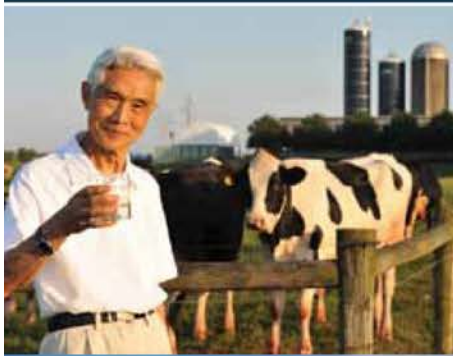




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**Volume 16: Issue 2
2013**



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EDITOR'S NOTE

Dear Readers,

Big things are happening at the IFAMR these days. First, I am pleased to present our second issue of 2013. The issue contains a case study from the 2010 Student Case, along with a teaching note, written by Dr. Greg Baker of Santa Clara University. The annual IFAMA student case competition is an amazing event that keeps growing both in terms of student teams and industry participation. It is an exciting two days. I hear there are 24 teams this year, up 40% from last year. Second, this issue contains a great piece on nanotechnology. The authors provide an excellent primer on nanotech and its application to agribusiness. Third; keep a lookout for our second upcoming special issue on Wicked Problems. We published Part 1 on this topic in the fourth quarter of 2012. There was so much interest and material, we needed to add a second issue. Finally, you will see a call for our next special issue in collaboration with USDA-ERS entitled: *Food demand, diet, and health—the role played by managers and agribusinesses*. Dr. Christopher Davis heads up a team of five editors who are soliciting contributions from scholars, industry executives, and policymakers to explore how managerial decisions, firm strategy, and store format are tied to health issues and health claims through food marketing, advertisement, refrigeration, product labeling, packaging, product reformulation, and shipping. How is the food industry shaping consumer demand and health outcomes? Visit the IFAMR website and an advertisement announcing the call in this publication.

Enjoy the issue.

Peter Goldsmith, Executive Editor, IFAMR



International Food and Agribusiness Management Review
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The World Market of Fragrant Rice, Main Issues and Perspectives

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Abstract

Worldwide rice production totaled 481 million metric tons in 2011, including 7.1% in trade. Fragrant rice is estimated to account for 15-18% of the rice trade procuring the highest prices on the world market. Some new players are interested in entering this premium segment, including the US, Vietnam, and other rice growers and traders. The fragrant rice commodity chain is deciphered through a meta-analysis of data on rice cropping and trading. We conclude on a possible split between fragrant and coarse rice markets. The upcoming challenges for fragrant rice industry are discussed with the next release of genetically modified varieties; water scarcity in rice cropping; and land use trade-offs between fragrant and coarse rice.

Keywords: fragrant rice, basmati, jasmine, world trade, premium market

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Introduction

Rice is a dietary staple for at least 62.8% of the inhabitants on the planet and accounts for 20% of the caloric intake for the world population. In Asia it accounts for 29.3% (Timmer 2010). This segment varies from 26.8% for China to 69.8% for Bangladesh. Recent increases and drops in agricultural commodity prices affected the rice trade market, but fragrant rice prices did not really decrease after the peak in the spring of 2008 and, it has remained the highest priced sector of the world rice market. Fragrant rice is priced on the world trade market at USD \$1,050 per metric ton (T) or more, whereas coarse rice is USD \$440-580/T (FAO 2012). Currently, fragrant rice is a niche market for the premium segment, whereas the main market for coarse rice trading is through government procurements related to food policy and security in Asia and Africa.

Fragrant rice is generally identified by three main factors: appearance, aroma and taste (Chaudhary, Tran and Duffy 2003). It is characterized as a superfine grain, with a pleasant and subtle aroma. It has a soft texture and extreme grain elongation with a breadth-wise swelling that occurs with cooking. Basmati and jasmine are premium long grain rice. Their high value comes from the characteristic fragrance in both the raw and cooked states, and for the distinctive shape of the grain, which upon cooking elongates to almost double its length whilst its width remains the same. In addition to having a desirable taste and texture, basmati and jasmine rice are reported to be a good source of slow releasing carbohydrates, i.e. it has a low glycemic index compared with other rice (Singh, Singh and Khush 2000). Basmati rice has traditionally been grown in the north and northwestern part of the Indian sub-continent for centuries. The best cropping conditions for jasmine are found in north and northeastern Thailand. Fragrant rice grows best and produces the best quality grains under warm, humid, and valley-like conditions. Because of the attractive price premiums, some stakeholders are prone to provide fragrant rice, not sourced from its genuine regions and consequently offer consumers less aroma.

This article examines the fragrant rice trade and its business prospects by analyzing recent, original, diverse and scarce data available in 2012. It is sourced from several databases and contrasted with previously published analyses. The research question is: Will fragrant and coarse rice segments have the same future in trade? A meta-analysis of data issued from published reports was conducted and positioned within a comprehensive literature review focused on fragrant rice. This article discusses fragrant rice pricing, trading and cropping. The competing ways in which the fragrant rice market is developed are explored including: Genetically Modified (GM) or Geographical Indication (GI)—with a short focus on forthcoming land use trade-offs between fragrant *versus* coarse rice cropping under water scarcity.

The Present Market of Fragrant Rice

Price of Fragrant Rice

Fragrant rice is priced on the trade market at \$1,100 /T or more, whereas coarse rice is \$440 - 580/T (FAO 2012). After nearly tripling to record highs between November 2007 to May 2008 (Child and Kiawu 2008), global trading prices have dropped sharply. Price quotes for Thailand's high-quality long-grain milled rice—a benchmark for global trading prices, have

declined by more than 40% since May 2008. Prices for U.S. long-grain milled rice more than doubled from November 2007 to late April 2008, and have since declined by more than 30%. By comparison, the prices of fragrant rice didn't drop, albeit declining slightly; they are always the highest from 2005 to 2012, and ranged from \$825 to \$1,111/T in October 2012 (see Figure 1).

