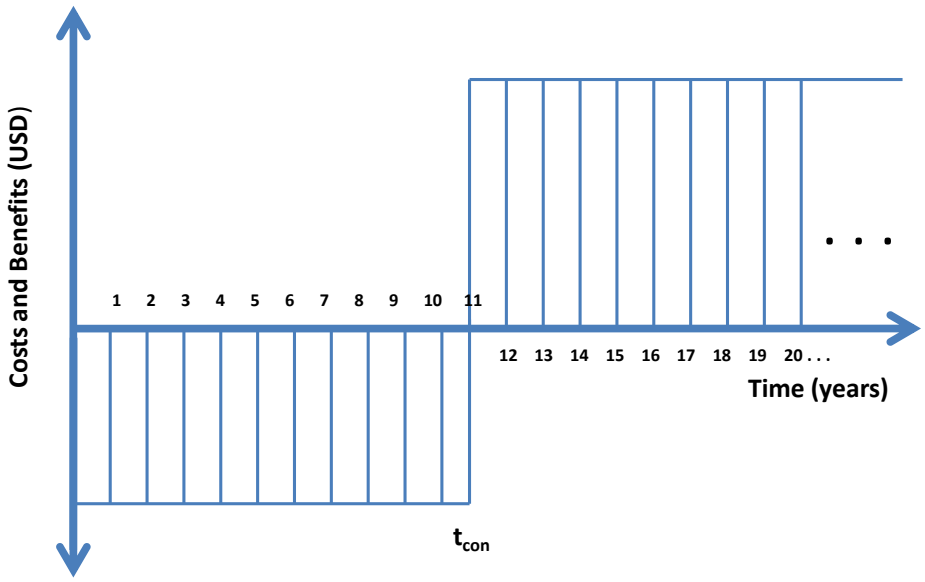

Figure 1. Economic Benefits and Costs of Conventional Wheat Breeding
One Variety, Eleven Year Development Time (t_{con} = 11)

t_{con} = development time (time to market, TTM), of new wheat variety using conventional breeding assumed to equal 11 years (Table 1)

Costs include all of the costs of maintaining the wheat breeding program, including labor, buildings, tools, and equipment, as reported for the period 1977-2006 by Nalley, Barkley, and Chumley (2008). These costs averaged approximately 5 million USD, in constant 2006 dollars. The economic gains, or revenues, that are attributable to the wheat breeding program are calculated (equation 1), following Nalley, Barkley, and Chumley (2008).

(1) $REV_t = A_t * P_t * KAES_t * GEN_t$ (mil USD) = (mil acres)*(USD/bu)*(%)*(bu/acre)

Table 1. Wheat Variety Development Time for Conventional and Doubled Haploid Methods.

Organization	Breeder	Conventional (years)	Doubled Haploid (years)
Pioneer Hi-Bred	Greg Marshall	12	8
Westbred/Monsanto	Joseph Shapiro	12	9
Agripro/Syngenta	Rollin Sears	11	6
Kansas State University	Allan Fritz	10.5	6.5
Colorado State University	Scott Haley	9.5	7
Washington State University	Michael Pumphrey	8	6
Scenario One: Baseline		11	7
Scenario Two: "Long"		12	9
Scenario Three: "Short"		8	6

Source. Telephone interviews and e-mail correspondence with wheat development experts, January 25 through February 7, 2011 (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011).

Units for each variable in the equation are reported in parentheses following the equation. The variable REV_t is defined as revenues in year t, and A_t is acres planted in the geographical area under investigation (Kansas). The variable P_t is the average market price of wheat in United States Dollars per bushel (USD/bu). The variable $KAES_t$ is the percent of Kansas wheat acres planted to varieties produced by the KAES, and GEN_t is the annual rate of genetic gain due to the wheat breeding program, holding constant all other factors such as weather, input use, soil quality, etc. Several features of the revenue calculations deserve emphasis.

First, implicit in the model are the simplifying assumptions that the rate of genetic gain and the rate of varietal adoption are constant over time. The rate of genetic gain represents a constant average for the period 1977-2005. This rate is likely to change in the future, due to diminishing returns to wheat variety selection, unforeseen developments in wheat breeding, and the variable rate of varietal discovery and release. However, given that the future is uncertain, the approach taken here is to assume that the best forecast of the future rates of genetic gain and varietal adoption are the same as the past, with numerous sensitivity analyses conducted to account for unforeseen changes.

The prices are constant, adjusted for inflation, to eliminate the impact of rising general price levels on the dollar value of the program. All prices in the analysis below are presented in constant 2010 USD. Next, the revenues attributable to the KAES estimated using this equation are a conservative estimate, since KAES varieties are planted outside of the state of Kansas. These acres are ignored, not because they are not important, but because of data availability. Wheat varieties developed by KAES are widely grown throughout the Southern Great Plains region. Thus, the dollar values of revenues reported here are underestimates of the actual value of the KAES program. The measure of genetic gain (GEN_t) is taken from Nalley, Barkley, and Chumley (2008), and is equal to 0.206 bu/acre, representing the annual increase in yields due to the KAES wheat breeding program, holding all other wheat yield determinants constant.

Summary statistics were calculated for the economic variables of the Kansas wheat industry (Table 2), reported for three time periods; (1) 1977-2006, (2) 2001-2010, and (3) 2006-2010. This analysis uses the average values for the five-year time period of 2006-2010 to reflect the most current data available. These data also reflect smaller numbers for Kansas harvested acres (column one), percent Kansas acres in KAES varieties (column two), and percent Kansas acres in all public varieties (column three). The price of wheat is higher in the selected period, due to the unprecedented high commodity prices that have occurred since 2008 due to biofuels, income growth in low-income nations such as China and India, and poor weather in agricultural regions.

The wheat breeding program data (Table 2) are used to estimate the value of the KAES wheat breeding program on an annual basis. This research aims to estimate the economic value of the proposed doubled haploid laboratory to be located in Manhattan, Kansas. To do this, we extend the simple model of a wheat breeding program (Figure 1) with a model of the impact to include a DH lab on such a program (Figure 2). There are two impacts of the adoption and use of DH methods on a wheat breeding program. First, the wheat variety development time, or time to market (TTM), can be reduced significantly (Table 1). Second, the annual rate of genetic gain (GEN_t) can be enhanced due to efficiency gains of the DH method, through molecular markers and other techniques that allow DH to enhance the rate of growth in wheat yields. We will con-

sider both potential impacts of DH methods of a wheat breeding program. The first impact is reduced development time (Figure 2). The variable t_{con} is defined as the development time (time to market, TTM), of new wheat variety using conventional breeding methods, assumed to equal 11 years. The variable t_{dh} is defined to be the development time (time to market, TTM), of new wheat variety using doubled haploid (DH) breeding methods, assumed to equal 7 years. These two times are the baseline scenario, based on the interviews results (Table 1).

Table 2. Summary Statistics of Kansas Wheat Breeding Program Variables, 1977–2010.

Period	Kansas Harvested Acres[1] (acres)	% Kansas acres in KAES Varieties[2] (%)	% Kansas acres in Public Varieties[2] (%)	Kansas Wheat Price[1,3] ($/bu)	Annual Genetic Gain[4] (bu/acre)	Value of Kansas Wheat[1,3] (mil USD)	KAES Wheat Breeding Annual Costs[1,3] (mil USD)
1977-2006	10,373,333	53.1	69.9	5.93	0.206	2,029	5.41
2001-2010	8,780,000	50.3	61.4	4.73	0.206	1,610	8.34
2006-2010	8,680,000	38.4	50.0	5.77	0.206	1,916	8.34

[1] USDA/NASS, *Kansas Farm Facts*.
[2] Author calculation, based on USDA/NASS, *Wheat Varieties*.
[3] Dollar values are in real 2010 USD, deflated by the Personal Consumption Expenditure (PCE) of Department of Commerce, Bureau of Economic Analysis (USDC/BEA).
[4] Nalley, Barkley, and Chumley (2008).

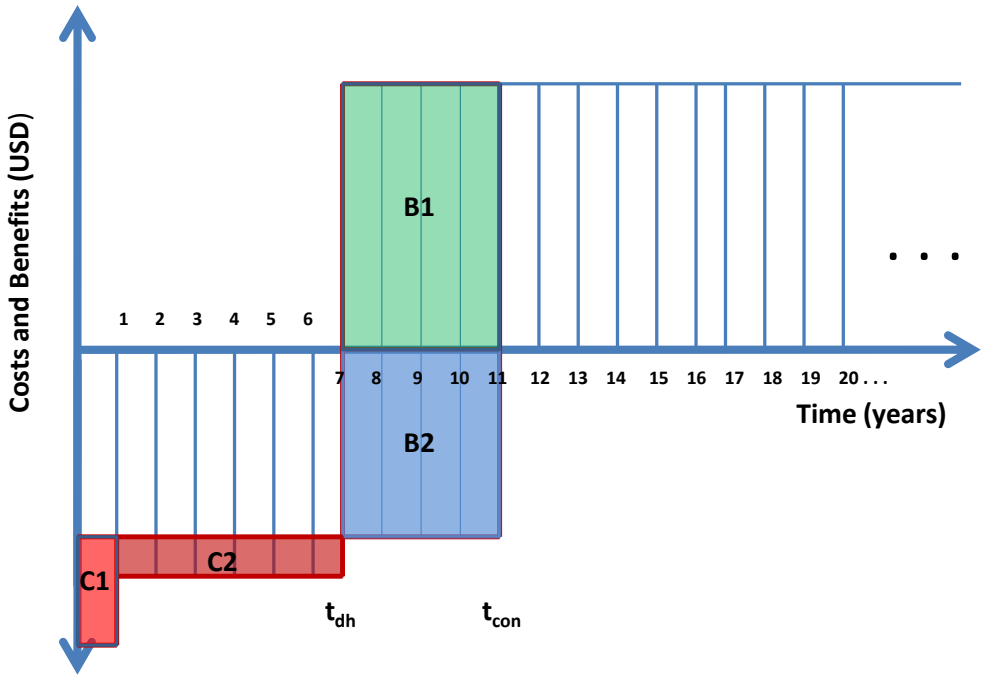

Figure 2. Economic Benefits and Costs of Coventional and Double Haploid Wheat Breeding. One Vareity, Seven Year Development Time (t_{dh} =7)

B1 = Increased revenues from sale of wheat variety four years sooner than conventional (t_{con}-t_{dh} = 4)
B2 = Decreased wheat variety development costs from earlier release date (t_{con}-t_{dh} = 4)
C1 = Initial costs of building doubled haploid laboratory, estimated to be equal to 6 m USD
C2 = Annual operating costs of doubled haploid laboratory, estimated to be equal to 1 m USD

t_{con} = development time (time to market, TTM), of new wheat variety using conventional breeding assumed to equal 11 years (Table 1)
t_{dh} = development time (time to market, TTM), of new wheat variety using doubled haploid breeding assumed to equal 7 years (Table 1)

The reduction in varietal development time (t_{con}-t_{dh} = 4) has significant economic impacts on the wheat breeding program, by reducing costs and increasing revenues. Area B1 (Figure 2) represents increased revenues from the sale of a new wheat variety four years sooner than conventional methods would allow, and area B2 represents decreased costs of wheat variety development resulting from an earlier release date. Much of the analysis reported here is the measurement and evaluation of areas B1 and B2 using the best estimates available. The costs of the DH laboratory are disaggregated into two types: (1) building costs ($BUILDC_t$, C1), and (2) annual operating costs ($ANNUALC_t$, C2, equation 2).

$$(2)\quad C_t = BUILDC_t + ANNUALC_t \qquad \text{(mil USD) = (mil USD) + (mil USD)}$$

Area C1 (Figure 2) represents the initial, one-time, costs of building a doubled haploid laboratory. These costs are estimated to be equal to 6 million USD. The area C2 represents the recurring annual operating costs of the proposed doubled haploid laboratory, estimated to be equal to one million USD per year. Recall that the DH laboratory does not replace the traditional wheat breeding program, but enhances the variety propagation component of the program. The economic model of the adoption and use of a DH laboratory (Figure 2) emphasizes the large gains in both (1) cost savings in reduced development time, and (2) increased revenues resulting from the earlier release of a new, higher-yielding, wheat variety. The models developed above are for a single variety. In a real-world wheat breeding program, these models must be expanded to accommodate continuous advances in wheat varieties, resulting in cumulative gains over time. This more realistic scenario is incorporated into the model (Figure 3).

This more realistic model (Figure 3) demonstrates the forecasted future agronomic impact of the KAES wheat breeding program, for both the conventional breeding program and the possibility of the program with a DH laboratory, for the next 15 years. The current conventional breeding program provides genetic gains equal to 0.206 bu/year (Nalley, Barkley, and Chumley 2008). This rate isolates the impact of genetic advances on yield, holding all other factors constant in a multiple regression framework. If the DH laboratory were to be built in 2011, a new variety could be released seven years later (in 2018), with increased yield potential. One way to think of this discrete jump in future yields is that the new DH variety released in 2018 would have the same genetic potential as varieties released by the conventional wheat breeding program four years later, in 2022, assuming no increase in genetic gain efficiency. However, the illustrated gain is likely to be larger, since it includes the possibility of enhanced efficiency of wheat variety development.

The large discrete change in 2017 reflects the first benefit of the use of Doubled Haploids in wheat breeding. The second benefit is enhanced rate of genetic gain, which is captured by the steeper slope of the yield trend for the DH laboratory case. The graph is drawn assuming that the rate of change in yield potential is 150 percent greater with the use of Doubled Haploids, relative to the baseline scenario of the conventional breeding program. This rate of change is based on wheat breeder interviews (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011), further discussed below. The analysis proceeds in the next section with the careful measurement of costs and benefits, and quantification of several summary financial measures.

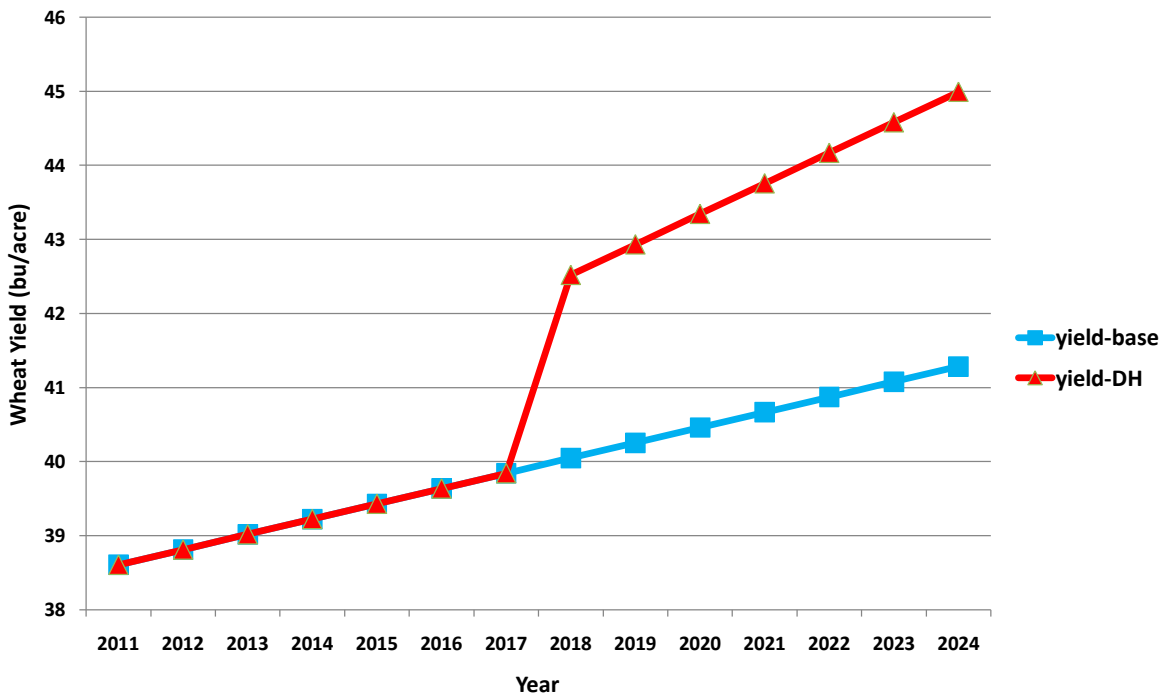

Figure 3. Comparison of Conventional and Double Haploid Wheat Variety Development: Agronomic Benefits. Seven Year Development Time, Increase in Genetic Gain

Research Methodology: Cost-Benefit Analysis

The purpose of this analysis is to estimate the economic impact of the proposed doubled haploid laboratory in monetary terms. The major financial performance indicators that are estimated below include: (1) Net Present Value (NPV), (2) Benefit-Cost Ratio (BCR), and (3) Internal Rate of Return (IRR). The Net Present Value (NPV) is defined as the sum of the present values (PVs) of individual cash flows from a project or business. The NPV summarizes the total discounted economic value of a project (equation 3). Net Present Value is a preferred method of evaluation because it considers the time value of money (Kay et al. 2012), where B represents dollar benefits, C represents costs, i is the "discount rate," assumed to equal ten percent, t is the time period (year), and T is the ending year of the analysis.

$$(3)\ NPV = \Sigma B/(1+i)^t - \Sigma C/(1+i)^t, \quad t = 0, \ldots, T$$

The Benefit-Cost Ratio (BCR) is a financial indicator that attempts to summarize the overall monetary value of a project or proposal (Kay et al. 2012). A BCR is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms. All benefits and costs are expressed in discounted present values (equation 4). The variables are as defined above for NPV.

(4) $BCR = [\Sigma B/(1+i)^t] / [\Sigma C/(1+i)^t], \quad t = 0, \ldots, T$

The Internal Rate of Return (IRR) is a measure of the financial rate of return of a project or proposal, where given the (period, cash flow) pairs (n, Cn) where n is a positive integer, the total number of periods N, and the net present value NPV, the internal rate of return (IRR) is given by r in:

(5) IRR: $NPV = \Sigma B/(1+r)^t - \Sigma C/(1+r)^t = 0, \quad t = 0, \ldots, T$

The IRR provides information that is not available from either BCR or NPV, since it estimates an actual rate of return comparable to other financial investments (Kay et al. 2012, p. 319).

The financial performance measures described above are used together with the economic model of a proposed doubled haploid laboratory (Figure 2) to estimate the economic impacts of the proposed laboratory. The overall benefits and costs of the proposed doubled haploid laboratory are captured in the areas C1, C2, B1, and B2 (Figure 2), and are estimated using the formulae for benefits (equation 1) and costs (equation 2).

Variables Used in the Cost-Benefit Analysis

Building costs ($BUILDC_t$) are assumed to be six million constant 2010 US dollars, an upper estimate of costs at the time of this study (Table 3). Annual costs of operating the laboratory ($ANNUALC_t$) are assumed to be one million constant 2010 US dollars, also considered to be an upper estimate (Table 3). Since the cost estimates are likely to be higher than actual costs, the resulting financial measures are conservative estimates, erring on the side of higher costs and lower revenues, to provide conservative estimates of the financial performance measures.

Following Barkley (1997) and Nalley, Barkley and Chumley (2006, 2008), revenue estimates were made for Kansas only, due to data availability, and to provide a conservative estimate of the economic gains resulting from the proposed doubled haploid laboratory. The revenue estimates were calculated (equation 1), with assumed parameter values (Table 3). The data for harvested wheat acres in Kansas, percent acres planted with KAES varieties, and wheat prices are for the 2006-2010 period. The trend is toward lower use of public wheat varieties, including KAES varieties (Table 2). Therefore, the “baseline” and “low” scenarios for percent Kansas acres in KAES varieties is likely to be appropriate in the future. The values used in the analysis are mean (average) values for this most recent five-year period. This method incorporates the most up-to-date data, but eliminates extreme values by averaging, or "data smoothing."

Table 3. Assumed Parameter Values of Model Variables.

	- - - - - - - *Assumed Parameter Values*- - - - - - - - -		
	Low	**Baseline**	**High**
2006-2010 Kansas Wheat Averages			
Kansas Harvested Acres (million)[1]	8.00	8.68	10.00
% Kansas acres in KAES varieties[2]	25.00	38.40	50.00
Wheat Price (2010 USD)[3]	3.27	5.77	7.07
Annual Genetic Gain [4]			
Conventional	0.206	0.206	0.206
Doubled Haploid	0.206	0.309	0.412
Time and Discount Parameters			
Discount rate	0.075	0.100	0.125
Time Horizon (years)	25	50	100
Doubled Haploid Laboratory Expenditures			
Building costs, one year (m 2010 USD)	5	6	10
Annual Operating Costs (m 2010 USD)	0.5	1.0	2.0
Variety Development Time			
Conventional	8	11	12
Doubled Haploid	6	7	9

[1] The high value occurred in 2003, the lowest recent value was 8.4 million acres in 2010.
[2] The high value is the percentage of Kansas acres in all public varieties (Kansas, Oklahoma, Texas, Nebraska, and Colorado) over the five-year period 2006-2010, the low value is one-half of the high value.
[3] Marketing year average price; low value from 2001, high value from 2008.
[4] The low value represents a constant rate of annual genetic gain for both conventional wheat breeding and doubled haploid (DH) wheat breeding, taken from Nalley, Barkley, and Chumley (2008). The baseline value represents 150% faster annual genetic gain for DH methods, and the high value represents 200% faster annual genetic gain for DH methods.

The baseline scenario represents the most accurate estimate of each of the parameters used in the analysis. To gain a deeper understanding of how financial measures change when agronomic and economic conditions change, two additional scenarios were estimated, in which all model parameters are assumed to take on "low" and "high" values, allowing for analysis of how robust our financial estimates are to unexpected changes in parameter values. The values of each of the three scenarios were calculated (Table 3), given the selected "high" and "low" scenario values (Table 3).

The assumed value for annual genetic gain is taken from Nalley, Barkley, and Chumley (2008). For conventional wheat breeding methods, the value is assumed to remain the same as was estimated for the period 1977-2006 (0.206 bushel per acre per year). As described in the description of the doubled haploid method of wheat breeding above, wheat breeders believe that the annual rate of genetic gain will increase when doubled haploid methods are available and adopted, particularly when used with molecular markers. This enhanced rate of gain in Kansas wheat yields is assumed to be equal to 150 percent in the baseline rate, and 200 percent in the "high"

scenario. The "low" scenario uses the conventional wheat breeding rate of genetic gain (0.206 bushels per acre per year, Table 3). This represents the case where there are no changes in the rate of genetic gain between conventional and doubled haploid wheat breeding methods, an extreme and unlikely case. However, if the rate of genetic advance slows due to diminishing returns in wheat variety selection, the “low” scenario could reflect that possibility. These rates of change are based on correspondence with wheat breeders (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011), and do not reflect any actual measurement. However, the range between zero and 200 percent increase in the rate of annual genetic gain certainly captures the true range that will occur when the doubled laboratory becomes operational.

The financial analysis assumes values of a 50-year time horizon and a discount rate of ten percent. Both parameters are altered in the "high" and "low" scenarios to provide a range of possible financial performance measures, representing the likely economic impact of a doubled haploid laboratory under a wide variety of economic conditions. Note that all genetic contributions in wheat breeding are permanent and cumulative. Thus, even if the DH technology is replaced or becomes obsolete in the future time period under considerations, the benefits will continue to accumulate. The varietal development times (Table 3) were provided by the interviewed wheat breeders (Fritz 2011; Haley 2011; Marshall 2011; Pumphrey 2011; Sears 2011; Shapiro 2011).

Baseline Results

The baseline results represent the most likely outcome of the proposed doubled haploid laboratory. The financial results are strong: the Net Present Value (NPV) equals 173 million 2010 USD, and the benefit-cost ratio (BCR) is over 11 (Table 4). Restated, the overall financial value of the proposed double haploid laboratory is approximately 173 million constant 2010 US dollars, and for every dollar invested in the laboratory, over 11 dollars are returned to the Kansas wheat economy.

Table 4. Model Results: Variety Development Time.

	Scenario		
	Short	**Baseline**	**Long**
Conventional	8	11	12
Doubled Haploid	6	7	9
Net Present Value (NPV)[1]	155.091	173.286	125.234
Benefit Cost Ratio	10.169	11.245	8.404
Internal Rate of Return	0.341	0.334	0.267

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent.

The baseline internal rate of return (IRR) equals 0.334, indicating a high return on the doubled haploid laboratory investment. The wheat breeding industry is highly competitive, with both public and private breeders using similar techniques, methods, and genetic stock. Therefore, these high returns are unlikely to result in large financial gain to wheat breeding programs. Rather, the wheat seed industry and wheat producers are likely to gain from wheat varieties with higher yields. Wheat consumers are also likely to gain from reduced costs of wheat products. One major result of applying economic analysis to technological change is that the public wheat seed

industry will be able to remain viable and compete with private wheat breeders if they build and adopt the doubled haploid laboratory. In contrast, the public wheat breeding industry is likely to be at a major disadvantage if it does not build and use a DH laboratory (Figure 3). Since the per-unit costs of using the DH lab are not significant, the use of DH will allow public and private wheat breeders to use the technology equally.

One interviewed private wheat breeder said, "We will get further, faster using DH in wheat variety development" (Shapiro). Given the significant decrease in wheat variety development times associated with DH methods, any wheat breeding program that does not use DH techniques is likely to be unable to compete with programs that use the new technology.

Financial performance measures were also estimated for "short" and "long" scenarios (Table 4). These results indicate that the overall economic gains of the doubled haploid laboratory are robust to differences in projected wheat development times. Therefore, under the most likely laboratory conditions, the internal rate of return (IRR) varies between 26 and 34 percent, and the benefit-cost ratio (BCR) varies between 8.4 and 11.2. The proposed doubled haploid laboratory would provide significant economic benefits for all of the wheat breeding programs that use it, even if their specific use, breeding methods, and variety development times vary (Table 4).

Sensitivity Analysis

The results demonstrate that the proposed laboratory is likely to be a financial success under a very wide range of possible situations and events.

Kansas Wheat Acres and Price

Sensitivity analyses were conducted for possible fluctuations in economic variables. Results indicate that the financial performance indicators remain positive under a wide range of three variables: (1) Kansas wheat acres planted, (2) percentage of Kansas wheat acres planted to KAES varieties, and (3) wheat prices (Table 5). The internal rate of return varies between 0.266 and 0.367 under a wide variety of assumed parameter values. Under virtually any foreseeable circumstances, the doubled haploid laboratory is highly likely to provide economic rates of return much higher than could be obtained in alternative investments.

Annual Genetic Gain

One of the important assumptions of the model developed and estimated here is the potential rate of increase of the rate of genetic gain in wheat varieties due to the discovery, introduction, and adoption of doubled haploid methods for the wheat seed industry. Wheat breeders indicated in interviews that the use of double haploid techniques is highly likely to increase the upward trend in yields of newly released wheat varieties. To capture a wide range of possible rate increases in wheat yields, three scenarios were considered: (1) a "low" scenario, where the rate of change in genetic gain remains constant when doubled haploid methods are used, (2) a "baseline" scenario, where the rate change increases by 50 percent, from 0.206 bushels per acre per year to 0.309 bushels per acre per year, and (3) a "high" rate of genetic gain, assumed to be equal to 200 percent, increasing the rate of genetic gain from 0.206 to 0.412 bushels per acre per year (Table 6).

Table 5. Model Sensitivity Results: Kansas Wheat Acres and Price.

	Scenario		
	Low	**Baseline**	**High**
Kansas Harvested Acres (mil)	8.000	8.680	10.000
Net Present Value (NPV)[1]	158.386	173.286	202.211
Benefit Cost Ratio	10.364	11.245	12.955
Internal Rate of Return	0.323	0.334	0.351
% Kansas acres in KAES varieties	25.00	38.40	50.00
Net Present Value (NPV)[1]	106.914	173.286	230.743
Benefit Cost Ratio	7.321	11.245	14.641
Internal Rate of Return	0.282	0.334	0.367
Wheat Price (2010 USD)	3.27	5.77	7.07
Net Present Value (NPV)[1]	90.959	173.286	216.316
Benefit Cost Ratio	6.377	11.245	13.789
Internal Rate of Return	0.266	0.344	0.360

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent.

Table 6. Model Sensitivity Results: Annual Genetic Gain.

	Scenario		
	Low	**Baseline**	**High**
Annual Genetic Gain			
Conventional	0.206	0.206	0.206
Doubled Haploid	0.206	0.309	0.412
Net Present Value (NPV)[1]	59.655	173.286	286.917
Benefit Cost Ratio	4.527	11.245	17.962
Internal Rate of Return	0.263	0.334	0.378

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent.

The results for the "low" scenario (Table 6) are important to consider. Even if the rate of genetic gain were to remain unchanged, the economic impact of the proposed doubled haploid (DH) laboratory remains positive and large. In this case, the use of DH methods provides large, positive economic returns, including a new present value (NPV) equal to nearly 60 million constant 2010 US dollars, a benefit-cost ratio (BCR) of 4.5, and an internal rate of return (IRR) equal to over 26 percent. We can conclude that any positive increase in the value of genetic gain forthcoming from the adoption of doubled haploid methods will contribute large economic gains to the Kansas wheat industry. If the rate of genetic gain were to double ("high" scenario, Table 6), then the financial indicators are truly impressive, reflecting a large technological shift in the ability of land, labor, and other inputs to produce grain.

Time and Discount Parameters

Cost-benefit analysis requires that future dollars be appropriately discounted to account for the "time value of money." Two assumptions that need to be made are: (1) the appropriate "discount rate," or rate that future dollars are valued relative to current dollars, and (2) the length of the "time horizon," or how many future years are to be incorporated into the project. The results demonstrate that the financial outcomes of the estimated model are robust to a wide range of assumed parameter values of the discount rate and the time horizon (Table 7). The net present value (NPV) varies from a low of 105 million constant US dollars (high scenario) to a high of over 300 million constant 2010 USD (low scenario, Table 7) under changes in the discount rate, and the benefit-cost ratio varies between 8 (baseline scenario) to 16 (low scenario). However, the large, positive levels of each of the three financial indicators under the range of assumed values provides some evidence that the proposed doubled haploid laboratory is a solid investment opportunity.

Table 7. Model Sensitivity Results: Time and Discount Parameters.

	Scenario		
	Low	**Baseline**	**High**
Discount rate	0.075	0.100	0.125
Net Present Value (NPV)[1]	301.211	173.286	105.470
Benefit Cost Ratio	16.080	11.245	8.042
Internal Rate of Return	0.334	0.334	0.334
Time Horizon (years)	25	50	100
Net Present Value (NPV)[1]	115.324	173.286	183.662
Benefit Cost Ratio	8.173	11.245	11.804
Internal Rate of Return	0.332	0.334	0.334

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent

Doubled Haploid Laboratory Expenditure

Additional important and interesting results of the sensitivity analysis include how the costs of the doubled haploid laboratory affect the financial outcomes of the Kansas wheat breeding industry (Table 8). The simple economic model presented above disaggregated total costs facing the doubled haploid laboratory into two cost categories: (1) one-time building costs, and (2) recurring annual operating costs. Both categories are altered in three scenarios (low, baseline, and high, Table 8) to quantify the economic impact of cost changes on the wheat breeding program. The results demonstrate that given a reasonable range of cost assumptions for both building costs and annual operating costs, the financial outcomes of the proposed doubled haploid laboratory remain solidly favorable relative to other opportunities (Table 8).

Under a wide range of potential levels of both building and/or annual operating costs, the financial indicators of the doubled haploid laboratory remain robust. Restated, under virtually any reasonable cost situation or eventuality, the doubled haploid laboratory remains financially viable and a solid investment, with returns much higher than alternative investment opportunities.

Table 8. Model Sensitivity Results: Doubled Haploid Laboratory Expenditures.

	Scenario		
	Low	**Baseline**	**High**
Building costs, one year (m 2010 USD)	5	6	10
Net Present Value (NPV)[1]	174.286	173.286	169.286
Benefit Cost Ratio	11.951	11.245	9.094
Internal Rate of Return	0.3465	0.334	0.294
Annual Operating Costs (m 2010 USD)	0.5	1.0	2.0
Net Present Value (NPV)[1]	178.743	173.286	162.371
Benefit Cost Ratio	16.601	11.245	6.834
Internal Rate of Return	0.361	0.334	0.291

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent.

Implications and Conclusions

This research set out to measure and analyze the economic impacts of a proposed doubled haploid laboratory in Manhattan, Kansas. Interviews with wheat breeders provided quantitative calibration of the major effects of a doubled haploid laboratory. The interviewed wheat breeders identified two major advantages to doubled haploid (DH) technology: (1) greatly accelerated time to market for new wheat varieties, and (2) faster genetic gains in wheat yields. An economic model was built based on previous literature, knowledge of the wheat industry, and information gleaned from the wheat breeder interviews. A baseline scenario was estimated for the most likely set of conditions facing the future of the introduction of a doubled haploid laboratory into the wheat breeding industry of the Great Plains.

The estimated results of the baseline case provided some evidence that both of the advantages of DH methods would provide truly large economic gains to the wheat industry, and to wheat consumers in Kansas, in the United States (US), and throughout the globe. For every dollar spent on a doubled haploid laboratory, over 11 dollars are generated in the wheat market. The economic value of the doubled haploid laboratory is conservatively estimated at over 173 million dollars over the next 50 years, and the rate of return for the doubled haploid laboratory is conservatively estimated at over 33 percent. This is a significant investment, with both a high rate of return and a large gain in the well-being of wheat producers, wheat consumers, and wheat industry participants. Given these large, positive economic gains, we conclude that the sooner the doubled haploid laboratory is built and operational, the sooner wheat producers and consumers will take advantage of the large technological advance that brings with it large economic gains.

While it can be challenging to forecast the future, the economic evaluation of the doubled haploid laboratory indicates that the large and socially significant returns are robust to a wide range of possible future economic changes, including price and quantity movements in wheat markets. The economic analysis presented here suggests that the doubled haploid laboratory is highly likely to be a successful financial investment, with large positive rates of return to Kansas wheat producers and consumers.

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An Empirical Study on Governance Structure Choices in China´s Pork Supply Chain

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Abstract

China´s pork chain is changing in several ways. Specialized and commercial productions are gaining importance although small scale (backyard) pig production still dominates production. Similarly, small slaughterhouses continue transactions with pig producers in spot market relationships, while big pork slaughtering and processing companies are actively exploring and advancing different forms of integration. This study explains the governance structure choices in China´s pork chain from both transaction cost economics and transaction value analysis perspectives using Structural Equation Modeling (SEM). It is revealed that governance choices in China´s pork chain are the joint effect of transaction cost and collaborative advantages.

Keywords: China's Pork Supply Chain; Governance Structure; Structural Equation Modeling

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Introduction

China is a large, developing country with a fast-growing economy and an industrial structure which is undergoing great transformation. The pork sector is the most important livestock sector in China, and Chinese people consume more than 50% of the pork produced in the world.

China´s pork chain is changing in several aspects. Although the small scale (backyard) pig production still dominates the production mode in China, specialized and commercial productions are gaining importance. A similar situation takes place in slaughtering and processing industry. Slaughtering and processing industries are core companies in China´s pork chain, and they conduct various governance structure forms to integrate with their downstream chain agents. Small slaughterhouses continue the transactions with pig producers in spot market relationships, while big pork slaughtering and processing companies (called dragon-head companies) are actively exploring and advancing different forms of integration. They collaborate with pig producers using mechanisms such as long-term contract, "company-cooperatives-pig farmers" and vertical integration.