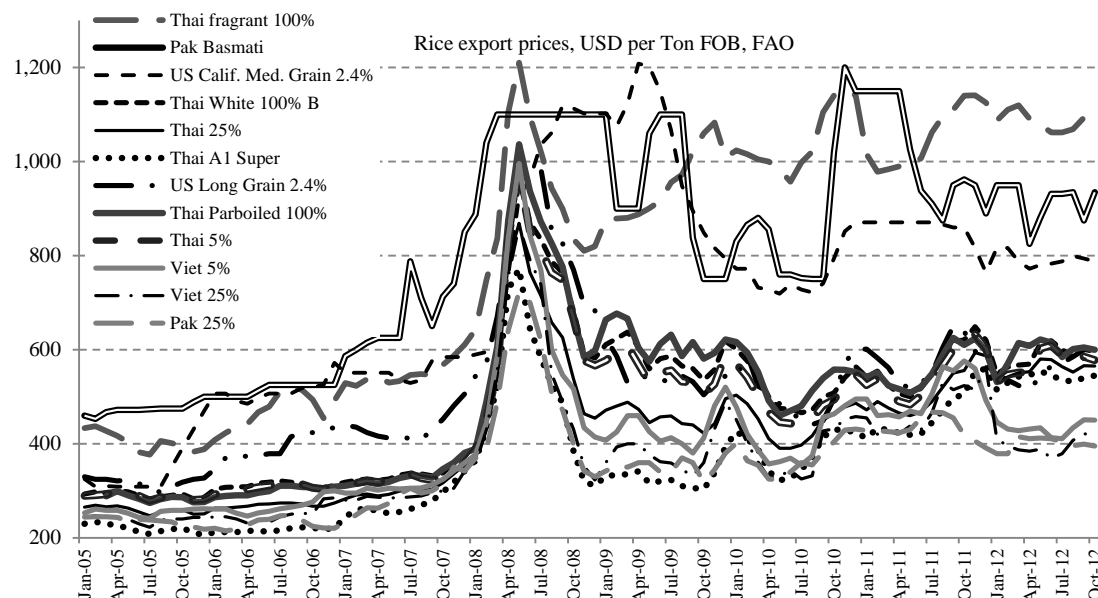


Figure 1. Rice export price, USD/T Fob, January 2005 – October 2012

Source: adapted from FAO, 2012

* %: broken grain percentage

Although unstable, the evolution of rice prices clearly shows an apparent split between the trend of specialty rice prices and the flattening of price curves for coarse rice varieties, ranging from \$530 to 600/T. However, the analysis of coefficient variation, from 2005 to 2012, does not pinpoint differences within the dispersion of prices between fragrant and coarse rice categories.

Factors affecting basmati pricing seem to be related to the increasing demand from major importers and harvest variation. The dispersion of basmati's prices may be due to varying exports from both India and Pakistan. Challenging basmati prices, jasmine is higher. Jasmine pricing is sensitive to variation as it is clearly an export-oriented crop. However, the dispersion of basmati pricing is two to three times more important than jasmine. No clear differences exist between the dispersion of fragrant rice prices and coarse rice prices, apart from basmati. More generally, it was revealed that Thailand is a price maker on the rice market as it counts for a third of worldwide rice trade (Ghosray 2008). However this is not proven yet on fragrant rice segment, where basmati and jasmine are both sold with balanced influence. Although operating on the same premium segment, basmati and jasmine are not direct competitors as they address specific demands from different importers.

The price premium of fragrant rice attracts many players and increases competition between domestic and trade markets. From 2003 to 2007, domestic rice prices were often lower but close

to world prices in India and Thailand (Dawe 2008). Despite the low percentage exported from overall cropping, trade highly influences the domestic rice market through price volatility, as commodity stakeholders are prone to export when trade prices are high. Consequently, domestic rice prices are under the influence of trade prices, although 83% of rice crop is not traded (Dawe 2008). Hence frequent market shortages probably also foster fraudulent blending.

Fragrant Rice Trade

Rice trading is low and accounts for only 7.13% of the rice production, globally. Fragrant rice (mainly basmati and jasmine) is included in this production and accounts for around 15-18% of the worldwide rice trade. Fragrant rice is considered marginal in worldwide trade and largely ignored in well-documented overviews of rice marketing (Baldwin and Childs 2011; FAO 2012; Young and Wailes 2003). Basmati trade increased from 5.2% to 8.3% in all world rice trade from 2003 to 2008, with a record of 2.45 million T, on milled basis.

Recent studies have found that basmati aroma is favored by Indian-Pakistani and Turkish communities living in Europe, while jasmine addresses the sensory preferences of Asian consumers living in North America (Suwansri et al. 2002). Jasmine has low export potential for glutinous rice eating countries and is not a competitor in basmati consuming countries. Jasmine is finding a niche and growth potential in new markets for fragrant rice, where consumers do not have well established preferences (Suwannaporn and Linnemann 2008).

The WTO recognizes that governments see rice as a sensitive and special commodity (FAO 2012). Governments are able to control, and sometimes stop rice trade through taxing, governmental distribution agencies and price regulation. This exception regime is said to be leading to a safer food security system by providing lower rice prices for local populations in developing countries where authorities pay attention to rice availability for their own inhabitants. Despite holding the position as the second largest rice exporter, Vietnam chose to ban rice trade for several months in 2008 (Childs and Kiawu 2008). Egypt, India and Bangladesh did the same. Indian restrictions on non-basmati shipments were relaxed in July 2011 (FAO 2012).

The ban process did not directly affect the fragrant rice segment, as this category was not included in this ban period. In 2008, India applied a minimum export price (MEP) of \$1,200/T, plus a tax of \$180/T on basmati rice exports. Pakistan applied a MEP of \$1,300/T for basmati rice and \$1,500/T for super basmati, from January to August 2008. During the same time period, jasmine rice remained export-oriented. Jasmine accounts for 15 to 18% of Thai rice exports in volume, but contributes to half of rice exports incomes in Thailand. In 2010, India's basmati exports were estimated at 1.8 million T, Pakistan was 1.05 million T, Thailand exported 2.65 million T of perfumed rice and, Vietnam exported 0.24 million T of fragrant rice (Slayton and Muniroth 2011). These exports, identified as fragrant rice, represent 5.7 million T accounting for 18.3% of the worldwide rice trade. In Asia, trade stakeholders state that Vietnam and Cambodia garner 20 to 35% of fragrant rice market in Hong-Kong and Singapore, but receive very low prices, compared to Thai jasmine prices. However, no solid evidence of this situation is actually confirmed.

Trade of coarse rice is spread throughout several countries, with the eight first importers making 34.3% of overall rice trade. As shown in Table 1, the first six rice exporters accounted for 80.8% of overall rice trade in 2011, while they comprise 62.9% of world rice production (FAO 2012).

Table 1. Importance of the main rice producers and exporters

October 2011	Production*	rank	Export*	rank	Trade rate	Fragrant exports*
China	138.0	1	0.8	6	0.6%	
India	103.0	2	5.0	3	4.9%	1.8**
Pakistan	6.5	11	3.0	5	46.2%	1.05**
Thailand	21.2	6	8.5	1	40.1%	2.65**
USA	6.0	12	3.1	4	51.7%	
Vietnam	28.0	5	7.3	2	26.1%	0.24**
World	481.0		34.3		7.1%	5.7**

Source: adapted from FAO 2012,

* Million T

** data 2010 from Slayton and Muniroth 2011

The fragrant rice trade is rather concentrated. In 2008, the top five clients of India have a share of 84.9%, of basmati exports from this country, those of Pakistan 68.5%, and those of Thailand 51.7% of jasmine. Basmati is primarily exported to Saudi Arabia, EU, Kuwait, Union of Arab Emirates and USA, while jasmine is shipped to China, Hong-Kong, Singapore, USA, EU and Macau. According to GDP per capita, high-quality (grains) fragrant rice is exported to rich countries, whereas fragrant broken grain is often exported to Africa, mainly the Ivory Coast, Senegal and Ghana (Slayton and Muniroth 2011).