Furthermore, slaughtering and processing industries are greatly encouraged to integrate with pig producers, as advanced in the *Formulation of Development Plan on National Slaughtering and Processing Industry (2010-2015)*, issued by the Ministry of Commerce in China. The issues of establishing good brands as well as ensuring pork safety and quality are also addressed. Therefore, this study aims to answer the following questions:

1. Why do different governance structure forms co-exist in China's pork supply chain, and why are the big slaughtering and processing industries driving integrations in the chain?
2. What should the pig producers, slaughterhouses, processors and policy makers do to advance integrations in China's pork supply chain?

Transaction Cost Economics (TCE) has been at the forefront of the development of governance-related issues. It offers a set of normative rules for choosing among alternative governance arrangements (Masten 1993), which lies in that organizing transactions involves costs (Ménard 2001) and governance structure affects transaction cost economizing result (Williamson 1998). Its "discriminating way" permits hypotheses about organizational forms to be formulated and tested (Masten 1993, 119).

However, several strands of viewpoints have criticized TCE from different perspectives, mainly concentrating on theories, methodologies and empirical studies. Among them, the Transaction Value Analysis (TVA) provides the logical insight from a marketing strategy perspective, pointing out that a single-party cost minimization without analyzing the interdependence between exchange partners in the pursuit of joint value is not sufficient in governance choice studies (Zajac and Olsen 1993). It has been found that transaction value refers to "collaboration advantages" that achieved by exchange partners; thus, this study uses "collaboration advantages" to express transaction value in the empirical part.

This study deduces the relationship among transaction cost, "collaboration advantages" and level of integration, using structural Equation Modelling (SEM) and data from 350 slaughtering (pro-

cessing) companies. The factors that influence transaction cost and "collaboration advantages" are also explored. It is discovered that "collaboration advantages" positively influences core companies' choices in integration with their downstream partners in Chinese pork supply chain. It is also revealed that willingness and capability to collaborate are the factors that influence "collaborative advantages".

Based on the findings, this study is expected to explore some managerial implications and provide suggestions to the chain actors and chain administrators. It suggests that big slaughtering and processing companies make full use of their resources in capital, technology, and public reputation to integrate with pig producers in various modes. Administrators in the pork chain, on one hand, should make sure that policies maintain the stability of the pork market to reduce the environmental uncertainty. On the other hand, they have to support big processing industries in policy, finance, technology, logistics, information and innovation to enhance their growth and to encourage the integration they are promoting.

Theoretical Background and Research Hypotheses

Transaction Cost Economics Theory (TCE)

The concept of transaction cost originates in Coase´s famous 1937 paper "The Nature of the Firm" and it was used to explain the nature and limits of firms. Transaction cost theory was reintroduced and developed by Williamson (1975, 1985), who pointed out that "all cost differences between internal and market procurement ultimately rest on transaction cost considerations" (Williamson 1996, 68). He also puts forward the term "New Institutional Economics (NIE)" in 1975. Relevant NIE studies are concentrated in modes of governance, enforcement mechanism, hierarchical structures, and bargaining strength.

New Institutional Economics introduced the concept of governance structure. Network governance is defined as the institutional matrix that encapsulates the configuration of multi-stage business arrangements within a given strategic network (Sauvée 2002). Hesterley et al. (1990, 403) defined that these governance mechanisms include any institutional arrangement that serves to influence the exchange process. Hendrikse (2003), also stated that a governance structure consists of a collection of rules / institutions /constraints structuring the transactions between the various stakeholders.

Transaction Cost Economics is an important school within the New Institutional Economics, which has the potential to offer valuable insights to agricultural economists who work in a variety of fields in the food and agricultural industries in both developed and developing economies (Dorward 1999). According to transaction cost economics, in a world without transaction costs, all activities would be carried out as exchanges between units, and it is due to the failure of markets, or arenas of exchange, to allow for many exchanges without prohibitively high governance costs that organizations come to exist (Williamson 1985, 1991). In other words, hierarchical organization is considered a response to market failure. Transaction cost economics is not only concerned with the emergence of organizations to manage transaction costs, but also with how the choice of organizational form may vary according to the specific types of exchange activities involved.

The two important assumptions of TCE, which are bounded rationality (Cyert and March 1963; March and Simon 1958; Nelson and Winter 1982) and opportunism, suggest that it is costly to identify untrustworthy individuals *ex ante* (Williamson 1996) and further indicate that all exchanges are costly. The theories put forth by Williamson (1975) and Klein et al. (1978) point out that transactions are seen to differ in terms of market contracting inefficiencies which originate from small numbers bargaining situations, while small numbers bargaining situations may exist *ex ante*. Therefore, TCE provides the insights that the governance of exchange agreements between economic actors is costly and governance forms vary in their ability to facilitate exchange depending on the attributes in the transactional environment (Leiblein 2003).

Transaction Cost Economics has been the dominant paradigm for analyzing issues in inter-firm relationships, channel structure, foreign market entry and so on. The central philosophy is that governance structure aims at mitigating all forms of contractual hazards found between the partners in a transaction-cost economizing way (Williamson 1996). In the framework established by Coase and Williamson, the organizational criterion is minimization of production and transaction costs (Williamson 1979). The choice of organizational governance form is seen as a central means through which management affects the costs of monitoring and administration or, more specifically, the costs of negotiating and writing contracts and monitoring and enforcing contractual performance (Williamson 1975).

The vast majority of empirical literature in TCE has examined the factors which influence the choice of governance form. Coles and Hesterly (1998) pointed out that transaction cost – whether they stem from asset specificity, uncertainty or measurement difficulties – are central to understanding vertical integration, but the impact of these factors should not be examined in isolation.

Important empirical evidence provided by Shelanski and Klein (1995) supports the relationship between vertical integration and transaction cost, which involve the explanations of asset specificity and uncertainty. The empirical studies in U.S. food industries from Frank and Henderson (1992) also supported the notion that transaction costs form a primary motivation for vertical coordination via nonmarket arrangements. The most influential transaction cost factors are related to uncertainty, input supplier concentration, asset specificity, and scale economics. Klein et al. (1990), Leblebici and Gerald (1981) suggested that environmental uncertainty undermines an organization's ability to predict future outcomes. Partners may act opportunistically when circumstances change, which may cause organizations to incur costs related to communication, negotiation, and coordination (Klein et al. 1990; Rindfleisch and Heide 1997; Williamson 1975, 1991). To economize on such transaction costs, organizations use an internal governance structure when environmental uncertainty is high (Klein et al. 1990; Williamson 1985).

Transaction Value Analysis (TVA)

Although TCE has become the dominant paradigm for analyzing issues in several areas such as inter-firm relationships, channel structure and so on (Ghosh and John 1999), several strands of viewpoints criticized TCE in different aspects, which are reviewed as follows:

- The first criticism comes from strategy-oriented literature and Transaction Values Analy-

sis (TVA). In this school, representative standpoints from Zajac and Olsen (1993) and Ghosh and John (1999) argue that TCE has made little headway into market strategy literature, emphasizing a single-party cost minimization without analyzing the interdependence between exchange partners in the pursuit of joint value.

- Another point comments that studies from TCE are still static and structural, neglecting the fact that governance form choice is actually a dynamic and process issue (Zajac and Olsen, 1993).
- Finally, mainstream economists criticize the lack of mathematical models to support the reasoning and contribute to testable predictions, an implausible critique in light of the remarkable set of empirical tests and analysis already available in New Institutional Economics (Ménard, 2001). And it is pointed out that there are two major weaknesses in the existing NIE theory, specifically: 1) how we relate the analysis of transaction costs to the dynamic innovation; 2) interaction between institutional environments and governance structures.

Transaction Value Analysis contends that TCE´s single-minded focus on cost minimization provides little insight into strategic marketing choices that are undertaken by exchange partners who create and claim value. TVA also pointed out that "while some might argue that transaction cost analysis does not neglect the issue of joint value inter-organizational strategies, but simply 'holds it constant', we suggest that even this interpretation maybe problematic" (Zajac and Olsen 1993, 132). They propose that it may be more appropriate to hold transaction costs rather than transaction value constant if a factor must be held constant to focus on more critical factors. Based on this point, TVA proposes another focus in analyzing the inter-organizational strategies which is claiming the maximized joint value of the two (or multi) exchange partners.

Zajac and Olsen (1993, 138) also emphasize the co-effect of transaction cost and transaction value on governance structure choice, putting forward that "when the pursuit of transactional value necessitates higher transaction costs, and expected joint gains outweigh transaction cost considerations, inter-organizational strategies having a greater joint value will typically require the use of less efficient (from a transaction cost perspective) governance structures." This sentence could be explained from three aspects:

First, it strengthens the point that both transaction cost and transaction value are changeable variables; neither transaction cost nor transaction value is a constant. Second, it pinpoints the importance of transaction value´s effect on governance structure choice. The structure is not only decided by cost, but also by the joint value expected to be achieved. Third, it underlies the co-effect of transaction cost and transaction value, compared with a matrix of low transaction and low joint value, exchanging partners may choose the structure matrix of high transaction and high joint value because the expected high joint value overwhelms the high transaction cost. While this structure is not efficient according to transaction cost economics due to its high transaction cost, it´s chosen due to its overwhelming joint transaction value.

However, the existing definition of transaction value in theories is neither clear nor concrete for an empirical study. Through the overview of transaction value analysis, it is found that transaction value refers to joint improvements achieved by exchange partners. To make this concept

clear and understandable, this study translates and explains transaction value as collaboration advantages:

Collaboration advantages refer to the joint advantages achieved through transaction (mutual activities) of agents in supply chains. These advantages form the mutual improvements in logistics systems, cash response, information exchange, technology and innovation and quality management.

It is noted that, as transaction cost differs from production cost, collaboration advantages in this study do not include the firm profits drawn by the exchange partners jointly.

Hypotheses

From the theoretical overviews stated previously, several hypotheses are generated, and they are explained as follows.

Based on the theoretical review of Transaction Cost Economics, it is concluded that in selecting a governance mode, organizations attempt to minimize transaction costs. A market governance mode is preferred when transaction costs are low. Because of economies of scale and scope, TCE assumes that the market will always be the lowest-cost producer of certain goods or service. Alternatively, an internal governance mode is preferred when transaction costs are high. It should be noted here that transaction cost itself is a negative value. The value of transaction cost refers to its absolute value. When the absolute value of transaction cost is expected high, the exchange partners tend to apply a more intense and stable governance structure to reduce the transaction cost.

The production cost advantage of the market is overwhelmed by the high transaction cost incurred. Then, it is assumed that a higher transaction cost would encourage the chain actors to increase the level of integration, and the first hypothesis of this research is:

Hypothesis 1: Transaction cost has a positive relationship with level of integration

Transaction costs are directly related to all the three independent constructs, asset specificity and uncertainty — both behavioral as well as environmental (Grover and Malhotra 2003). Uncertainty refers to the unanticipated changes in circumstances around a transaction. This uncertainty could preclude both the formulation of a contract *ex-ante* and/or the ability to verify compliance *ex-post*. The former (environmental uncertainty) can be reflected in constructs such as unpredictability of the environment, technology, and demand volume and variety. The latter (behavioral uncertainty) includes performance evaluation and information asymmetry problems. As discussed earlier, the effects of the bounded rationality constraint are accentuated by conditions of uncertainty (Grover and Malhotra 2003).

The concept of uncertainty has long been a central component of a number of theories of organization and strategy. March and Simon (1958) identified uncertainty as a key variable in explaining organizational behavior. Thompson (1967) suggested that an organization's primary task is coping with the uncertain contingencies of the environment, especially those of the task envi-

ronment. Pfeffer and Salancik's (1978) resource dependency theory suggests that organizations structure their external relationships in response to the uncertainty resulted from dependence on elements of the environment.

Behavioral uncertainty creates problems for performance evaluation. Exchange partners can use their own guile to create hidden costs by performing inefficiently and ineffectively (Rindfleisch and Heide 1997; Williamson 1985). Monitoring and enforcement costs must be increased (Williamson 1975). Organizations attempting to minimize transaction costs that arise as a result of behavioral uncertainty are likely to choose an internal governance structure (Anderson 1985; Gatignon and Anderson 1988; John and Weitz 1988; Williamson 1985).

Environmental uncertainty undermines an organization's ability to predict future outcomes (Klein et al. 1990; Leblebici and Gerald 1981). Thus, organizations have more difficulty in writing market contracts in changeable circumstances. As a result, partners may act opportunistically when circumstances change, causing organizations to incur costs related to communication, negotiation, and coordination (Klein et al. 1990; Rindfleisch and Heide 1997; Williamson 1975, 1991). To economize on such transaction costs, organizations use an internal governance structure when environmental uncertainty is high (Klein et al. 1990; Williamson 1985).

Therefore, behavioral uncertainty and environmental uncertainty are introduced into the measurement of the variable of uncertainty in this study, and we conclude the second hypothesis:

Hypothesis 2: Uncertainty has a positive relationship with transaction cost; i.e. higher uncertainty exerts high transaction cost

Asset specificity refers to the transferability of assets that support a given transaction. A 'specific' asset is significantly more valuable in a particular exchange than in an alternative exchange and leads to a 'lock-in' effect that causes hold-up problems (Barney 1999; Williamson 1975). Highly asset-specific investments (also called relationship-specific investments) represent costs that have little or no value outside the exchange relationship. Transactions not supported by high-specificity assets are not prone to hold-up problems. Hence, organizations opt for the least-costly governance mode available in the market (Barney 1999; Williamson 1975, 1979, 1985, 1994). And organizations attempt to protect against hold-up problems by using an internal governance structure (Rindfleisch and Heide 1997; Walker and Weber 1984; Williamson 1975, 1979, 1994).

These costs are mainly in the form of human specificity (e.g. training of salespeople, specifically for a certain partner) or physical specificity (e.g. investment by a supplier in equipment, tools, jigs, and fixtures to cater to idiosyncratic needs of a manufacturer). Investments in information systems that primarily serve the needs of one unique customer and cannot be leveraged across other external parties would also be another form of asset-specific investment. Therefore, we generate the third hypothesis:

Hypothesis 3: The relationship between asset specificity and transaction cost is positive

Based on the strategic management and transaction value analysis theories, it is proposed that when the expected "collaboration advantages" is high, exchanging partners tend to apply more

intense and stable governance structure to maintain or to increase "collaboration advantages". Thus, the fourth hypothesis is:

Hypothesis 4: Collaboration advantages and the level of integration have a positive relationship

As for how to measure collaboration advantages, it will be explained in the following parts.
The creation and claim of joint advantages depends on two factors as it is extracted from the transaction value and resource based view which are willingness to collaborate and capability to collaborate. Zajac and Olsen (1993) put the weight on both exchange partners´ concern for maximizing transaction value. This concern is explained as (1) knowing the partner´s preference and concern as a basis for exchange and mutual gain and (2) discovering ways in which similarities or shared interests can be exploited to maximize co-operative joint value that accrue to both parties. Therefore, we define this concern to know each other and cooperate with each other as willingness to collaborate, and it is one of the factors that affect the claim of "collaboration advantages", the greater the willingness they have, the greater the collaboration advantages are expected. Therefore, hypothesis 5 is generated as follows:

Hypothesis 5: Willingness to collaborate has a positive relationship with collaboration advantages

Barney (1991) asserts that firms achieve and sustain competitive advantages by developing valuable resources and capabilities. Firms internalize and maintain internally those activities in which their superior capabilities enable efficient production (Poppo and Zenger 1998).

Research of Hsiao et al. (2009) gives insight into the concept of capability in this study. It is stated in their points on logistical resources, where they include tangible assets (such as trucks or warehouses) and intangible assets (such as knowledge or skills, i.e. 'capability'). Olavarrieta and Ellinger (1997) defined capability as a complex bundle of individual skills and accumulated knowledge exercised through an organizational process that enables firms to co-ordinate activities and make use of their resources. They proposed that a logistic activity is executed or translated by an employee's capabilities and the most important is that the available capabilities also influence the make-or-buy decision. For instance, Argyres (1996) proposed that firms were vertically integrated into those activities in which they have greater production experience and/or organizational skills (capabilities) than the potential suppliers, and they outsource activities in which they have inferior capabilities. They assert that firms internalize a certain logistics activity in which they have superior capabilities to obtain joint advantages for themselves.

Therefore, the capability to collaborate of the chain partners in this study is defined as the skills and knowledge that enable chain agents to collaborate and make use of resources. The capability of collaboration not only includes logistics, but also technology, capital and intangible capabilities such as reputation, and public appeal. It is the capability or power of exchange partners to create and claim joint advantages. Each chain agent has its unique capability to collaborate and this capability influences the joint advantages and thus it influences make-or-buy decision. As a

result, exchange partners who have a great "capability" will help the two parts to achieve more joint competitive advantages. Therefore, the sixth hypothesis is generated as follows:

Hypothesis 6: Capability to collaborate has a positive relationship with collaboration advantages

Finally, it is proposed that the uncertainty of environment will affect the collaboration advantages gained from both exchange parts, and the last hypothesis is stated as:

Hypothesis 7: Uncertainty has a negative effect on collaboration advantages

With seven hypotheses generated, the conceptual model is presented as follows.

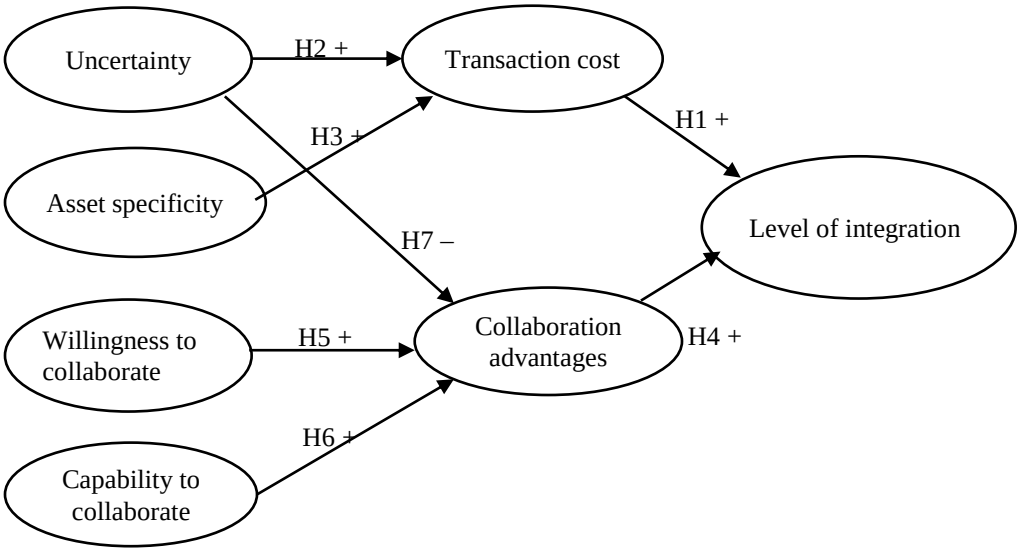

Figure 1. Conceptual Model

Methodology

Explanation and Measurement of Variables

To test the hypotheses and to reach the conclusions, a proper methodology is deduced by measurement of the variables and description of SEM model.