Fragrant Rice Production

Worldwide, the paddy crop was estimated at 721 million T for 2011, producing 481 million T of milled rice, while global rice trade was estimated at 34.3 million T, on a milled basis (FAO 2012). Specific data related to fragrant rice cropping is scarce, although it comes primarily from three countries: India, Pakistan and Thailand (Chaudhary, Tran and Duffy 2003). The USA started fragrant rice's cropping in 1990, but no data is available in this special category on the well documented USDA website. Among the suppliers of the USA Rice Federation, 13 millers are providing aromatic rice. In Asia, Vietnamese and Cambodian fragrant rice is said, by trade experts, to be exported to Thailand as coarse rice. The same is likely to occur for Nepalese and Bengali fragrant rice exported to India. Since scientific publications on fragrant rice not produced in India, Pakistan or Thailand is scarce, we will primarily focus on these three countries. Rice cropping is slightly better documented.

Jasmine rice, called *Hom Mali* or *KDML 105 (Khao Dawk Mali)*, originates from the Isaan region in northeastern Thailand (Rahman et al. 2009). Released in 1959, *Hom Mali* landrace was developed during the 1980s through a governmental initiative for export purposes. The main staple for local inhabitants of the Isaan region is glutinous rice and not jasmine. Jasmine rice cropping increased by 74% from 1990 to 1998, reaching 28.3% of rice overall acreage in Thailand, despite low yields varying from 1.9 to 2.3 tons per hectare (T/ha) (Rahman et al. 2009). Jasmine rice acreage seems sensitive to export perspectives.

According to Marothia et al. (2007), fragrant rice is an oligopsony market in the farm gate. The yield from fragrant rice is independent of farm size as it is not responsive to fertilizer. Because yields are low, such rice is cropped in marginal small farms in central India. Most districts of ancient Punjab are reported to be in the basmati belt. All these regions are located in Himalayan foothills with peculiar pedo-climatic conditions and specific knowledge on traditional cropping of basmati rice (Giraud 2008). The ancient Punjab includes present western Punjab in Pakistan, eastern Punjab and Haryana in India.

In western Punjab, which represents 91.2% of all Pakistan basmati crops, basmati acreage increased by 39.7% in ten years and yield increases of 32.8%. Basmati accounted for 61.6% of rice acreage and 50.3% of the rice production in Pakistan in 2007. Basmati acreage is unknown for India and its production is estimated from 4 to 7 million T according to varying sources. Basmati yields are still low with 1.7 T/ha in 2006 in western Punjab, compared to 2.1 T/ha for all rice produced in Pakistan, and 3.8 T/ha in the eastern Punjab region of India. Cropping basmati leads to 33.1% higher costs compared to non-basmati rice in India (Uttaranchal) and 44.9% lower yields, however, according to price premiums, the net return is still positive (+30.3%) for basmati farmers (Singh et al. 2006).

As cropping areas are stabilized in the studied countries, increases in fragrant rice production depends upon yield improvement, the substitution of fragrant rice instead of coarse rice crops, and improvements in the milling process to a minor extent. According to Mushtaq and Dawson, basmati rice acreage in Pakistan is not responsive to price shocks but more sensitive to variations in irrigated areas (2002). Varietal diversity explains 25% of overall increase of rice production in Indian Punjab, while the basmati ancient variety accounts for 3.8% of rice crop in the same State (Singh 2010).

While ongoing agricultural education helps farmers use best practices in rice growing, yield improvement is mainly coming from genetic selection and crossbreeding. Agricultural development centers are working to improve rice yields and spread crop areas (Singh et al. 2006; Bashir et al. 2007; Abedullah 2007; Rahman et al. 2009). However, end-use characteristics are related to the growing place, as an effect of *terroir*. The same seeds do not provide the same final traits according to variation in planting location. Hence the trade-off is between yield improvement and preserving pure lineage in fragrant rice parentage for new varieties.

On another hand, the influence of basmati on fragrant rice market might be a concern for biodiversity. A well-documented study of fragrant rice history in India, identified 316 Indian scented cultivars, most often erased by basmati salience in cropping, and scientific works (Ahuja et al. 2008). Attractive to traders, because of its price premium, basmati rice is sown on extended acreage. Consequently, it contributes to erasing other scented cultivars which are not sold for trade.

DNA testing for had been used for some time to validate and authenticate rice (Bligh et al. 1999). Authentication for Jasmine rice does not seem to be a major issue so far as it is not a subject of recent research publications (Piyasilp and Kusanthia 2003). A survey using DNA testing was carried out in 2003 by the British Food Standards Agency in order to measure the sincerity of labeling on basmati rice packages sold in the UK (Burns, McQuillan and Woolfe 2004). One-

third of the 363 samples, collected from a range of retail outlets and catering suppliers, were labeled originating from India, one-third from Pakistan, and the final one third were not labeled from any country of origin. A small number of samples were labeled as mixed origin. All samples claimed to be basmati rice. While 54% of the samples were found to contain only basmati rice, non-basmati rice was detected in 46%. In around 24% of all the samples, the non-basmati rice content was relatively small, i.e. less than 10%, and sometimes below the limit of measurement. However 17% of samples had non-basmati rice content greater than 20%. Of great concern were 9% of the samples which contained non-basmati rice content greater than 60%. The authentication of fragrant rice is an important topic since it procures the highest prices on trade market. The rice trade consists of several players, sensitive to market pressure. The demand for fragrant rice increases slightly, while production does not always follow this trend.

Presently, some difficulties exist in distinguishing fragrant rice from coarse rice on the market. Considering the perfectible traceability of each rice shipment along the commodity chain, there is evidence of a connection between fragrant and coarse rice on trade. The major difference, coming from aroma, seems less obvious with respect to a hybridization trend currently occurring within the rice seed industry. It is likely to affect the rice market in the near future.

Rice Market Perspectives

GM or GI?

Market pressures combined with expected earnings for stakeholders have led to higher yields in the most expensive rice. So far, genetic selection has produced several hybrids that now produce a modest return of fragrant traditional lines. In a market where demand exceeds supply, stakeholders are sometimes tempted to act in an opportunistic manner. Hence, the presence of “semi-basmati” or “improved jasmine” and “product uncertainties” is found in the literature-based field studies (Goel and Bhaskaran 2007). Another issue on authentication and traceability of fragrant rice is the genetic selection and parentage of hybrid lines.

Moreover, agronomic and climatic conditions vary greatly from one region to another. Genetic selection has enabled adapted hybrids to resist water scarcity, salt abundance, high temperatures as well as weed and pest attacks. These hybrids are coming from ancient lines in a modest extent. Hence the final attributes of such hybrid lines are far from genuine traits of pure lines. Patenting living resources is still a pending issue in the fragrant rice niche with tentative international patents on *Jasmati* and *Texmati* (Sarreal et al. 1997). As the patenting trend is active, the competing scheme of GI may be better considered in order to provide a valuable tool for local biodiversity preservation. Fragrant rice is a trade-oriented commodity that attracts a number of stakeholders due to its price premium, even though they are far from the regions of origin. Hence a clarification of crop areas and seeds line varieties may enhance authenticity of fragrant rice and improve the reliability of rice commodity chain actors as well (Marie-Vivien 2008).

Although previous publications suggest an optimistic future of genetically modified rice varieties (GM), little is known about the market release of transgenic rice (Bajaj and Mohanty 2005). According to Bashir et al. (2007), several GM lines of basmati are ready in R&D laboratories,

offering different traits such as resistance to pesticide, (Bt *Bacillus thuringiensis*) cold, salinity, and bacterial blight. Notwithstanding, rice exporters are still reluctant to produce and supply GM because of averse public reactions and the potential risk of export losses in Japan and Europe (Gruère and Sengupta 2009). Because of this concern, Thailand, as the first rice exporter, is strongly reluctant to accept GM technology for rice cropping. New jasmine varieties, such as RD15 or RD6, crossbred by IRRI laboratory, are ready for market, with higher yield and better blast resistance but lower fragrance. These GM jasmine varieties are not yet released on the market, and modern crossbreeding developments are helping to improve jasmine yields without the GM technology (Jairin et al. 2009).

We will probably see a debate on GM or GI of fragrant rice in the near future. The move to register basmati as a collective trademark in Pakistan may lead to improved traceability (Mohsin 2008). Thailand initiated a registration procedure for GI in order to protect indigenous know-how on jasmine rice cropping (Saenrueangmueang, Srisa-ard and Pansila 2009; Napasintuwong 2012) and jasmine rice Khao Hom Mali is a registered Protected Geographical Indication in the EU since February 2013 (European Union 2013). According to the trade orientation of fragrant rice, the GI scheme may fit well with the actual commodity chain organization that is prevailing in the rice industry. Based upon the products historical reputation of high quality and strong independent controls and compliance within code practices, the GI scheme is compatible with the important scale of production and broad marketing. Still under the free market regime, the fragrant rice trade may benefit from protecting the rice's origin in order to better anchor value in the regions of origin and to avoid misleading end-consumers. However, due to a probable GI-based segmentation on fragrant rice, a discrepancy between fragrant rice and coarse rice segments might be foreseen. Long grain coarse rice, and some fragrant GM rice varieties, may gain market share from importing countries where local consumers are more price sensitive or under the influence of strong branding strategies and less sensitive to aroma, origin or authenticity of rice.

Land Use and Water Scarcity

Another important challenge likely to develop soon is the trade-off in land use between sowing coarse rice with good yields versus sowing fragrant rice with high premium but low yields. This may influence the price making process on fragrant rice trade segment. Land use and water scarcity may affect the reliability of major rice exporters. For example, as India's domestic demand for rice increases, combined with the pressure on land and water usage, India may become an erratic rice exporter, (Kumar et al. 2010). India was the world's largest rice exporter in 2012 although it had applied a ban on coarse rice exports in 2008.

The Indian state of Punjab plans to shift agricultural activities away from water-intensive crops (rice, wheat), towards less water-intensive crops hoping for a more promising market potential. Water resource management makes Punjab's status as a grain exporter to other states increasingly problematic. One of the objectives of the governmental plan for water management in India is to reduce rice cultivation acreage in western Punjab from 2.8 to 1 million ha. As this State is the main cropping region for basmati, the implementation of this project may reduce Indian basmati production in forthcoming years. Punjab and Haryana produce 14.4% of Indian rice harvest in 2008 in a 99% irrigated area. In India, 80% of the rice production increase is related to yield

improvement, apart from Punjab where it is related to the extension of rice cropping (Prasanna, Lakshmi and Singh 2009). As Punjab is the main basmati cropping State and basmati is less sensitive to fertilizer, the Indian project for water saving could possibly lead to reduced basmati harvests.

On a global level, water usage will be a limiting factor for all rice cropping in the near future. Hence the trade-offs between coarse and specialty rice sowing will better integrate price premiums and water cost pressure as well. It remains to be seen whether this will act in favor of fragrant rice. The importation of water-intensive goods, such as rice is a water saving strategy for rich and dry countries—such as Saudi Arabia or United Arab Emirates. Such importers are able to pay for virtual water (Roth and Warner 2008).

Yield vs. Fragrance

Fragrant rice is well-known for its low yield, which produces approximately half that of coarse rice. Consequently the seed industry has sought to improve its yield and through crossbreeding of selected strains has shown promising agronomic traits. Year-after-year, new varieties of fragrant rice are released on the market which are providing better results at the harvesting stage. Stakeholders have also noticed that the fragrance of aromatic rice is becoming lighter. Thus, it is worth considering the possible effect that yield improvements have on aroma.

Since no extensive studies has been published on the cross-tabulation of agronomic and phenotypic traits of aromatic rice, a meta-analysis was conducted for the present research utilizing primary data from Akram (2009); Bhattacharjee et al. (2002); Rahman et al. (2009) and Baldwin and Childs (2011). By gathering sparse data from these studies, a dataset of 20 aromatic rice varieties was obtained on: yield; variety (T/ha); tall of observed rice plants (cm), maturity days (number of days between the date of sowing and the harvest's one); strength of the aroma (as indicated above) and year of release on the market (see Table 2)¹.

Table 2. Descriptive statistics of 20 fragrant rice varieties according to their yield, tall, maturity days, aroma and year of release

Statistics	Yield (T/ha)	Tall (cm)	Maturity (days)	Aroma	Year of release
mean	3.8	124.9	124.8	2.4	1987
min	0.7	90	90	1	1933
max	7.7	170	150	4	2010
std	1.45	24.18	18.68	0.88	19

A Principal Components Analysis (PCA) was carried-out in order to measure, whether the trend towards yield improvement is congruent or not with end-user oriented traits such as aroma. *Aroma* and *Year* of release on the market are discontinuous and illustrative variables; *Yield*, *Tall* and *Maturity* days are active variables. In agronomy, PCA provides useful insights for screening the crops' performance under certain conditions or traits combination (Hahn and Chae 1986; Eticha et al. 2010).