(1) Transaction cost

Transaction costs are both difficult to define and, once defined, difficult to observe and quantify (Dorward 1999). Coase (1960) describes in his well-known article "The Problem of Social Cost" the transaction costs he is concerned with: In order to carry out a market transaction it is neces-

sary to discover who it is that one wishes to deal with, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on. More succinctly, transaction costs are: search and information costs, bargaining and decision costs and policing and enforcement costs. This is the original scope of transaction cost and it is used in this research as the base to measure transaction cost.

Empirical work on direct measurement of transaction costs has been more nascent and limited, and has mostly been treated at the conceptual rather than the measurement level. Pilling et al. (1994) categorized transaction costs as associated with ex-ante costs of developing and setting up an exchange relationship, and ex-post costs of monitoring performance, and dealing with opportunistic behavior (Rindfleisch and Heide 1997).

Grover and Malhotra (2003) measured transaction costs by measuring the difficulty to associate with the supplier, difficulty to monitor the performance of the supplier, difficulty in addressing problems that might arise in the relationship with the supplier and the possibility of likelihood of the supplier taking advantage of its relationship with the firm being interviewed. Dierderen (2004) listed the costs of market transaction, hierarchy and social network. Market transaction includes searching costs, bargaining costs, enforcing costs; hierarchy includes of monitoring costs, incentive alignment costs, bonding costs and dead-weight losses; costs for social network includes networking costs, cooperating and retaliating costs.

All these indicate that the measurement of transaction costs could be derived from its original concept, which means that, transaction costs are able to be measured by the possible costs occurred in the transaction process between two exchange partners. Therefore, transaction costs in this study are reflected by five aspects, that is, searching cost, information cost, bargaining (negotiating) cost, contract making cost (decision cost) and monitoring cost. And these are the five indicators used in this study to measure transaction cost.

(2) Level of integration

As stated in section 3, an internal governance mode is preferred when transaction costs are high. Cooper and Ellram (1993) describe governance structures in different typologies, from spot market, short-term contract, long-term contract, joint venture to strategic alliance and vertical integration. Williamson (1975) characterizes two extremes of governance modes — perfectly competitive markets and vertically integrated hierarchies. Spot market could be considered as one extreme of internal governance mode, which carries zero level of integration. Zigger and Trienekens (1999) point out that when the structure of organization tends to be more intense and stable, the organization works more efficiently. Particularly, when chain agents encounter emergency, an intense organization structure shows a better response. Williamson (1987, 2000) considers that when companies invest more asset specificity and exchange more frequently, the opportunism will be reduced, and the structure is more intense. Therefore, the study will use the degree of intensity and stability to measure the level of integration.

(3) Uncertainty

Uncertainty comes in two forms: behavioral uncertainty and environmental uncertainty (Rindfleisch and Heide1997; Simon 1957; Slater and Spencer 2000; Williamson 1985). Uncertainty refers to the unanticipated changes in circumstances around a transaction. This uncertainty could preclude both the formulation of a contract ex-ante and/or the ability to verify compliance ex-post. The environmental uncertainty can be reflected in constructs such as unpredictability of the environment, technology, and demand volume and variety. The behavioral uncertainty includes performance evaluation and information asymmetry problems. Therefore, uncertainty is measured by two indicators: environmental uncertainty and behavioral uncertainty.

(4) Asset specificity

Williamson (1985) identified site, physical, human and dedicated asset specificity as distinct types of transaction-specific investments. It has, by and large, been measured as a latent construct in the context of human asset specificity. Scales for other types of asset specificity such as physical asset specificity or brand name capital are less readily available due to the difficulty associated with their measurement and operationalization. Buvik (2002) operates asset specificity as: the magnitude of the investments and/or adaptations made by the buyer in physical assets, production facilities, tools and knowledge tailored to the relationships. The measuring of asset specificity is that this study draws lessons from studies of Anderson (1985), Heide and John (1990), Klein et al. (1989), and Sriram et al. (1992) among others. And it is measured by physical asset specificity and relationship asset specificity.

(5) Collaboration advantages

The concept of collaboration advantages in this study originates from the transaction value research by Zajac and Olsen (1993). As we stated before, transaction value is not well defined in the existing theories. It is generated as the expected joint value that exchanging partners will gain during the process of their transaction. The mutual benefits that the chain agents will obtain from their exchange processes could be recognized and realized over time through enhanced information acquisition and exchange, along with the emergence of shared interests. It is also stated in the anterior part that “collaboration advantages” is used in this study in the place of transaction value as it is better for an empirical study.

Simatupang et al. (2002) found that the joint interests will be created through coordination between chain agents through operational linkages and organizational linkages, and the mutual improvements lie in logistics synchronization, information sharing, incentive alignment and collective learning, in which collective learning implies collaborated technological benefits, innovative benefits, etc., which are in line with the propositions mentioned in this section. It is addressed that the key of collaboration advantages is “joint”. Therefore, it comes from advantages created through all the mutual activities that happened between chain agents such as logistics, cash response, information exchange, technological coordination, innovation cooperation and joint quality and safety improvement system establishment. It includes interests that achieved jointly/mutually by exchange partners. “Collaboration advantages” is a collective concept just like transaction costs.

Empirical work on direct measurement of collaboration advantages has been more nascent and limited, and collaboration advantages are going to be measured in this study according to the definition given by six dimensions: logistics system, cash response, information exchange, technological exchange, innovative system and quality and safety management system.

(6) Willingness to collaborate

Willingness to collaborate is proposed as one of the factors that influence collaboration advantages, and it originates from the transaction value theories framework. Zajac and Olsen (1993) believe that the exchange partners´ willingness to know each other and their willingness to make the joint effort have effect on transaction value. Thus, these two dimensions will be applied to measuring willingness to collaborate.

(7) Capability to collaborate

On one hand, it is proposed that the exchange partners should have the willingness to collaborate; on the other hand, the chain agents need the capability to collaborate in order to create collaboration advantages.

The variable capability to collaborate comes from RBV theories. Researchers and practitioners interested in the RBV have used a variety of different terms to talk about a firm's resources, including competencies (Prahalad and Hamel 1990), skills (Grant 1991), strategic assets (Amit and Schoemaker 1993) and stocks (Capron and Hulland 1999). Wade and Hulland (2004) define resources as assets and capabilities that are available and useful in detecting and responding to market opportunities or threats (Sanchez et al. 1996; Christensen and Overdorf 2000). Capabilities are defined as repeatable patterns of actions in the use of assets to create, produce, and/or offer products to a market (Sanchez et al. 1996). Capabilities transform inputs into outputs of greater worth (Amit and Schoemaker 1993; Capron and Hulland 1999; Sanchez et al. 1996; Schoemaker and Amit 1994). Capabilities can include skills, such as technical or managerial ability, or processes, such as systems development or integration.

As stated above, capability to collaborate of the chain partners in this study is defined as the skills and knowledge that enable chain agents to collaborate and make use of resources. It is considered as competitively tangible and intangible resources (capability) of the firm that could be utilized to achieve the collaboration between chain agents aiming to maximize the collaboration advantages. Tangible capability refers to the ability to offer goods and services such as capital, technology, logistics systems; intangible capability refers to the ability to transform inputs into outputs of greater worth such as business reputation, public appeal, and managerial skills. Thus, the capability to collaborate is measured by tangible and intangible capability to collaborate.
All the measurable variables of each latent variable are listed in Table 1. The measurement of measurable variables is stated in the questionnaires found in Appendix 1.

Table 1. Latent Variables and Measurable Variables

Latent variables	Measurable variables
Transaction Cost	1. Searching Cost (SRC) 2. Information Cost (INC) 3. Bargaining Cost (BAC) 4. Decision Making Cost (DEC) 5. Monitoring Cost (MOC)
Level of Integration	1. Level of Stability of the Governance (SGG) 2. Level of Intensity of the Governance (IGG)
Uncertainty	1. Environmental Uncertainty (ENU) 2. Behavioral Uncertainty (BHU)
Asset Specificity	1. Physical Asset Specificity (PAS) 2. Relationship Asset Specificity (RAS)
Collaboration Advantages	1. Logistics Advantages (LGA) 2. Cash Response Advantages (CRA) 3. Information Use and Exchange Advantages (IEA) 4. Technology Advantages (TEA) 5. Innovation Advantages (INA) 6. Quality Management Advantages (QMA)
Willingness to Collaborate	1. Willingness to Know the Partner (WTK) 2. Willingness to Make Joint Effort (WTE)
Capability to Collaborate	1. Tangible Capability to Collaborate (TCC) 2. Intangible Capability to Collaborate (ITCC)

Description of SEM

Supply Chain Management research very often involves an analysis of relationships among abstract concepts. For this type of analysis, Structural Equation Modeling (SEM) is a very powerful technique because it combines measurement models (confirmatory factor analysis) and structural models (regression analysis). The usefulness of SEM lies in its ability to test hypotheses that are difficult if not impossible to evaluate with other analytical methods into a simultaneous statistical test (Gimenez et al. 2005). Thus, SEM is the proper methods for this study to test the hypotheses and explore the influencing factors. The software SPSS 17.0 and Amos 17.0 were adopted to analyze the data and test the results of the models.

The study uses measurable variables to measure the seven latent variables in two conceptual models. Likert-type scale method is used to measure these items, and it is widely used in psychology and management, etc. research areas. Likert-type scale usually uses 4 to 6-point scale as measurement levels, in which 5-point scale has a better internal consistency. Then, a five-point Likert-type scale anchored from “strongly disagree” to “strongly agree” is adopted in the measurement.

Empirical Evidence

With the methodology, the study utilizes the data from China´s pork chain case to test the hypotheses.

Data Collection

In China´s pork chains, the slaughtering (slaughtering-processing) companies are core agents of the chain as they are the main organizations who drive the chains´ governance structure development. Therefore, this paper chooses the governance structure between slaughtering (slaughtering-processing) companies and their upstream chain agents which are pig farmers, as the research domain.

Before conducting the formal investigation, trial interviews were initiated in September, 2010 and final questionnaires were revised according to the result of the trial interviews. Formal investigation was carried out during 3 months from October to December, 2010. A sample of 350 slaughtering (slaughtering-processing) companies in three biggest pig production and pork processing provinces in China, –*Jiangsu* Province, *Henan* Province and *Shandong* Province (see figure 2), were chosen. These three provinces all have large population: 76 million, 93 million and 99.2 million respectively by the end of 2008.

Figure 2. Geographic location of *Jiangsu*, *Henan* and *Shandong* Provinces in China

Jiangsu Province is in *Yangzi* River Triangle Economic Area, which is one of the three most important economic areas in China. These areas have abundant natural resources, human resources and high technology, open economic policies and fairly established foreign investments. *Shandong* province develops particularly in the fast in past ten years, mainly thanks to the great development in the livestock sector and harbor-related business. The Chinese government is investing heavily in establishing a new economic area in the downstream of Yellow River, and it incorporates *Shandong* province. *Henan* province is one of the important economic parts in middle-east China, and one of its most important economic supporters is the pig industry.

With regard to the pork sector, all the three provinces are big pig producers and processers. According to the statistics provided by China´s meat organization, 19 companies in *Shandong*, 9 companies in *Henan* and 4 companies in *Jiangsu* are listed the 50 most competitive meat producing companies in China in 2005, which in all account for 64% of the 50 most competitive meat producing companies. And among the 44 companies that slaughter more than 200,000 heads of pigs in 2005, 17 of them are companies in *Jiangsu*, *Shandong* and *Henan*. The biggest three companies *ShuangHui*, *JinLuo* and *YuRun* come from *Henan*, *Shandong* and *Jiangsu* respectively. There are 434 pork slaughtering and processing companies in *Shandong* in 2008, and 98 of them slaughter 200000 heads of pigs per annum. It is reported that pork producing companies are concentrated in these areas, which is proper for the survey as the questionnaire object is pork slaughtering (processing) industries.

In total, 350 questionnaires were conducted in these three provinces in the form of personal investigation, personally delivery and electronic delivery. The total returned ratio is 93.1% with 6.9% of the questionnaires being not valid (see Table 2).

Table 2. Questionnaire Information

Provinces	Total	Face-face	Delivered personally or by e-mail	Effectively returned	Returned ratio
Jiangsu	100	60	40	92	92%
Shandong	150	50	100	139	92.7%
Henan	100	40	60	95	95%
Total	350	150	200	326	93.1%

Finally, 326 questionnaires were effectively collected. According to the Ministry of Commerce in China, a company who slaughters more than 200,000 heads of pigs per annum qualifies as a large scale one in the pork industry. We can see from Table 3 that large scale companies still account for a smaller percentage of the pork industry in China. The 326 slaughtering (slaughtering-processing) companies are differentiated from their scales, core businesses and governance structures, shown in the following Table 4 and Table 5.

Table 3. Scales of 326 Companies

Scale	Number	Ratio
Large scale	60	18.4%
Middle and small scale	266	81.6%
Total	326	100%

Table 4. Core Businesses of 326 Companies

Core business	Number	Ratio
Slaughtering only	262	80.4%
Slaughtering and processing	64	19.6%
Total	326	100%

Among the 326 companies, 80.98% still conduct spot market transactions with their upstream pig farmers, while the other 19.02% are using governance structures such as contracts, cooperatives and integrations. “Company – production base – pig farmers” is a governances structure of

long-term contract production, and "company – cooperatives – pig farmers" is the more integrated alliance governances structure (see Table 5).

Table 5. Governance Structures of 326 Companies

Governance Structure	Number	Ratio
Spot market	264	80.98%
Company – production base – pig farmers	27	8.29%
Company – cooperatives – pig farmers	24	7.36%
Integration	11	3.37%
Total	326	100%

The data used in this study comes from surveys in the measurement of the seven variables in the empirical model. The designing of the questionnaire has taken into consideration the related studies and the need of this research. It is designed according to the explanations of the measurement items.

The reliabilities of the data are tested first, and the results indicate that all the Cronbach's α value of the data are more than 0.70 (see appendix 2), which means all the data are reliable for further analysis.

Model Results and Explanations

According to structural equation analysis procedures, goodness of model fit should first be tested to determine whether the model is well built. Bagozzi and Yi (1988) pointed out that the goodness of structural equation fit should be evaluated from three perspectives, which are preliminary fit criteria, fit of internal structure of model and overall model fit.

This study uses overall model fit goodness to evaluate the fit between model and observed data. The overall model has three types, namely the absolute fit measures, incremental fit measure and parsimonious fit measures. Absolute fit measures are used to determine how the overall model can predict the covariance matrix or correlation matrix. Major indicators include value of chi-square statistics, goodness of fit index (GFI), square root of the average residual (RMSR), mean square root of approximate error (RMSEA) etc., in which when GFI value is greater than 0.8 and RMSR and RMSEA values are less than 0.1 means the model has good fit. Incremental fit measures include indicators such as adjusted goodness of fit index (AGFI), normed fit index (NFI), comparative fit index (CFI) etc., when AGFI and NFI values are greater than 0.9 it means that the model is well fit. Indexes for parsimonious fit consist of a parsimonious normed fit index (PNFI), parsimonious goodness of fit index (PGFI), etc., usually PNFI, PGFI value higher than 0.9 is ideal. However, Doll et al (1994) suggest that the criterion that GFI and NFI should be greater than 0.9 is too conservative, and the model is quite well fitted when GFI and NFI are greater than 0.8.

Based on these indexes, statistical software Amos 17.0 and SPSS 17.0 are applied to the SEM model test, and the results of the model fit are shown in Table 6.

Table 6. Model Fit Indicators

Model fit indicators	Value	Ideal value	Explanation
CMIN/DF	2.24	---	---
GFI	0.911	>0.9	Ideal
RMR	0.035	<0.05	Ideal
RMSEA	0.081	<0.05	Accepted
NFI	0.965	>0.9	Ideal
TLI	0.946	>0.9	Ideal

From Table 6, we can see that the observed data is well fit the model, which means the collected data and model could well reflect the real situation. The path parameters between variables are shown in Figure 3 and the test results of parameter are shown in Table 7.

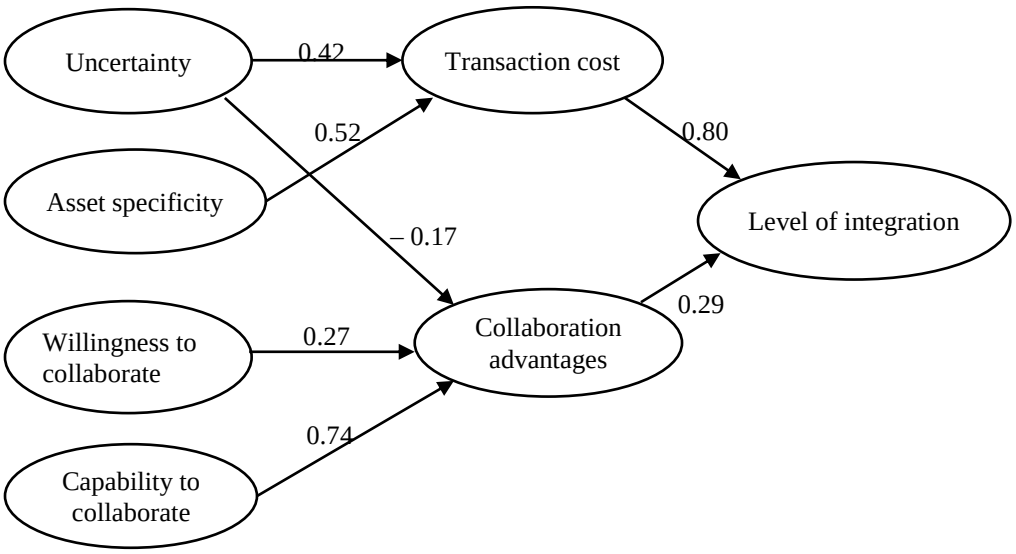

Figure 3. Paths and parameters of SEM Model

The parameters and their regression weights are listed in Table 7.