¹ The whole dataset is shown in Appendix 1.

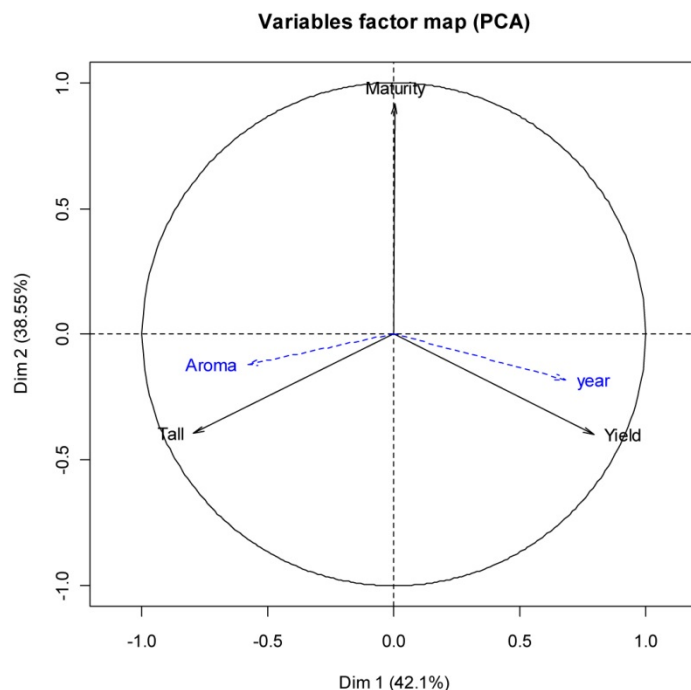


Figure 2. PCA on yield improvement vs. tall and maturity days of fragrant rice varieties

Note: Active variables are *Yield*, *Tall* and *Maturity* days in unbroken lines; illustrative variables are *Aroma* and *Year of Release* in broken line.

Figure 2 shows the results of the PCA with the 1st factor opposing *Yield* to *Tall* explaining 42.1% of the overall variance of the fragrant rice studied varieties. Meanwhile the 2nd factor is based on *days required for Maturity* and explains 38.55% of the variance. *Aroma* is an illustrative variable and is related to *Tall*. These results explain 80.65% of the overall variance within the studied dataset, and are congruent with those from Kibria, Islam and Begum (2008) who found a highly significant negative association between aroma and grain yield. The illustrative variable related to the *Yield* is the *Year* of the market release, indicating that the variety selection is leading to improved yield by decreasing the tall. The contribution of the variables to the 2nd axis indicates that the required days for *Maturity* are less correlated to the *Yield* (see Appendix 3).

The Ascendant Hierarchical Clustering (AHC) carried-out on the basis of the PCA found three classes with respectively low, medium and high yield, and interestingly, with strong and moderate aroma (see Appendix 2). The first class of fragrant rice varieties with low yield and strong aroma is the oldest one and the third class with varieties showing higher yield and lighter aroma is the most recent (see Table 3).

Compared with coarse rice, old varieties of fragrant rice are usually tall (170 cm for basmati, 140 cm for jasmine). None of the aromatic rice is known to be small. Hence, the tall of the plant is a predictor of aroma—with respect to old parentage. However, the rice plant is prone to lodge when the grains are mature and heavy. There is a risk of loss before harvest with tall plants, because once the plant is lodged, moisture and contamination by aflatoxins can occur from humid ground. Better yield is then obtained from shorter plants. As a side effect, the aroma

seems less present in new fragrant rice varieties released on the market because the primary outcome in genetic selection are yield-driven and cause reduced tall in the plant. This yield-oriented trend does not lead to a clear split between fragrant and coarse rice. The blending between these two categories becomes easier when the aromatic difference is less obvious. Consequently, rice, stated as aromatic, but including both fragrant and coarse varieties, may be shipped more frequently than pure fragrant rice.

Table 3. Descriptive statistics of 20 fragrant rice varieties according to their cluster based on Yield, Tall and Maturity days

	Statistics	Active variables			Illustrative variables	
		Yield (T/ha)	Tall (cm)	Maturity (days)	Aroma	Year of release
Class 1	mean	2	138	140	3	1971
	max	3	170	150	4	1996
	min	1	115	120	2	1933
	std	0.94	29.28	11.73	1.00	24.17
Class2	mean	4	128	114	2	1990
	max	5	160	140	4	2009
	min	2	91	90	1	1959
	std	0.75	19.09	15.88	0.79	14.81
Class 3	mean	5	99	137	2	1999
	max	8	116	150	2	2010
	min	4	90	121	1	1989
	std	1.64	11.81	12.71	0.50	10.15

Fragrant Rice Branding

Large variability in rice varieties is not helpful when seeking an accurate monitoring of fragrant rice production. Still questionable is the effect of crossbreeding: How often can a hybrid be crossbred and still qualify as belonging to the fragrant rice family? What is the significant lineage from pure lines for hybrid rice: 50%, 5%, or 1%? No scientific evidence is published on this, whereas some trade stakeholders are prone to label any hybrid basmati that has at least one remote lineage with basmati. The same is true for jasmine rice, and there is far from a domestic jasmine local breed in Surin (Thailand); Jasmine-Early-Short sown in Arkansas (USA), *Jasmati* patented by Rice Tec. Inc. for the North American market (Sarreal et al. 1997); or *Thasmin* cropped in Argentina.

Cropped in the USA, the fragrant rice, *Jazzman*, is a newly released variety challenging the imported jasmine from Thailand, and targets the commercial North American domestic market (Baldwin and Childs 2011). Naming this new rice *Jazzman* is quite clever. The pronunciation is close to jasmine. Jazz music comes from a major rice cropping area in USA. Hence, *Jazzman* sounds like a perfect stereotype for a rice brand in North America. Primarily, new varieties are released on the market utilizing branding and naming schemes that sound local. This practice raises the role of GI in protecting local names and local agronomic resources as well, against potential commercial abuses. This will be a major issue in the near future with the assessment of aroma as new varieties are less aromatic but still seek local parentage.

How is aroma best assessed in rice? Fragrant rice is said to have an average 2-acetyl-1-pyrroline (2-AP) content of about 150 to 400 parts per billion (ppb) (Sarreal et al. 1997). Several sources indicate that 2-AP was found as the major volatile component of rice aroma at 500-600 ng/g concentration (Lorieux et al. 1996; Buttery et al. 1983; Yoshihashi, Nguyen and Kabaki 2004).