It can be seen that all the hypotheses given by the research are proven by the model in the case of China´s pork chain. Both transaction cost and "collaboration advantages" have influence on the level of integration. Transaction cost theory is confirmed as one of the most important theory references in the studying of governance of supply chain. In China´s pork chain case, transaction cost is the most important factor that influences the choice of core pork chain agents in governance structure. In the process of chain governance structure change and evolution, transaction cost has been a key reason.

Table 7. Regression Weights (Group number 1-Default Model)

Paths	Estimate	S.E.
Transaction Cost ← Uncertainty	0.422	0.014 ***
Transaction Cost ← Asset Specificity	0.522	0.022 ***
Collaboration Advantages ←Capability to Collaborate	0.741	0.026 ***
Collaboration Advantages ←Willingness to Collaborate	0.269	0.015 ***
Collaboration Adtantages ←Uncertainty	-0.171	0.014 ***
Level of integration ← Transaction Cost	0.805	0.033 ***
Level of integration ← Collaboration Advantages	0.292	0.016 ***

Note: the parameters are estimated unstandardized values.
S.E.: Standard error of regression weight
***: significant on the level of significance for regression weight at 0.1% level.
From the results we can see that all the paths passed the regression test. Combined with the hypotheses raised in this research, the final hypotheses test result is shown in Table 8.

Table 8. Tests of Hypotheses According to the Model

Hypothesis Code	Hypothesis Content	Result of Model
H1	Transaction cost has positive relationship with the level of integration	Approved
H2	Uncertainty has positive relationship with transaction cost	Approved
H3	The relationship between asset specificity and transaction cost is positive	Approved
H4	Collaboration advantages and the level of integration have positive relationship	Approved
H5	Willingness to collaborate has positive relationship with collaboration advantages	Approved
H6	Capability to collaborate has positive relationship with collaboration advantages	Approved
H7	Uncertainty has negative effect on collaboration advantages	Approved

However, although the influence of transaction cost is stronger than "collaboration advantages" on the level of integration, "collaboration advantages" functions in the slaughtering and processing companies' choice in integrations. When facing higher transaction cost and good "collaboration advantages", cooperative partners tend to choose more intense and stable governance structures to minimize the transaction cost and maximize the "collaboration advantages". It also means that cooperative partners´ purpose of choosing more intense and stable governance structure is not only to lower transaction cost, but also to increase "collaboration advantages".
The relationship between transaction cost and the level of integration is in line with Williamson´s point on the relationship between transaction cost and vertical integration. "Collaboration advantages" is proven to be another factor that influences governance structure choice.

The influences of uncertainty and asset specificity on transaction cost are confirmed on the transaction cost theories base. Great uncertainty of the environment and behavioural uncertainty between exchange partners increase the transaction cost. A company with high specificity also exerts high transaction cost. These conclusions in transaction cost theories also find their proofs in China´s pork chain.

It is also revealed that companies´ capability to collaborate has greater influence on collaboration advantages than that of willingness to collaborate on "collaboration advantages", which means

strengthening companies´ capability helps improve the "collaboration advantages" that is jointly claimed. On the other hand, the willingness to collaborate is also important as it also has a positive relationship with "collaboration advantages".

Finally, uncertainty shows a slight negative relationship with "collaboration advantages". It means that uncertainty is a factor that influences both transaction cost and "collaboration advantages". The more uncertain the environment and the behaviour between exchange partners is, the less collaboration advantages that the collaboration partners will obtain.

Conclusions and Discussion

Based on the whole analysis, the study arrives at several conclusions, and it proposes some questions for future discussions.

In China´s pork chain, transaction cost is not the only factor that influences the slaughtering and processing industries´ decision in governance mode, and "collaboration advantages" plays a role in choosing a governance structure. To conclude and also to answer the first question raised in the introduction, different levels of integration modes co-exist in China's pork chain because the slaughtering and processing industry is undergoing a transformation in which different companies choose to apply different integration modes considering both transaction cost and "collaboration advantages".

Large-scale slaughtering and processing industries choose to transact with small-scale pig producers in more intense and stable relationships in order to reduce the transaction cost that is exerted by the hold-up behaviours of small pig producers. They also aim to improve the mutual advantages through collaboration. These advantages include improvements in logistics, cash response, quality management and technological renovation, among which quality management and logistics are mostly focused on. This answers the question why big slaughtering and processing companies are driving integration with pig producers.

Spot market relationship dominates the governance structure among the numerous backyard pig farmers and small family slaughterhouses because they are connected by acquaintance relationships and the transaction cost in turn is low. Their relationship is reliable as they know each other in the neighbourhood. Therefore, a spot market relationship is suitable for their exchange.

The research contributes to empirical and theoretical knowledge mainly in two aspects.
First, for chain actors and policy makers, it is noted that, in order to drive the integrations in China´s pork chain, the advancement of "collaborative advantages" among chain members should be promoted. For big slaughtering and processing companies, the mutual advantages achieved through collaboration in logistics systems, information exchange, technology and quality management are motivations that force them to integrate. On one hand, they should strengthen their willingness to collaborate with pig producers; on the other hand, they should make full use of their capabilities to collaborate.

For policy makers, they should greatly encourage commercialized pig production and big-scale slaughtering and processing. At the same time, policy makers should give sufficient financial,

technical and professional support to advanced slaughtering and processing industries, improving their capability to accelerate integrations of China´s pork chain. These answer the second question given in the beginning of this study.

Second, the study provides empirical evidence for the application of TVA theories in governance structure studies in supply chain. Empirical results from China's pork chain indicate that TVA is a complementary theory to TCE in governance structure studies. TVA and TCE are not contradictory, and they together provide a more completed view to the existing studies in governance structure.

However, there are some points that the study would propose for discussions in future studies.
First, compared with the traditional studies in governance structure choices in supply chain management, using transaction cost economics theories, this study applies both transaction cost economics theories and transaction value analysis theories. In addition, it obtains its empirical evidence from China's pork chain case. But, this framework needs to be consolidated by more evidences from other empirical cases in the agricultural sector and in other developing or developed countries. Will the same evidence be achieved from other cases?

Second, the governance structure choice process in this study is deduced statically. In fact, the choice of governance modes is a dynamic process that requires long-term adjustment. Chain actors initialize governance modes choice, then they create norms, encounter managing conflicts, and develop trust in their relationships, and they will assess the governance performance gap and thus refine the governance structure. Later, they initialize a new round of governance mode choice. Then, how could this dynamic process be described? And what methods should be applied?

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Appendix 1.

Questionnaires to slaughterhouses (processing) companies in China's pork chain

Your Name: _____Your Title:_____

Contact Information：_____

Company's Name：_____Company Location:_____

Declarations：

1. The questionnaire is only for research purpose, the results to be generated will not be used for any business intention.
2. Please fulfill the questionnaire as objective as possible.
3. The score-value questions are evaluated with five-grade marking system
4. If you have any doubts about this survey, please don't hesitate to contact us

Thank you very much for taking time from your busy schedule to fulfill our questionnaire!

Department of Agricultural Economics, Polytechnic University of Madrid, Spain
Department of Economics and Management, Nanjing Agricultural University, China

[A] Basic information of your company

1. The main work you are responsible for your company is:

⑴ Sales/market ⑵ Purchasing ⑶ Logistics

⑷ Production/Operation ⑸ R&D ⑹ Others_____

2. The main business of your company is (are):

(1) Pig slaughtering (2) Pork processing (3) Both pig slaughtering and pork processing

3. The scale of pig production of your company is (annually):

⑴ 1-5 heads ⑵ 5-100 heads ⑶ 100-500 heads (4) more than 500 heads

4. The scale of pig slaughtering of your company is (annually)

(1) 1-50 heads (2) 50-1000 heads (3) 1000-5000 heads (4) 5000-10000 heads

(5)10000-50000 heads (6) 50000-100000 heads (7) 100000-200000 heads

(8) more than 200000 heads

[B]The relationship between your company and your upstream agent

1. In which way you do business with your biggest upstream supplier?

(1) Oral Contract (2) sign sales contract (3) sign producing and sales contract (4) upstream agent participate my company (5) I participate my upstream supplier (6) others _____

2. When you have to choose the upstream chain supplier, the main factors that you consider are: (please give an order to the following factors according to their importance, from high to low, in your opinion)

⑴ Quality ⑵ Production scale ⑶ Credit

(4) Producing experience

(5) Stable supply from the supplier ⑹ Low cost of the supplier

Order: _____

[C] Questions for scoring

- **Instructions for the score：**

Please give a score "*1 to 5*" to the following items according scales from "strongly disagree" to "strongly agree":

"1" means that you **strongly disagree** with the description that the item gives.

"2" means that you **disagree** with the description that the item gives.

"3" means that you **agree** with the description that the item gives **to some extent**.

"4" means that you **agree** with description that the item gives.

"5" means that you **strongly agree** with the description that the item gives.

- **Example:**

1. Regulations of the industry changes frequently

If you are strongly agree with the item "Regulations of the industry changes frequently" please choose "5"; agree, choose "4", agree to some extent, choose "3", disagree, choose "2", strongly disagree, choose "1".

All items go after this example.

- **Notes:**

"Cooperative partner" means your upstream chain agents which have any form of cooperative relationship (acquaintance, oral contract, formal contract, formal/informal cooperatives, joint venture, joint ownership, merger/acquisition etc.) with you.

If you don't have any cooperative relationship with any upstream agents, then it refers to up-stream chain agents that do business with you. "Both parts" means you and your cooperative partner

- **Transaction Cost**

1. It is very difficult to get information about the pig industry	1	2	3	4	5
2. It is very difficult find proper business partner (pig supplier)	1	2	3	4	5
3. It is very difficult to know the information about your cooperative partner	1	2	3	4	5
4. It is very difficult to exchange information with your cooperative partner	1	2	3	4	5
5. It is very difficult to get on an agreement with your cooperative partner	1	2	3	4	5
6. It is very difficult to agree on the conditions of the contract between you and your partner	1	2	3	4	5
7. It is very difficult for you to decide to sign the contract with your partner	1	2	3	4	5
8. It costs you a lot effort (time, fund, labour, etc.) to finally sign the contract	1	2	3	4	5
9. It is very difficult for you to monitor your partner	1	2	3	4	5
10. If your partner betrays the contract, you suffer great loss	1	2	3	4	5

- **Level of Integration**

1. Frequency of transactions between you and your cooperative partner is higher than that between you and a common upstream chain agent	1	2	3	4	5
2. Your most important business of your firm only happens with your cooperative partner	1	2	3	4	5
3. Both you and your cooperative partner rarely betray the contract	1	2	3	4	5
4. You and your cooperative partner have a long time of cooperation	1	2	3	4	5
5. Either you or your cooperative partner gives up your cooperative relationship easily	1	2	3	4	5

- **Uncertainty**

1. Regulations of the industry change frequently	1	2	3	4	5
2. Demand of the clients is uncertain	1	2	3	4	5
3. Competition among the counterparts is fierce	1	2	3	4	5
4. Technology of the whole industry changes fiercely	1	2	3	4	5
6. Your cooperative partner and you do not exchange business information well	1	2	3	4	5
7. Your cooperative partner is not reliable	1	2	3	4	5
8. Trust between you and your partner is not established for a long time	1	2	3	4	5

- **Asset Specificity**

1. If you switch to other products, you will lose a lot of investments in facilities and tools	1	2	3	4	5
2. If you switch to other products, you will lose a lot of investments in human resources	1	2	3	4	5
3. If you switch to new suppliers, you will lose a lot of investments in time and efforts in establishing relationship with your former key supplier	1	2	3	4	5
4. You invest a lot of time and effort in maintaining collaborating relationship with your most important suppliers	1	2	3	4	5

- **Collaboration Advantages**

1. Logistics between you and your cooperative partner will be ensure the products supply	1	2	3	4	5
2. When emergency happens, the logistics system will not be broken easily	1	2	3	4	5
3. Payment between you and your cooperative partner could be realized quickly	1	2	3	4	5
4. Cost of cash flow between you and your partner is lower than that between you and other partners	1	2	3	4	5
5. You and your partner can share information about cost, price, product safety, quality and quantity etc.	1	2	3	4	5

6. You and you partner could use the fastest and most convenient way to communicate	1	2	3	4	5
7. You and your partner can adopt the new technology of the industry quickly	1	2	3	4	5
8. You know how to change and improve technology adjusting the demand from your cooperative partner	1	2	3	4	5
9. You and your partner can collaborate to co-innovation	1	2	3	4	5
10. You and your cooperative partner can benefit from the co-innovation	1	2	3	4	5
11. You and your cooperative partner collaborate to adopt good quality management practices in the industry quickly	1	2	3	4	5
12. You and your cooperative partner jointly to establish good practices to ensure food safety	1	2	3	4	5
● **Willingness to Collaborate**					
1. You have great willingness to know your cooperative partner' s preference	1	2	3	4	5
2. You consider the mutual knowing as the basis of cooperation	1	2	3	4	5
3. You have great willingness to discover similarities and common interests between you and your cooperative partner	1	2	3	4	5
4. You have great willingness to make great effort to maximize the joint value between you and your cooperative partner	1	2	3	4	5
● **Capability to Collaborate**					
1. Between you and your cooperative partner, at least one has capital to enhance your collaboration	1	2	3	4	5
2. Between you and your partner, at least one holds key technology of the industry	1	2	3	4	5

3. Between you and your partner, at least one has strategic logistics systems	1	2	3	4	5
4. Between you and your cooperative partner, at least one has good business reputation	1	2	3	4	5
5. Between you and your cooperative partner, at least one has public appeal in the industry	1	2	3	4	5
6. Between you and your cooperative partner, at least one has good relationship and managerial skills	1	2	3	4	5

Appendix 2.

Reliability Analysis

1. Cronbach's α analysis for reliability of transaction cost

Code of item	Cronbach's α
SRC 1 SRC 2	0.703
INC 1 INC 2	0.786
BAC 1 BAC 2	0.793
DEC 1 DEC 2	0.744
MOC 1 MOC 2	0.846

2. Cronbach's α analysis for reliability of l level of integration

Code of item	Cronbach's α
IGS 1 IGS 2	0.776
SGS 1 SGS 2 SGS 3	0.915

3. Cronbach's α analysis for reliability of uncertainty

Code of item	Cronbach's α
ENU 1 ENU 2 ENU 3 ENU 4	0.907
BHU 1 BHU 2 BHU 3	0.842

4.Cronbach's α analysis for reliability of asset specificity

Code of item	Cronbach's α
PAS 1 PAS 2	0.851
RAS 1 RAS 2	0.965

5. Cronbach's α analysis for reliability of collaboration advantages

Code of item	Cronbach's α
LGA 1 LGA 2	0.764
CRA 1 CRA 2	0.859
IEA 1 IEA 2	0.860
TEA 1 TEA 2	0.860
INA 1 INA 2	0.785
QMA 1 QMA 2	0.843

6. Cronbach's α analysis for reliability of willingness to collaborate

Code of item	Cronbach's α
WTK 1 WTK 2	0.884
WTE 1 WTE 2	0.792

7. Cronbach's α analysis for reliability of capability to collaborate

Code of item	Cronbach's α
TCC 1 TCC 2 TCC 3	0.902
ITCC 1 ITCC 1 ITCC 1	0.890

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VION Food Group: New Challenges

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Abstract

VION, headquartered in the Netherlands, is a leading European meat processor and food ingredients company. Less than a decade ago the company surprised friends and foes by entering the industry through a series of large and well-timed takeovers that changed the face of the European meat industry. A new strategy for VION is needed, as competition in the meat industry is rapidly becoming global in nature and having a profound impact on the competitive dynamics in Europe. Major global players including Smithfield Foods (based in the USA), Brazil's JBS Swift, and Perdigão, are penetrating and expanding into European territory. New geographical markets for meat companies emerge in Eastern Europe and Asia. Meanwhile, incumbent competitors such as Danish Crown (based in Denmark) and Tönnies (Germany) are beefing up their competitive efforts, while many meat market segments in Europe have reached maturity. The diversity of distinctive and hard-to-copy strengths of major competitors confronts VION with much food for thought. For instance, a number of competitors (such as Perdigão) have important cost advantages over VION. Others enjoy a very strong supply base (such as Danish Crown), have outstanding technological capabilities, and own important genetic assets (such as Smithfield). Will the competition be able to set new rules of the game in the European meat industry? What strategy should VION pursue to maintain the initiative in changing the European meat industry, and stay ahead of the competition?

Keywords: teaching case, strategy, industry development, European meat industry

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IFAMA Agribusiness Case 15.2

Introduction

Seven men in the eye of a hurricane – that is how to picture the spring 2008 strategy meeting when the executive board[1] of the VION Food Group (VION), headquartered in Eindhoven, the Netherlands, sat down to exchange thoughts and views on future strategies for the company. With a solid financial position **(Exhibit 1)** and more than 16,000 employees in 2007, VION is one of the largest meat processors in Europe, leading in fresh beef and holding 2nd position in fresh pork. The sales of VION, growing rapidly from a mere €760 million in 2002 to more than €7 billion euro in 2007, were expected to stabilize around €10 billion in 2008 after acquiring Grampian, one the UK's largest food companies.[2]

Daan van Doorn, CEO of VION, commented on the Grampian acquisition that:

> *"The combined (VION/Grampian) group will become a major player in the European food industry. VION holds a central position in the supply chain and translates market and consumer developments to the agricultural sector. VION thereby provides an active contribution to and investment in a sustainable future for the agricultural sectors in the Netherlands, Germany and the UK."*

The tranquility in the VION boardroom was in great contrast to the howling wind produced by a hefty storm outside. It did not go unnoticed that the storm formed a perfect metaphor for the dynamics of the international meat industry which VION, originating as a rendering operation, entered as a newcomer less than 5 years previously. With a series of well-timed acquisitions, VION has grown to be a leading meat processor in Europe. The industry dynamics, however, are generating ever stronger headwinds, particularly in the form of mounting competition from global players. Concurrently, although not discerned yet, the global economy was heading towards a severe downturn.

The battle for Europe's meat markets began during 2005, not long after the rise of VION as a leading firm in the industry. The competitive battling continued and seems to be accelerating in 2008. In search of growth markets, large global firms, including Smithfield Foods based in the USA or Brazil's JBS Swift and Perdigão, are penetrating and expanding into European territory. Neither are incumbent competitors such as Danish Crown in Denmark and Tönnies in Germany sitting still. So with VION still digesting part of the takeovers constituting the VION Fresh Meat division as a leading meat producer in Europe, the seven men in the boardroom are engaged in the ongoing quest for a robust, competitive strategy in an ever changing industry environment. The VION executive board members are keen not just to defend the company's position but also to move forward and grow in attractive market segments.

What should the executive board of VION do to secure the leading position of the company in the European meat industry? More in particular, which rules of the game are developing fastest

[1] Early 2008, the Executive Board among others includes Daan van Doorn (Chief Executive Officer), Ton Lammers (Chief Finance Officer) and Peter Beckers (Chief Strategy Officer).

[2] In 2008 VION acquired Grampian (2007 sales 2.5 billion Euro, 17.500 employees). The acquisition strengthened the position of VION in the UK markets for fresh pork, bacon, and sausages.

in the meat industry and have to be followed, and which ones should be pro-actively changed or shaped in favor of VION to give the company an edge over the competition?

Ownership, Governance and *raison d'être of VION*

VION is a private firm owned by a single shareholder, the Dutch farmers union[3] ZLTO (The Dutch Organization for Agriculture and Horticulture, Southern Region). By 2008, ZLTO could register more than 18,000 members, of which 30–40% are livestock farmers. For more than a century the organization has been furthering the interests of its members (farmers and horticulturists) particularly in the levels of income and business continuity (**Exhibit 2**).

The VION governance structure is designed to secure a high degree of management discretion on the owner side. Apart from the demand that company activities be consonant with the ZLTO mission, i.e. furthering the long-term interests of its members and securing a steady stream of dividends, it is VION's Executive Board running the company and setting the strategy.

To keep a clear division line between the company and the farmers union, a multi-layered governance structure was put in place, including a trust office between ZLTO and VION. The VION supervisory board includes 4 members from the outside and 4 who represent ZLTO, a composition that balances strategic influence between this single shareholder and the VION executive board even further.

The lines of separation laid down in VION's governance structure enable ZLTO to act as a strategic shareholder with influence on long-term developments only, while the executive board runs the company shielded from short-term political dynamics within and around the farmers union. The structure also protects against potential conflicts deriving from the supplier relations between VION on one hand and livestock farmers with ZLTO membership on the other.

The VION *raison d'être*, i.e., the ultimate intended impact of the company's strategic actions, is to secure long-term market demand for goods produced by farmers in the Dutch agricultural complex. At the time of VION's strategic transformation in 2005, the chairman of ZLTO and supervisory board member Anton Vermeer expressed that vision:

> *"A healthy meat processing industry is a prerequisite for long-term survival of the livestock farmers. It is an indispensable layer linking the primary production system on the one hand and the industry for food distribution and retail on the other."*

The leadership position of VION in the market for fresh meat in the Netherlands and Germany, placed against the backdrop of the above statement, can be seen as a way to secure a sustainable market for cattle farmers in the Netherlands. The key defense mechanism against attacks on their market by foreign players is a set of seemingly unchangeable rules of the game in the fresh meat industry[4]. First, high-quality fresh meat is highly perishable and therefore cannot be transported

[3] ZLTO is a farmers union (aimed to further interests of farmers), and NOT a cooperative.

[4] It should be stressed here that these rules of the game are true for fresh meat only. For frozen meat and meat products, the situation differs, as these products are less perishable and better transportable over long distances – in the case of frozen meat, even from continent to continent.

over long distances in an economically viable way. New entrants would have to buy market share by taking over meat production plants in VION's own backyard. The alternative, namely to set up new fresh meat production plants in a highly mature industry, is not considered to be a viable option. Second, supermarkets and food service clients demand just-in-time delivery, which also hampers long-distance transportation of fresh meat and increases both the complexity and long-term nature of buyer-supplier relations.

In addition to the above, it can be argued that furthering the development of the Dutch meat processing industry alone will not be enough. The Dutch agricultural sector at large is facing the challenge of securing demand for their goods in a globalizing food industry with ever fewer and larger international players on the processing and retail side who are driving cross-border competition.

Company History

VION originated as an animal by-products processor in the 1930s, expanded the business via takeovers in the 1980s, branched out in value-added products based mainly on gelatin in the 1990s, and made a massive move into the meat industry in the period 2004–2005[5]. On July 1, 2006, the company gave itself a new name, switching from SOVION to VION Food Group. This marked the completion of the strategic transformation from an animal by-products processor, gelatin and drug delivery company with €760 million sales in 2002 towards a leading, €7.1 billion company in the European meat industry by 2007. That was not an easy journey. The commonly accepted view at the time was that the ailing meat industry in the Netherlands was just about to collapse, along with parts of the German meat industry. As illustrated by CEO Daan van Doorn:

> *"Five years ago banks were not willing to invest in the meat industry, which made it difficult to find the required capital to pursue our strategy."*

By contrast, newspapers have devoted whole pages to VION since the turnaround and the company has received nominations which include Best European Entrepreneur of the Year, and Growth Strategy of the Year.

In 2008 major activities of the VION corporation revolve around the markets for beef, lamb and pork (approximately 86% of annual turnover) in Western Europe, driven by a business that encompasses slaughtering and meat processing. At the same time, the company is expanding into the convenience food business, while remaining active as a leading and growing European firm in animal by-products processing, and as a worldwide leading player in the gelatin business **(Exhibit 3)**.

VION Corporation: Three Divisions and a Business Unit

VION consists of three divisions (Fresh Meat, Ingredients, Convenience) and one separate business unit (Banner). The principle at corporate headquarters is to provide the divisions and their business units with a high level of autonomy under strict financial control.

[5] For more details, see the business case "*Sovion NV: Reshaping the meat industry in Europe*", August 2005.

The basic idea is to enable the units to respond optimally to market and industry developments and keep corporate overheads as low as possible.

VION Fresh Meat: Active in processing, producing and obtaining economic value from meat products (pork, beef and lamb), VION Fresh Meat employed 6,447 persons in 44 operating plants and 14 country offices in 2007, realizing a turnover of €5.4 billion. The Fresh Meat division operates worldwide, with meat processing plants concentrated in the Netherlands and Germany, and with sales offices all across Europe plus one in Australia. Key customers served by the division include *retailers* (such as Ahold, Wal-Mart, Aldi, Metro Group, Carrefour and Tesco), *food service companies* (such as Burger King and McDonald's), and the branded *food industry* (including Unilever and Nestlé). The VION Fresh Meat strategy is largely focused on margin-driven growth in the Dutch, German and UK markets, and increased export to Italy, France, Spain, Greece, Eastern European countries, the USA and countries in Asia. In line with the corporate philosophy of high business unit autonomy and market responsiveness, VION Fresh Meat and the constituting business units are linked with the other VION divisions and businesses on a pragmatic and transactional basis. VION has put the newly acquired Grampian into a new division, VION UK. This division is managed from the UK and led by executive board member Ton Christiaanse. In the UK, VION currently has four business operations. Key Country Foods is a major UK retail bacon processor. VION also holds a majority share in J&J Tranfield (acquisition of majority of shares in beginning of 2008), a leading supplier and manufacturer of pizza and sausages. VION Food UK Ltd is responsible for the sales of bacon, fresh pork, beef and convenience products to the UK market. VION company Oerlemans Foods, belonging to the VION Convenience division, offers fresh frozen vegetables, potato products and fruit through the UK sales office.

VION Ingredients: With 62 operating plants around the world, 5 international offices and 4,512 employees, the Ingredients division achieved a turnover of €0.7 billion in 2007. The VION Ingredients division is the European market leader in blood products and animal proteins. Business units of the division include Sobel, Rousselot, and Sobel 5Q. The Sobel business unit, operating in the animal by-products industry, includes Rendac (collecting and processing fallen stock and other risk-involved animal by-products), Sonac (producing and selling ingredients from animal-based raw materials), and Ecoson (producing biofuels from slaughter by-products). Rousselot is the second largest gelatin producer in the world with a market share of 19% behind the number one Gelita which had a 24% market share in 2007. Rousselot gelatin is used by clients in the food and pharmaceutical industries, and the adhesives and photo paper industries among others. Sobel 5Q is a business unit which coordinates the sale of slaughter by-products originating from all VION operations. The VION Ingredients strategy is aimed at consolidation of its leading positions in the market for fat in Europe and blood products in China, strengthening of the Sonac position in natural casings, and expansion of Rousselot (gelatin) in South America.

VION Convenience: This division concentrates on the development, production, and marketing of meat-based convenience foods and also non-meat foods including fish, vegetables and vegetarian products**.** In 2007 the division achieved a turnover of €1.2 billion with 3,884 employees, 30 plants and 14 international offices (shared with the Fresh Meat division). The seven business units of the division include Frozen Retail, Frozen Vegetables, Processed Meat & Chilled Food, VION Retail NL (serving retailers with customized food products and services),

Pre-packed Fresh, Food Service and Tranfield. The strategy of this division revolves around innovation, consolidation and optimization of the brand portfolio, and further development of market research and intelligence. VION Convenience aims to further internationalize its product portfolio via sales offices, and the division is expected to double its sales to about €2.5 billion within the next five years.

Banner is a separate business unit, prominent in the development and production of gelatin and non-gelatin based oral dosage forms for the pharmaceutical, food supplement and cosmetics industries. The business unit is mentioned separately since it no longer fits in with VION's aim to be market leader (top 3) in selected market segments. The money that can be made by selling Banner can be used for further acquisitions.

European Meat Industry Wisdoms

The meat industry receives serious attention from observers and analysts working for governments, EU offices, universities, journals, consultancies, and also the leading meat companies, who try to understand what is going on in the business and where it is heading. From the vast stream of information, thoughts and opinions, five major industry wisdoms can be distilled which seem to drive strategic thinking in the contemporary European meat business.

1. *Food retail is leading and consolidating, food suppliers need to follow*. The retail consolidations are outpacing those of food processors and producers. The retailer bargaining power increases due to these consolidations plus the strength of their private labels or store labels, so they have alternative resources for purchasing, and they are able to negotiate favorable prices due to large volumes[6].

2. *Bigger is better in meat production.* The meat industry is largely a commodity business where economies of scale and high volumes drive costs down, particularly in slaughtering.

3. *The pressure on margins remains high*. Competition in the meat industry is intense and is intensifying further, among other reasons due to the increasing export power of Brazilian meat companies, the aggressive price policies of producers operating from relatively low-cost countries within the European Union, and the rising strength of the euro over the dollar and other currencies. Further pressure on margins is caused by rising costs to secure food safety, preventing and fighting cattle diseases, as well as societal pressures for natural environment protection measures and animal welfare. On the other hand, margins can be improved or sustained through processing slaughter by-products into value-added products.

4. *Future growth of demand is in value-added food propositions*. Differentiation is believed to be an escape route from the current commoditization trap, but most meat companies in Europe have problems distinguishing themselves from their competitors. They use similar production methods, of course leading to products with almost identical quality and taste. In this light, it is relevant to note that fresh meat is a 'must-have' item for supermarkets, and on-time delivery and freshness is at least as crucial as a good price.

[6] Competitiveness of the European Food Industry, EU report, 2007.

5. *Access to a stable pool of farmers able to supply both good quality and quantity at a competitive price is the bedrock of the processor's value-adding processes*. Farmers, however, tend to be suspicious of the attempts by meat firms to work on a partnership basis with them instead of trading for cattle and pigs on a spot-market driven, transactional basis with a focus on price. This hampers the attempts of meat processors to enhance the performance of farmers.

Considering that a majority of the meat companies in Europe have these five wisdoms on their radar screen, an important question is, which competitors will be able to take advantage of those forces by acting upon them, and how? Which competitors will be best in playing by the rules of the game in this industry? Which competitors will be able to bend the rules in their favor, or set new ones?

The Competitive Landscape of the European Meat Industry

A glance at the meat industry in Europe from a bird's eye view shows a crowd of global, national and local companies (Figure 1). Some are consolidating their positions, some are struggling, and others have a foothold for further expansion.

Figure 1. A Bird's Eye View of the Meat Industry in Europe
Source. VION Company Presentation, 2007

European meat firms generally focus on slaughtering and processing, whereas most companies from other continents also incorporate downstream activities such as farming and sometimes even genetics. The worldwide operating meat firms **(Exhibit 4)** differ in terms of species they

process. Most companies, however, have pork and beef in their portfolio. The competitors also differ in the levels of integration of their value chains, ranging from genetics and cattle breeding to convenience food manufacturing (**Exhibit 5**). A third key difference is the ownership structure, including cooperatives (e.g., Danish Crown), publicly listed firms (e.g., Smithfield), and privately held companies (e.g., VION). All global meat competitors with operations in Europe show a solid home base, while increasingly seeking market opportunities overseas.

Pork: Regarded from a global perspective, seven out of the top 20 pork producers are European companies operating from their domestic regions, while eight of the largest producers are US-American, four are Brazilian, and one is of Chinese origin **(Exhibit 6)**. Looking at 7 large European pork producers and with non-European competitors moving in, the European pork business is becoming quite crowded, and that is driving increasingly strong competitive pressures. Seen in this light, consolidation is likely to progress on a Europe-wide scale. The world's top 3 pork producers, Smithfield Foods (USA), Danish Crown (Denmark) and VION are competing both for access to European customers and to the suppliers. Danish Crown is the largest fresh pork processor in Europe with a 10.7% market share in 2007, with VION following in a close second position (8.9%), and the German Tönnies placing third (4%). Smithfield Foods, considered the world's number 1 pork producer, entered the European market in 2005, starting up and acquiring operations in Romania and Poland. Meanwhile, they have built positions through acquisitions and joint ventures in Spain and France, with some smaller operations in the UK and the Netherlands.

Beef: VION became the European market leader in fresh beef, with a 7.4% market share after acquiring a 50% stake in the Germany-based Südfleish in 2007. Second largest in Europe is the Irish Food Group, operating 23 processing plants and realizing a turnover of around €1 billion in 2007. Cremonini, a leading beef processor in Italy, is the third largest player in the European beef scene. In 2007, Cremonini's beef processing company INALCA was acquired by the Brazil-based JBS Swift, the world's largest beef producer entirely focused on beef activities. By contrast, the USA-based Smithfield Foods has divested all beef activities, selling their beef unit to JBS Swift for USD 565 million in cash in March 2008.

Lamb: In the less crowded and much smaller market for lamb meat, JBS Swift is VION's main competitor**.** The key players in this market are well established in geographical territories which have high entry barriers that, in turn, are rooted in the land-bound nature of lamb production.

The VION Meat Strategy

The VION Fresh Meat division has the bulk of its activities geographically focused in the Netherlands, Germany, and, after the acquisition of Grampian, also the UK (**Exhibit 7**). The driving philosophy is to be market leader (in pork, beef and lamb) through margin driven growth and increased exports to the UK, Italy, France, Spain, Greece, Eastern European countries, the USA, and Asia. To achieve this, VION stays close to its strengths: building and maintaining durable relations with farmers and customers, exploiting the core capability of growing through acquisitions and turning the acquired processing companies around. Moreover, expanding and developing capabilities to thrive in differentiation-driven business, as opposed to low-cost activities, is high on the managerial agenda. In tune with this, the VION Convenience division

assists VION Fresh Meat in the ongoing search for new products. Innovation, receiving top management attention since 2005, can be considered to be another spearhead. As VION's Chief Strategy Officer Peter Beckers puts it:

> *"In generics innovation is possible as well.*"

Apart from defending the relatively stable meat business activities in Europe through cost cutting, and seeking growth through ongoing innovation of processes, technologies and propositions to customers, it has been no secret that an important part of VION's future growth will be realized through acquisitions and joint ventures in the meat industry. According to CFO Ton Lammers:

> *"VION has a war chest of €150 to €200 million for future acquisitions, and more capital will become available with the projected divestment of Banner."*

Adding value to slaughter by-products can also deliver financial advantages for VION and reduce the pressure on fresh meat margins. On top of that, VION acquisition power can be boosted even further, as CFO Lammers explained in a 2007 interview:

> *"On Earnings Before Tax Depreciation and Amortization (EBITDA) of almost €300 million, one can borrow over €1 billion*."

The question remains, where should VION seek value-adding takeovers and what is the right timing, given the competitive situation? In case opportunities in beef and pork processing run out in Northwest Europe, VION would not be short of options. New opportunities lie ahead both in Southern and Eastern Europe, and in meat business based on other species.

Looking Ahead

With the European meat market under siege of leading global protein companies, and stiff competition from within, VION executive board members tend to take the emerging industry dynamics as a source of new opportunities for VION. However, there are concerns as well. The diversity of distinctive and hard-to-copy strengths which VION faces in major competitors confronts the company with much food for thought.