A gas chromatography analysis identifies 72 volatile components for basmati aroma (Tava and Bocchi 1999). Despite the availability of an accurate method, the ways used to assess aroma along the commodity chain are rather simple. According to Maraval et al. (2008), the method for aroma assessment in rice was first developed by International Rice Research Institute (IRRI) in 1971. A basic laboratory technique is utilized which includes one gram of freshly harvested milled rice is placed into a centrifuge tube (50 mL, round bottom) and 20 mL of distilled water is added. The tubes are then covered with aluminum foil. The samples are placed in a boiling water bath for 10 minutes. The cooked samples are allowed to cool and the presence of aroma is determined for every sample by sniffing. Brown rice may also be used with the cooking time increased to 30 min. The samples are scored as *strongly aromatic*, *moderately aromatic*, *slightly aromatic*, and *non-aromatic*. A strongly scented variety is used as a check for comparison. Akram (2009) shows a binary scale for aroma (*strong*, *moderately strong*), but it is still very subjective. The Thai agricultural standard for fragrant rice defines aroma test for jasmine by “*boiling in salt solution and smelling*” (Kongsere 2008).

Surprisingly, the assessment of rice fragrance is still rather empirical, while robust methods of characterization do exist. However, the end-market evolution towards ready-to-eat meals does not lead consumers to identifying rice based on its genuine aroma when microwaveable seasoned rice methods are utilized in favor of the 20 minutes required for cooking pure fragrant rice. Nowadays, rice is primarily sold to end-users in plastic bags for safety and hygiene reasons. Consequently the aroma of fragrant rice is not a distinctive attribute for choice when purchasing before cooking. End-consumers in USA and Europe are less familiar with aroma of fragrant rice.

To summarize, the difference between coarse and fragrant rice is not obvious. The quality of the rice is measured by the rate of broken grains, whether they are aromatic or not. Genetic selection is providing new varieties with higher yields and less aroma. The level of aroma *per se* is assessed through a very simple and insufficiently codified method, allowing a broad range of subjective statements of what is fragrant rice. These trends give an implicit signal to collectors, traders, and millers: mixing different varieties of rice is not that illicit as far as it allows providing the always demanding world market with the required quantity and quality, in due time.

Trade-Oriented Sources

When looking for specialty rice, data on the trade is often available on the Internet, while data on the crop is by far less salient. Data on fragrant rice is mainly provided by trade sources (Ministry of Commerce in India and Thailand and rice exporters association in Pakistan), whereas agricultural ministries are supposed to have such databases. Overall fragrant rice production, for both export and domestic usage, is still unknown as data on the crop is not available. The most recent data on fragrant rice exports is sourced from the commodity chain stakeholders (country's board of trade) gathered by experts (Slayton and Muniroth 2011).

Due to a great variety of rice formats, the comparison of price/weight ratio is difficult when data is available on paddy, brown, husked, milled, parboiled or broken rice. Rice's loss in weight varies from 10% to 37% according to variety, cropping area and the type of machinery utilized during the harvesting, processing and packaging stages along the commodity chain (Bhattacharjee, Singhal and Kulkarni 2002). The first month for recording the rice campaign in Thailand is January, April in India, and July in Pakistan. Large databases from the FAO or USDA do not distinguish fragrant from coarse rice, except for price monitoring.

A comparative overview of databases presents a frustrating trade-off when analyzing global data. Discrepancies exist among recent data versus more detailed but older information. Erratic discrepancies exist between public and private sources—for the same year and same country. Our research found data scarcity and heterogeneity for this niche market. As a trade-oriented commodity, fragrant rice generates more data in value rather than in volume, making room for great permeability between fragrant and coarse rice production. This is an enlightening issue with respect to our research question: Will fragrant and coarse rice segments have the same future on trade?

Conclusion

The observations outlined in this paper provide a suitable orientation toward helping design a better future for the fragrant rice sector. While coarse rice is related to food security in cropping countries, fragrant rice is a trade-oriented commodity. Hence, the same regulations do not work with both rice categories. The export standards in India, Pakistan and Thailand, should be revised and rapidly implemented. Clean and fair practices should be promoted throughout the fragrant rice commodity chain in order to prevent the blending of coarse and fragrant rice. A noticeable split between coarse rice, as a commodity for usual markets, and fragrant rice as a specialty niche and valued market should be considered, as mentioned above. Price volatility may be the basic scenario for coarse rice, according to harvest variations and persistent high domestic demand in the main rice producing countries. For fragrant rice, high price might be the baseline with respect to stable increase of demand from rich importing countries.

In Thailand, fragrant rice is not a staple of the local diet; therefore fragrant rice production is mainly dependent upon trade policy. In India, where inhabitants are fragrant rice eaters, rice cropping is a strategic and sensitive issue with respect to food sovereignty; hence food policy may take the lead. However trade policy is also relevant as India's fragrant rice is not only a rich cultural heritage but also a trade-oriented commodity. In Pakistan, rice belongs to both the local diet and business trade, so food and trade policies should agree to compromise. Pakistani consumers are mainly wheat eaters, but their cultural identity includes basmati as staple food. For new players, such as USA, fragrant rice cropping is a rising issue for food sovereignty; for others, such as Vietnam and Cambodia, fragrant rice may be considered as a good trade opportunity, underlying the needs of a reliable commodity logistics chain.

Fragrant rice will not remain a quiet niche market; regardless of stability, price increases are foreseen (see Figure 4).

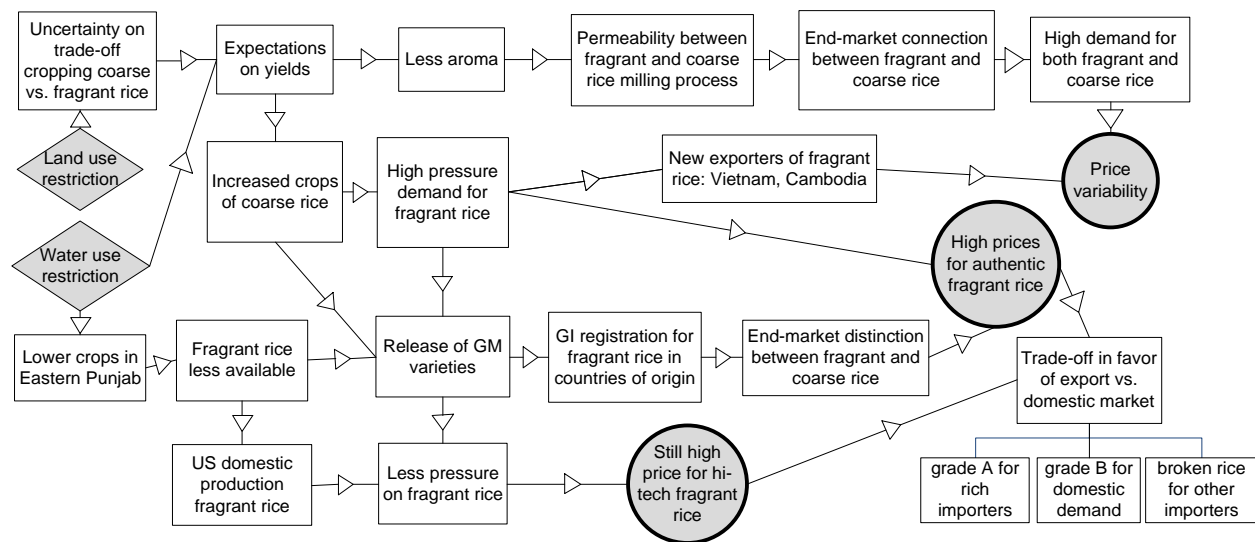


Figure 4. Scenarios for fragrant rice: between split and connection with coarse rice