For instance, Smithfield Foods is well-geared for competing on costs when it comes to pork processing, as the company is known to run a highly efficient, low-cost business model, driven by high levels of supply chain integration (including farming), large scale, and focus. Their business model based on full vertical integration has been honed over the past decades. Yet they are successfully branching into convenience food. Also growing turkey in their domestic USA market, and with robust bridgeheads vested in Eastern and Southern Europe, they may begin competing in the northwestern regions of Europe at some point in time. Being a publicly listed firm, Smithfield enjoys access to relatively cheap capital for takeovers.

Brazil-based companies are also eagerly seeking chances to increase their stake in Europe. Sadia, the biggest poultry producer in the world, has shown interest in taking over European meat

companies, together with another Brazil-based food company called Perdigão. Moreover, the JBS-Inalca joint venture established in Italy in 2007 has provided another Brazilian giant with a firm foothold in the European Union. The Brazilian competition has the advantage of very low-cost domestic production, a huge unexploited potential for exports, and economies of scale – both in terms of production, sales power, and capital for takeovers. As an illustration of the Brazilian cost advantages over their European counterparts: in 2007, the production costs of one kilogram of pig meat were on average €1.50 in the Netherlands versus €1.08 in Brazil (2004 cost prices corrected for feed price increases). If and when the European Union allows the import of Brazilian meat, this could have serious consequences for VION.

Closer to home, Danish Crown cooperative, enjoys substantial advantages from stable and high-quality supplies on the basis of mutually attractive purchasing arrangements with livestock farmers who are members of the cooperative. As a consequence, the company is likely to be well-geared for competing both on differentiation and cost through smart inputs into its processing activities. Danish Crown, however, is also known to operate with low solvency levels, driven by limited market conformity when it comes to the price they have to pay for members' supplies.

Considering VION amidst its competitors, some industry observers take the distinctive VION ownership structure as an advantage. Having ZLTO as a single shareholder allows for a long-term strategy, rather than a focus on quarterly profits. The farmers, though, are not de facto supplying VION. Tönnies, a privately owned German company, competes with VION for supplies. As a consequence, VION cherishes both the capabilities and the attitude required to live up to the daily challenges of a free market setting on the supply side.

Being part of a multi-business corporation, though loosely integrated, provides the VION Fresh Meat division with potentially distinctive strengths through cross-business synergies. VION, however, has yet to develop the synergies that could make a difference in terms of outperforming the competition. For example, VION is likely to enjoy benefits from a closer touch and better grasp of consumer market needs through the Convenience business relations.

But none of these advantages are strong enough, distinctive enough, or difficult for competition to copy. None of these will secure a long-term sustainable position in the European meat industry by default.

The storm outside the office building was not their greatest concern as the executive board talked strategy in the VION boardroom that day. More than enough questions were on the table. Could they rely on the charts? Were the mainstays strong enough to win the competitive race on the pan-European and even global scale? Which of their strengths should they practice to perfection? How could they make good use of the industry rules of the game to maintain the lead and put more distance between themselves and their competition in the European meat industry?

Exhibit 1

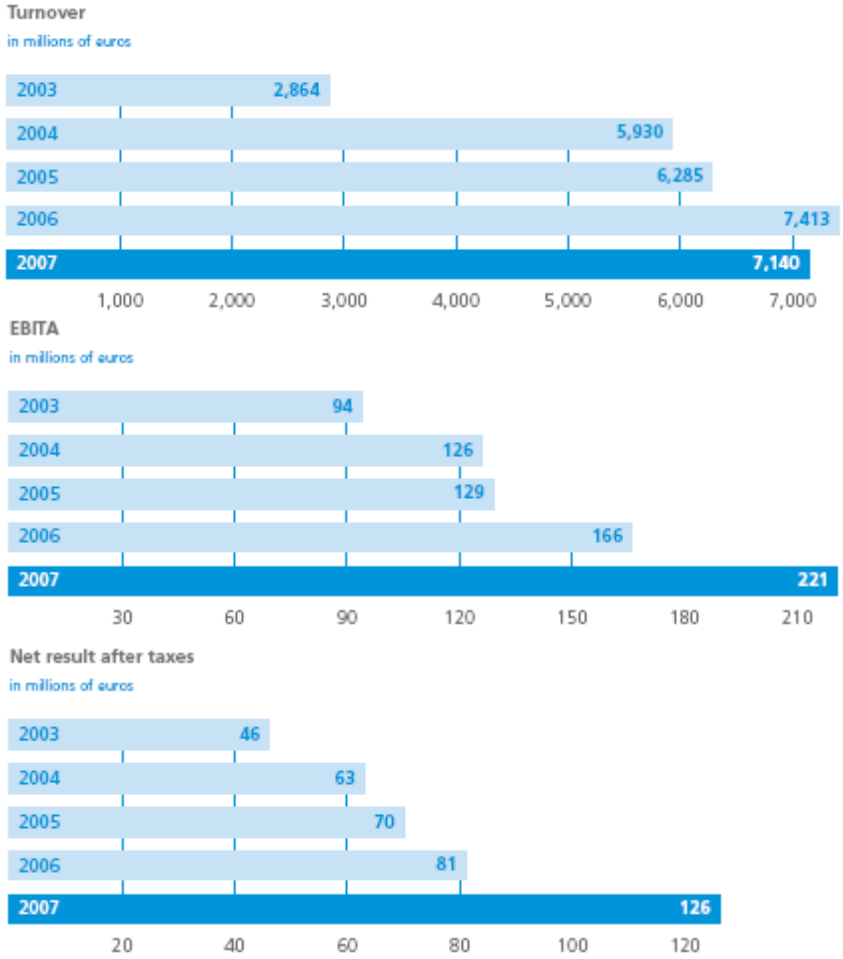
Turnover
VION food group achieved a turnover of €7.1 billion in 2007. The turnover has been rapidly increasing from €760 million in 2002 (known as Sovion at the time) to €2.9 billion in 2003. From 2003 to 2005 the turnover increased to €6.3 billion. In 2007 VION recorded a turnover of €7.1 billion. The leaps in turnover have mainly been the result of acquisitions of various companies in the meat segment of the food industry.

EBITA
The Earnings Before Interest, Taxes and Amortization (EBITA) have increased from €94 million in 2003 to €129 million in 2005 and €221 million in 2007.

Net Result after Taxes
The net result after taxes has increased from €46 million in 2003 to €70 million in 2005 and €126 million in 2007.

Return on Capital Employed
The Return on Capital Employed (ROCE) has fluctuated from 13.0% in 2003, to 11.1% in 2005 and 17.5% in 2007.

VION Food Group financial overview 2003–2007



Source. VION N.V. Annual Report 2007

Exhibit 2.

ZLTO is a union of farmers and horticulturalists in the Dutch provinces Noord-Brabant, Zeeland, and the southern part of Gelderland. By 2008, the union listed approximately 18,000 members. The union furthers the interests of individual members, groups of members and entrepreneurs, and the collective interests of its members.

ZLTO is comprised of 65 departments divided over 4 regions, each with its own management team. Every member of the management team of a department has a portfolio with one or more policy issues in it. All portfolios, in turn, are represented in an administrative platform advising ZLTO's management team.

The organization has three separate divisions including ZLTO Interest Protection, ZLTO Projects, and ZLTO Advice, plus several related staff services.

ZLTO Interest Protection
ZLTO Interest Protection promotes the interests of members who desire to be both market-driven and society-oriented. Through its extended network, ZLTO Interest Protection is able to influence the future and innovation capacity of the agricultural and horticultural industries.

ZLTO Projects
ZLTO Projects stimulates structural teamwork within groups of agricultural entrepreneurs, initiatives for innovation in the agricultural sector, and practical execution of policies monitored by these groups of entrepreneurs.

ZLTO Advice
The advisers and specialists of ZLTO Advice offer tailor-made solutions for individual agricultural entrepreneurs. They are the experts to talk to regarding important choices for the future, such as succession and members' investments to grow their businesses.

Exhibit 3. Acquisitions and joint ventures by VION in 2007 and 2008

VION UK (Grampian will be integrated into the new VION division, VION UK)

2008 Acquisition of Grampian Country Food Group Ltd, one of the UK's leading food companies, supplying the major multiples with chicken, pork, beef and lamb. The company currently employs 17,500 staff (of which 4,500 in Thailand), with an annual turnover of £1.7 billion (€2.5 billion) and has production locations in the UK and Thailand. The head office is located in Livingston, Scotland.

VION Fresh Meat

2008 Joint venture with the Russian RAMFOOD. RAMFOOD is specialized in the production of fresh and pre-packed meat and sausages. The company supplies the Russian retail and food service market in the Moscow area. RAMFOOD Group of Companies consists of a slaughter plant, a meat processing plant, a transport company, warehousing facility, distribution center and own retail outlets. The company has an annual turnover of rubles 3,2 billion (more than €86 million) and employs well over 1,300 employees.

2007 50% acquisition of Südfleisch in Germany

VION Ingredients

2008 Joint venture with the Brazilian company Rebière, one of the leading companies in the Brazilian gelatin market, and one of the top 10 gelatin companies in the world. Rebière has about 400 employees.

2007 Joint venture with the Chinese company Wuhan NPC. The company is the largest producer of plasma powder and hemoglobin powder destined for animal feed in China.

2007 Acquisition of Gebr. Smilde, a producer and processor of animal fats for human consumption, with activities in the Netherlands, Germany and Austria. The company achieved a turnover of €285 million in 2006 and has about 200 employees.

2007 Joint venture with Combinatie Teijsen van den Hengel (CTH), a Netherlands-based company processing and selling natural sausage casings, based on slaughter by-products. CTH has production locations in Belgium, Germany, the Netherlands, Poland, Portugal, Spain and China, and employs about 500 persons.

VION Convenience

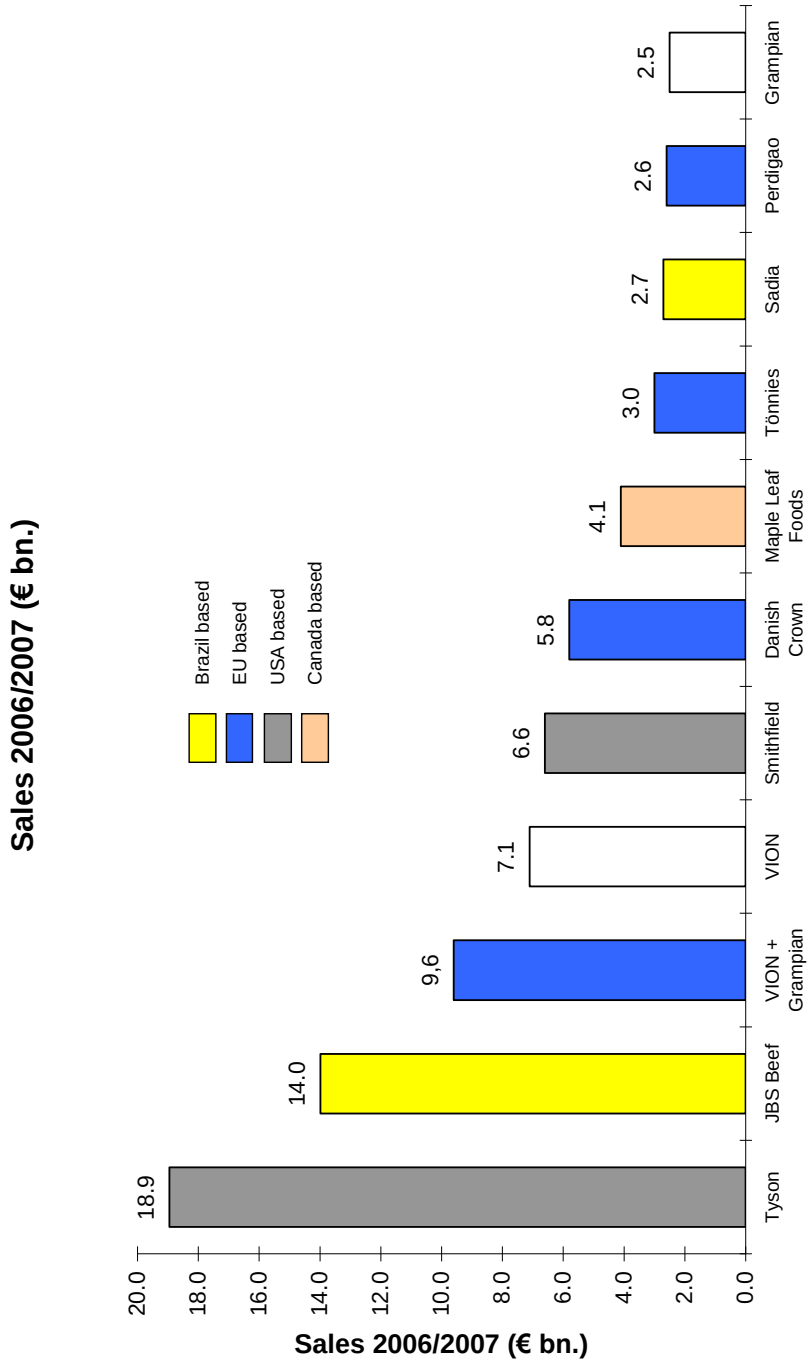
2008 Acquisition of a majority of the shares of J&J Tranfield. Tranfield is specialized in the production of sausages and pizza for the UK retail and food service market. Tranfield has an approximate turnover of €175 million and 1400 employees.

2007 Acquisition of the Dutch-based Oerlemans Foods. Oerlemans Foods is a Dutch company specializing in fresh frozen vegetables, potato products and fruit for the food service, retail and industrial markets. The company achieves 50 percent of its turnover in the Netherlands, Germany and the United Kingdom. Oerlemans is a €120 million turnover company and has about 750 employees.

2007 Acquisition of shares in Christian Salvesen, a transporter of frozen foods.

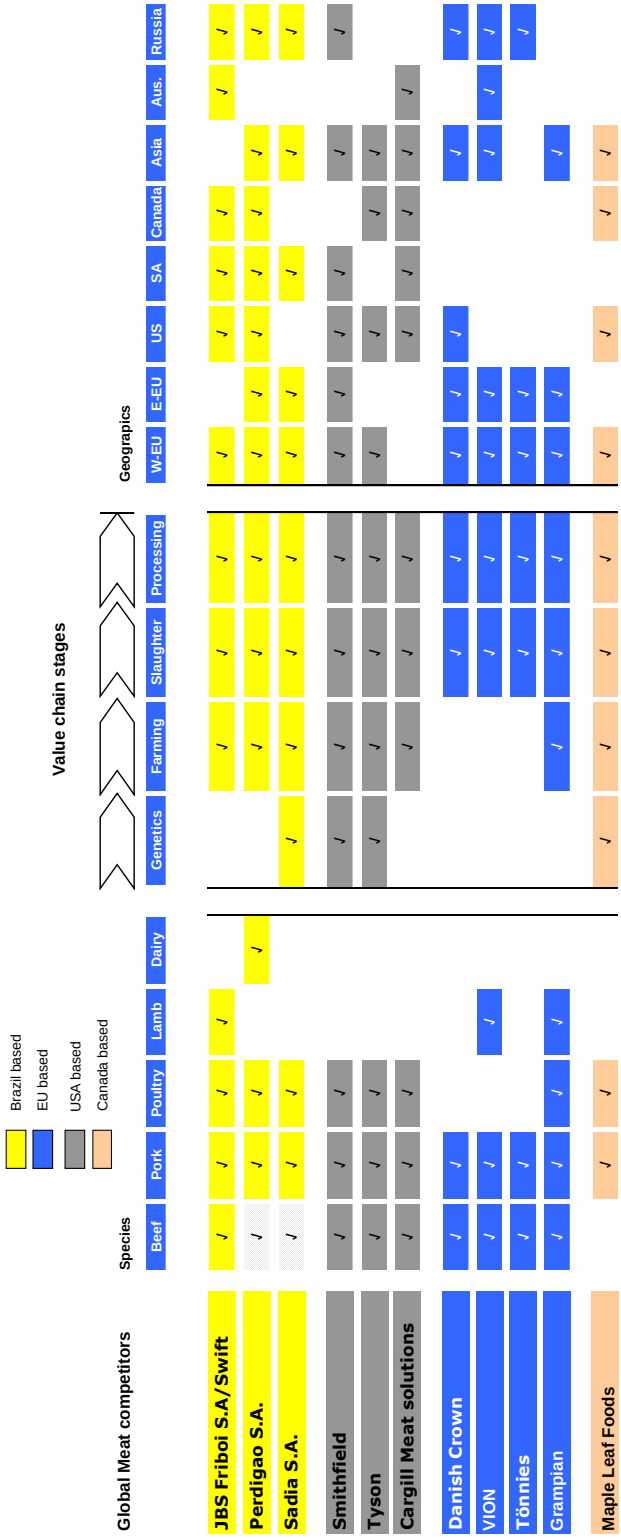
2007: Acquisition of the German company Artland Fleischwaren, a producer of meat-based food products. The company has about 500 employees. The subsidiary Keba, a producer of deep frozen snacks, has also been incorporated in the acquisition.

Exhibit 4. Overview of the Global Meat Players



Source. VION Company Presentation, 2008

Exhibit 5. Business Scope of Major Global Meat Companies



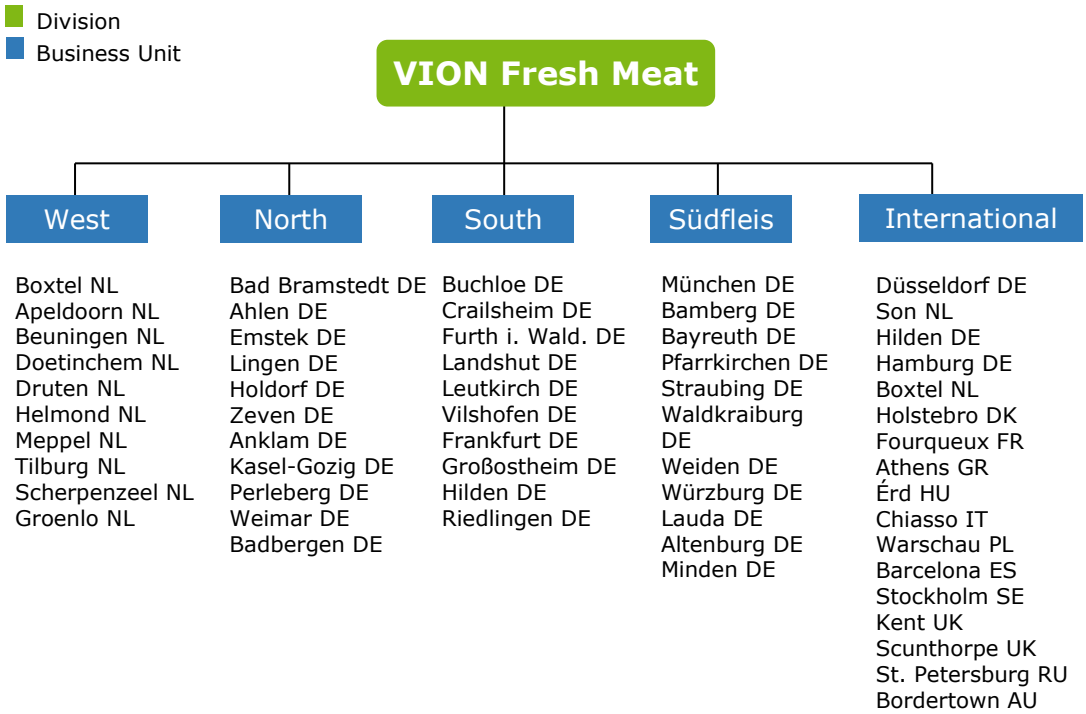
Source. Adapted from VION Food Group documents, 2007

Exhibit 6. The 20 Largest Pig Processors in the World

Company and country	Pigs slaughtered/year
1: Smithfield Foods (PSF-Animex) *USA/Poland*	30 million
2: Danish Crown (Flagship-Sokolow) *Denmark/UK/Poland*	22 million
3: Vion *Netherlands/Germany*	19 million
4: Tyson Foods (IBP) *USA*	17 million
5: Cargill (Excel-Seara) *USA/Brazil*	10.4 million
6: Friboi (Swift) *USA/Brazil*	10 million
7: Tönnies *Germany*	10 million
8: Olymel *Canada*	8 million
9: Maple Leaf *Canada*	7 million
10: Hormel Foods *USA*	6 million
11: Westfleisch/Barfuss *Germany*	5.4 million
12: Sadia *Brazil*	4.1 million
13: Seaboard *USA*	4 million
14: Cooperl *France*	3.7 million
15: Perdigao *Brazil*	3.5 million
16: Indiana Packers *USA*	3.3 million
17: Socopa *France*	3.1 million
18: Grampian Country Foods *UK*	3 million
19: Ng Fung Hong/ Shanghai Food Group *China*	3 million
20: Aurora *Brazil*	2.7 million

Source. DLG/Agriculture, 2007

Exhibit 7. Locations of VION Fresh Meat



Source. VION company presentation, 2007

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A Seismic Change: Land Control in Africa. Is this a Wake-Up Call for Agribusiness?

Industry Speaks

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Abstract

Africa has often been described as the 'forgotten continent' but dramatic changes have occurred in African agribusiness over the last ten years. On the one hand, the greatest transfer of land ownership since the colonial era continues apace. These deals are sometimes seen as a land grab, or new form of colonialism. On the other hand this new investment and the involvement of large scale agribusiness also offers the potential of bringing new technologies and techniques to the region. Could this technology transfer help Africa to replicate the Brazilian 'miracle'?

The wider agricultural community, more familiar with tales of feuds and famine in Africa, has largely overlooked many of these changes, but this paper argues that it behoves the Agribusiness community to understand what is happening, and to ask: is it time for Agribusinesses to invest in Africa?

Keywords: land grab, Africa, Land ownership, development, agribusiness

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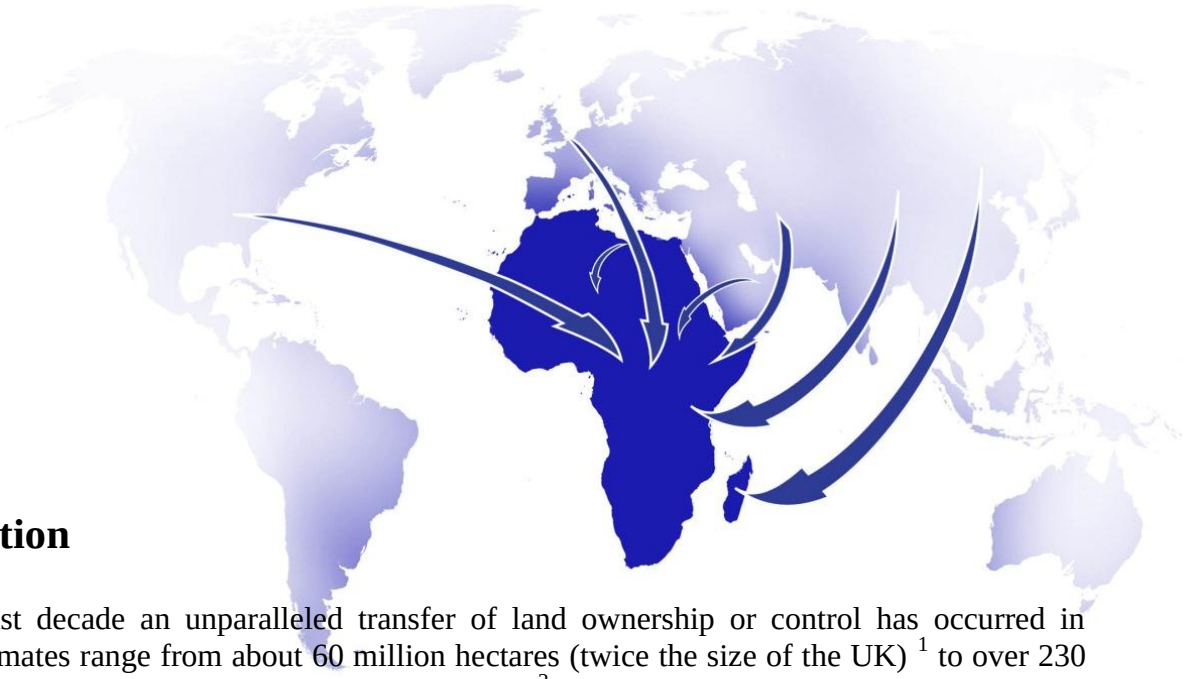

Introduction

Over the past decade an unparalleled transfer of land ownership or control has occurred in Africa. Estimates range from about 60 million hectares (twice the size of the UK) [1] to over 230 million hectares (about the size of northwest Europe)[2] has changed hands. Despite conducting business in 128 countries, Alltech, has seen little discussion within Agribusiness about this seismic change and the implications for future food production on the African continent.

There are several possible scenarios of how this unparalleled land transfer will play out:

- First, the investment by Chinese, Middle Eastern, Indian organizations and South African investors could lead to the implementation of improved agribusiness technology, which will in turn result in a better standard of living in Africa as a whole, with sustainable jobs and sustainable prosperity;

- Alternatively, the same investment could result in no appreciable benefit to the locals, who will be removed from the land, and the jobs and wealth will be created primarily for outside investors;

- Third, the investment could result in a short term benefit for local people and governments but suffer from the 'tragedy of the commons', in which the unregulated resources of the country are expended, resulting in a deterioration in the environment and a long term drop in productivity;

- Or fourth, a combination of local government interference, bureaucracy, and corruption could prevent the new African agriculture model from reaching its full potential.

[1] World Bank report: Rising Global Interest in Farmland (2011) http://siteresources.worldbank.org/INTARD/Resources/ESW_Sept7_final_final.pdf
[2] Oxfam report: Land and Power (2011) http://www.oxfam.org/en/grow/policy/land-and-power

The hope is that the agricultural development success experienced in Brazil can be replicated, to achieve the first scenario. It is clear that the changes are widespread, in more than 35 countries, and massive in scale. The broader Agribusiness sector should be aware of these changes, as they are likely to affect global markets.

The Once-Forgotten Continent

Although sometimes seen as the 'forgotten continent', Africa has long been subject to outside interest in its natural resources. News organizations have questioned if this is 'a new land grab'. This time, in addition to minerals, agriculture is drawing foreign interest. Dramatic changes are occurring throughout Africa including South Sudan, Ethiopia, Madagascar, Tanzania, Congo, Kenya, Liberia and Senegal. This time, however, the leading investors are from Asia, particularly China, India and Korea.

Social unrest, political policies and corruption have made some of the developed productive lands in Africa difficult to farm, but countries such as Ethiopia and Sudan, are being re-examined for the potential of their land. These changes are being driven by a combination of a rapid increase in food prices, the need for Biofuels, and developments in agriculture, as well as a need for arable land. For example, Muhammad Abdur Razzaque. Minister of Food and Disaster Management for Bangladesh, has said that:

"Whether from the public sector or the private sector, the government of Bangladesh is fully behind any attempts to seek out unused land beyond its borders," [3]

The abundance of land and (in some regions) water is allowing the production of valuable agricommodities. Indeed, Peter Brabeck-Letmathe, Chairman of Nestle suggests that a key element in the new wave of land transfers is actually as much of a 'water grab' as a land grab:

"With the land comes the right to withdraw the water linked to it, in most countries essentially a freebie that increasingly could be the most valuable part of the deal." [4]

These resources, combined with eager local governments, has seen the speed and the number of land deals soar. The Chinese have acquired land in Tanzania, while the Koreans attempted to acquire 1.3m hectares in Madagascar. One of the richest companies in Saudi Arabia has purchased land in Ethiopia. The Indians have purchased land in many different countries and the European Swiss company has started producing biofuels in the Congo. Other examples are listed in here.

[3] Guardian newspaper, 17 November 2011 http://www.guardian.co.uk/global-development/2011/nov/17/bangladesh-shopping-for-land-abroad

[4] Foreign Policy, April 15. 2009, The Next Big Thing: H2O; Peter Brabeck-Letmathe http://www.foreignpolicy.com/articles/2009/04/15/the_next_big_thing_h20

- **Ethiopia**: 815 foreign-financed agricultural projects approved between 2007 to 2010 (Guardian)
- **Ethiopia:** a new 150,000 ha livestock farm (FAO, 2009)
- **Ethiopia:** 300,000 hectares to the Indian company, Karuturi[5]
- **Democratic Republic of Congo**: 2.8m hectares of palm oil for biofuels for China.
- **Gabon**: Olam (Singapore) acquired 300,000 ha to produce Palm oil. **Ethiopia, Kenya, Madagascar, Senegal and Mozambique:** 80 Indian companies have invested around $2.4 billion in buying or leasing huge plantations in these countries
- **Madagascar**: Korea's Daewoo company attempted to lease 1.3 million hectares
- **Liberia:** A Malaysian conglomerate in 2009 signed a 63 year lease for 230,000 ha.to grow palm oil & rubber
- **Liberia**: An Indonesian producer signed a 2010 agreement to develop 220,000 ha. to produce palm oil.
- **Madagascar:** has 452,000ha Biofuel project (FAO, 2009)
- **Mali**: 544,500 ha. (Oakland Institute, 2010)
- **South Sudan** - A former commodities trader leased 800,000 ha near Darfur
- **North Sudan** - South Korean companies have bought 700,000 ha. for wheat
- **South Sudan** - United Arab Emirates acquired 750,000 ha. .
- **South Sudan** - between 2004 and 2009 Saudi Arabia leased 376,000 ha. to grow wheat & rice

Figure 1. Examples of Recent Land Transfers

All of this is part of an unparalleled transfer of land ownership. Skeptics have viewed this as a new form of colonialism. These charges have been denied in some places, such as Ethiopia, which see potential for greater food security. Berhanu Kebede, Ethiopia's Ambassador to the UK, says that

"The phrase "land grab" implies that wealthy foreign investors are misappropriating land and that Ethiopia has no control over the process. In fact, Ethiopia chooses to allocate land to investors depending on best use….In view of rising world food prices, Ethiopia has embarked on sound economic, social and ecological measures, which enable efficient and effective use of all our resources."

While agreeing that *"If all governments capably represented the interests of their citizens, these cash-for-cropland deals might improve prosperity and food security for both sides,"*[7] many rep-

[5] http://www.channel4.com/news/africa-succumbs-to-colonial-style-land-grab
[6] http://www.guardian.co.uk/global-development/poverty-matters/2011/apr/04/ethiopia-land-deals-food-self-sufficiency
[7] http://www.reuters.com/article/2011/07/26/us-investment-land-idUSTRE76P77P20110726

resentatives of African citizens and non-governmental organizations (NGOs) such as Oxfam, Worldwatch have raised concerns as to the intentions of these companies; the impact of removing indigenous people from their land holdings (which they are often farming at a subsistence level) with no alternative jobs or resources provided; the equity of the deals being struck, and the authority of some of the people making the deals. Some question the shift in focus by the World Bank towards development of large-scale agribusiness through encouragement of foreign direct investment rather thank support of small indigenous farmer.[8] The World Bank counters that encouraging governments to regularize land tenure systems helps everybody, including those whose rights have not been formalized, and encourages investment in the land whether by smallholder or large investor.[9]

Either way, when large scale farming operations first come to a region social disruption is inevitable, and the outcomes difficult to predict. Availability and pricing of both labor and the resulting agricultural products are certain to change. Opportunities for entrepreneurs, either as part of a supply chain, or in ancillary goods and services are also likely. The response of the community may also come into play, whether through cooperation or resistance. There are few modern examples of an abrupt transformation of agriculture from small scale farming into large operations, but the experiences of Brazil and India offer some lessons.

The 'Miracle of the Cerrados'

Brazil's success at converting previously unusable land into some of the most productive in the world has undoubtedly shaped investor thinking. Modern farming practices have dramatically improved the agricultural outcomes through modern genetics, (including those adapted to the tropics and sub tropics for animals and plants), improved irrigation programs that minimize the waste of water, and technological tools.

As a result, over the last decade the value of Brazil's crops more than quadrupled, from $23bn to $108bn. Less than 30 years ago Brazil was a food importer; now it is the largest exporter of beef, poultry, sugar cane and ethanol and the second largest of exporter of soy (after the US).

The soil of the *cerrado*, where this 'miracle' has taken place, was thought to be too poor for agriculture. Rather than a 'miracle' this success is the result of long-term investment in improving quality; developing new species of plants such as tropical grasses (from Africa) and soybeans, the application of technology from SAP to radio transmitters for weather monitoring, the development of new farming techniques that are better suited to the region, and a return to the oldest farming technique of all: integrated crops and crop rotation.[10] The solutions were developed specifically for the challenges of the *cerrado*, and history has already shown that Africa will require its own solutions, but there are certainly lessons to be shared.

Lessons from India may also be applicable to Africa, particularly those tailored for the millions of small farmers upon which both Indian and African agriculture are currently built. India is

[8] http://www.globalresearch.ca/index.php?context=va&aid=26608
[9] http://www.emergingmarkets.org/Article/2905600/World-Bank-rebuffs-land-grabbing-claims.html
[10] http://www.economist.com/node/16886442

using techniques from consumer marketing and mobile technology to help its farmers. Drawing on Hindustan Unilever's success with very small packets of products for poor consumers, some companies are developing small packets of fertilizer, herbicides and pesticides for farmers with less than a hectare of land, along with training in techniques such as micro-dosing.[11] To reflect the substantial differences between farming areas, as well as poorly educated farmers, mobile phones are used to deliver advice and information to supplement the local extension services.[12] Biotechnology tools are also being brought into play, both for efficiency and to develop sustainable farming practices.[13]

Together, these approaches offer the potential to achieve productivity never seen before in Africa. Without this modern technology, the gap between the yields being achieved in the western world and those in Africa will continue to grow. International capital and technology, alongside the resources of land available in Africa may be bridge that gap.

If that gap can indeed be bridged, the potential for Agribusiness is enormous, yet from the feed industry perspective, and meat production in general, the story of Africa has largely been overlooked. The director of an Indian company currently developing 300,000 ha in Ethiopia notes that:

"My business is the third wave of outsourcing. Everyone is investing in China for manufacturing; everyone is investing in India for services. Everybody needs to invest in Africa for food."

So far, very few of the international feed companies or ingredient companies have a presence in Africa.[14]

With this in mind, the questions posed earlier can be rephrased:

1. Will the investment by Chinese, Middle Eastern and Indian organizations lead to a better standard of living in Africa as a whole and with this a commensurate desire to consume more protein?

2. Will the investments in Africa and in particular South Africans result in sustainable jobs and sustainable prosperity?

3. Will the development of agribusiness in Africa avoid the 'tragedy of the commons', i.e., will the resources of the country be so unregulated that they are expended, resulting in a deterioration in the environment and potential for a long-term drop in productivity?

4. Is it possible that the agricultural development success experienced in Brazil can be repeated? In the case of Brazil, consumption of meat doubled in a ten year period. Can the same story be replicated in an African context?

5. Will the inevitable interferences of government and bureaucracy prevent the African agriculture model from reaching its full potential?

6. And perhaps the most relevant question for the feed industry: what role will the industry play in the new order?

The question for food producers is whether it's time to invest in building integrated meat production systems, feed companies, technology, genetics and, not least—management expertise? From the point of view of the developed world, it appears Africa could well be at a tipping point in its history. As with Brazil 20 years ago, is it the right time for Agribusinesses to invest?

The opportunity for progress in Africa is tremendous if the desires of the developed world can be matched with the resources of the developing world, in a manner that creates sustainable agribusiness models and does not simply become exploitative. Perhaps the 21st century will be the century of Africa establishes itself as an Agribusiness power.

[11] http://www.guardian.co.uk/global-development/poverty-matters/2011/dec/14/mini-pack-revolution-agricultural-development
[12] ibid [13] ibid
[14] http://radicalnotes.com/journal/2010/01/02/ethiopian-farms-lure-bangalore-based-karuturi-global-ltd-as-workers-live-in-poverty/

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