Returning to our initial research question, we conclude that the forthcoming competition related to water scarcity issues between coarse rice with high yield and fragrant rice with low yield will probably lead to lower fragrant rice cropping or the development of new fragrant varieties with higher yields and less aroma. This scenario is the end-market connection between fragrant and coarse rice segments and like other commodities, involves price variability. A second possible scenario may occur with the release of GM varieties designed to fill the gap between the low production of fragrant rice and its high demand. In such a case, a split may occur between coarse and fragrant rice, with still higher pricing for hi-tech fragrant rice, despite this new production. The stakeholder's reaction to both fraudulent blending of non-fragrant rice and release of GM fragrant rice on the market may lead to a third scenario positioned between the first two. Hence GI registration may speed-up for both jasmine and basmati. This scenario may favor a new segmentation between GM, GI, and blended fragrant rice, with the related price matrix. Albeit more probable, the outcome of the split is not totally known between fragrant and coarse rice on trade. To be defined, this forecast needs further investigations into the cropping, trading and shipping aspects of both coarse and fragrant rice.

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Databases

FAO: <http://www.fao.org/economic/est/publications/rice-publications/rice-market-monitor-rmm/en/>
USDA: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1286>
Pakistan: <http://reap.com.pk/download/index.asp>
India: <http://commerce.nic.in/eidb/default.asp> basmati code 10063020
Thailand: <http://www2.ops3.moc.go.th/> jasmine code 10063040

Appendix 1.

Table 4. Fragrant rice -related characters according to variety

Variety	Yield (T/ha)	Tall (cm)	Maturity (days)	Aroma	Year of release
Basmati 370	2.5	170	140	4	1933
Hom Mali KDML105	4.1	140	140	4	1959
Basmati Pak	2.0	170	120	4	1968
Basmati 198	3.0	139	130	2	1972
Dehradun Basmati	3.3	115	150	3	1973
Kashmir Basmati	4.4	160	90	3	1977
Basmati 217	0.7	120	145	2	1987
Basmati 385	4.0	130	112	3	1988
Kasturi Basmati	4.0	102	125	1	1989
Pusa Basmati 1	4.0	90	150	2	1989
Haryana Basmati	4.5	116	143	1	1991
Khushboo 95	4.4	130	114	2	1996
Super Basmati	3.4	115	117	2	1996
Taraori Basmati	2.5	115	145	2	1996
Rachna Basmati	4.2	135	95	2	1999
Basmati-2000	4.5	135	115	2	2000
Shaheen Basmati	4.5	134	120	2	2001
Mahi Sugandh Basmati	5.3	92	132	2	2004
Jasmine Early Short	2.1	91	92	2	2009
Jazzman	7.7	99	121	2	2010

Source: Adapted from Akram 2009, Bhattacharjee et al. 2002, Rahman et al. 2009 and Baldwin and Childs, 2011

Appendix 2.

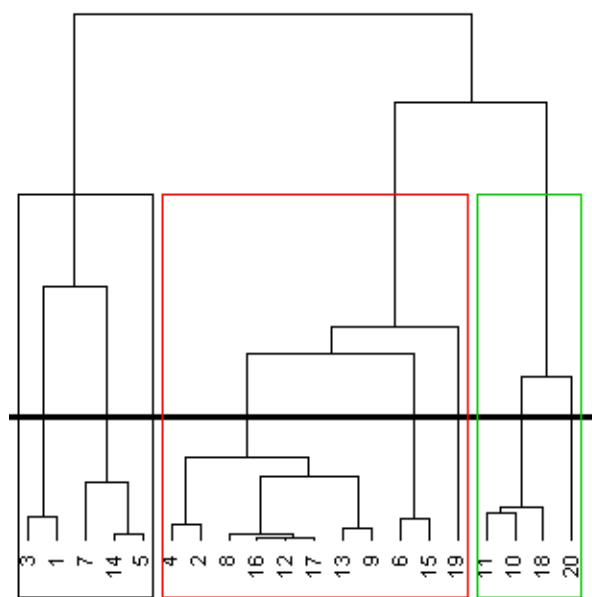


Figure 5. Ascendant hierarchical clustering on yield, tall and maturity days of fragrant rice varieties

Appendix 3.

Table 5. PCA results on yield improvement vs. tall and maturity days of 20 fragrant rice

Axis	Eigen values	% explained	% cumulated
1	1.26	42.10	42.10
2	1.16	38.55	80.65
3	0.58	19.35	100
variable coordinates	axis 1	axis 2	axis 3
Yield	0.79344462	-0.3989993	0.4596142
Tall	-0.7958337	-0.3938032	0.4599649
Maturity	0.00346721	0.917725	0.3972011
cos²			
Yield	0.62955	0.15920	0.21125
Tall	0.63335	0.15508	0.21157
Maturity	0.00001	0.84222	0.15777
variable contribution			
Yield	49.85	13.77	36.39
Tall	50.15	13.41	36.44
Maturity	0.00	72.82	27.17



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How Will Nanotechnology Affect Agricultural Supply Chains?

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Abstract

The development of nanotechnology creates an excellent opportunity to address complex technical issues of agricultural supply chains and heralds revolutionary changes. The potential application of nanotechnology to the agricultural and food supply chain is reviewed. Although there is evidence that nanotechnology could enhance agricultural supply chains, further research is necessary to determine whether awareness of the technical advances and benefits alone will be sufficient to overcome resistance to the implementation of these new technologies. Failure to embrace nanotechnology will deny the sector an opportunity to capitalize on improved product visibility, food safety, quality and security and associated economic benefits..

Keywords: nanotechnology, agricultural products supply chain, agri-food supply chain, nanosensors, nan composites, supply chain management, smart supply chain.

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Introduction

The next decade offers a period of unprecedented opportunity for newly-developed information and communication technologies (ICTs) to facilitate the rapid transformation of Supply Chain Management (SCM). SCM integrates major business functions and business processes within and across companies into a cohesive and high-performing business model. In addition to logistics management, SCM includes manufacturing operations and coordination of marketing, sales, product design, finance and information technology processes and activities (Nagurney 2006; Wikipedia 2012; CSCMP 2012).

Agricultural supply chains present one of the most significant opportunities for the utilisation of ICT developments to increase the efficiency and effectiveness of SCM. These supply chains have typically focussed on the movement of food from production to consumption. They include all the input supply, production, post-harvest, storage, processing, marketing, distribution, food service and consumption functions in the 'paddock-to-plate' or 'food-to-fork' continuum for a given food product (be it consumed fresh, processed and/or from a food service provider), including the external enabling environment. These functions typically span other supply chains, geographic and political boundaries and often involve a wide range of public- and private-sector institutions and organizations (Jaffee, Siegel, and Andrews 2008; Abatekassa and Peterson 2011; Porter, Baker, and Agrawal 2011).

Agricultural supply chains have unique characteristics which distinguish them from generic supply chains. Firstly, the agricultural chain from production to consumption is highly fragmented. As a result, information about market supply-and-demand and competitors and partners is widely dispersed and difficult to analyse. Secondly, the market price of agricultural production is subject to seasonal variation; and finally, the perishable nature of fresh produce limits the level of adjustment that can be made to accommodate variations across regions and seasons, in particular managing demands for logistics, warehousing, transportation and distribution level activities (Sporleder and Boland 2011).

Nanotechnology is a rapidly evolving technological solution that has enormous potential in agricultural supply chains. However, most of the current focus is on the technology itself, rather than how it could be applied to agricultural supply chains. The benefits from the technology are widespread; it has the potential to improve both products and processes, and in some cases, create new ones. As is to be expected with new technologies, there are also concerns about toxicity, the impact on human and environmental health and loss of privacy.

Nanotechnology is concerned with manufacturing to dimensions or tolerances of 100 nanometres to below 1 nanometre - from the ultraviolet wavelength to atomic dimensions (Franks 1987). Customized manufactured products are made from atoms; their properties depend on how those atoms are arranged. This is in effect the construction of functional systems on a molecular scale. Nanotechnology may be able to create many new materials and devices in a vast range of customized applications, such as medicine (e.g. engineered stem cells, implantable devices, customized antibodies), electronics (e.g. nanochips, nanosensors), materials (e.g. green concrete, smart polymers), food production (e.g. nano-modified, nano-additives) and energy creation (e.g., solar cells, light-trapping photovoltaics).

Alongside genetic technology and information technology, nanotechnology is one of the triad of advancements driving the future transformation of supply chains worldwide (Hewett 2006). Nanotechnology has already been applied to the management of supply chain processes associated with food quality, handling, packaging, and safety. In the field of agricultural supply chains, nanotechnology deployment is already bringing potential benefits to farmers, the food industry and consumers alike, through innovations in agri-food production, processing, preservation and packaging (FAO/WHO 2010).

A number of recent reports and reviews have identified the current and short-term projected applications of nanotechnologies in the agriculture food sector. The main areas of application include food packaging and food products that contain nanosized or nano-encapsulated ingredients and additives. The development of nanosized ingredients and additives appears to be directed towards enhanced uptake and bioavailability of nanosized substances in the body, although other benefits, such as improvement in taste, consistency, stability and texture have also been claimed (Kuzma and VerHage 2006; Bouwmeester et al. 2007; Chaudhry et al. 2007; Chaudhry et al. 2008; Groves 2008; FSAI 2008; Morris 2008; FAO/WHO 2010). For nanotechnology to move beyond its early promise, thereby transforming the management of agri-food supply chains and securing competitive advantage, the communications gap between technology providers and potential users needs to be bridged. Critical to this will be the recognition of the shared role of businesses, universities, research institutes and technology transfer organizations, in determining how nanotechnologies can improve agri-food supply chain management (Wilkinson 2002).

This paper reviews the application of nanotechnology to the agricultural supply chain. Because research into nanotechnology deployment in packaging is already well advanced, this paper will only highlight some examples of previous research before exploring in greater detail areas where research remains emergent. In the first section, issues related to nanotechnology in packaging will be reviewed under four basic types – polymer nanocomposites, antimicrobial, nanosensors and nanocoated films. In the second section we will report on the current application of nanosensor technology in tracking and tracing the supply chain. Following an examination of the potential application of nanotechnology in storage and distribution, the use of nanotechnology to enhance the supply chain safety and efficiency will be discussed. The final section concludes the study and summarises both findings and implications for future research.

Nanotechnology in Packaging

Some of the innovative developments in nanotechnology are likely to transform the food industry by revolutionizing food packaging and safety (Meetoo 2011). Most studies in this area have focused on food safety, examining how it can be used to control microbial growth, delay oxidation, improve tamper visibility, and create more convenience for both suppliers and consumers. Successful implementation would result in longer shelf life, safer packaging, better traceability of food products, and healthier food. This restricted application already supports development of improved tastes, color, flavor, texture and consistency of foodstuffs, increased absorption and bioavailability of nutrients and health supplements, new food packaging materials with improved mechanical, barrier and antimicrobial properties, and nano-sensors for traceability and monitoring the condition of food during transport and storage. Even before consideration of

more broad applications, it is predicted that nanotechnology will become one of the most powerful forces for innovation in the food packaging industry (Akbari, Ghomashchi, and Moghadam 2007).

Nanomaterials have multiple applications in food packaging systems, and these can overlap. Some immobilized enzymes, for example, can act as antimicrobial components, oxygen scavengers and/or nanosensors (Azeredo, Mattoso, and McHugh 2011). Accepting that there will be cross-over and blurring at the edges, there are four basic categories of applied nanotechnology research for food packaging: polymer nanocomposites, antimicrobial packaging, intelligent packaging concepts based on nanosensors, and nanocoated films. Of these, the research and application of polymer nanocomposites, antimicrobial packaging and nanocoated films is more advanced and some nano packaging products are already on the market. There is little doubt that intelligent packaging technology based on nanosensors will also have a significant impact on the food and agricultural supply chain. However allowance must be made for the inevitable delay between research outcomes and the development of a functional, commercial application.

Polymer Nanocomposites Packaging

Nanocomposite technology and materials can be used to improve the physical properties of packaging materials, to increase mechanical strength, thermal stability, gas barrier, physicochemical, and recyclability properties (Sorrentino, Gorrasi, and Vittoria 2007; Arora and Padua 2010). As Öchsner, Ahmed, and Ali suggested the properties of nanocomposites depend less upon their individual components than mixing two or more materials which are dissimilar on the nanoscale in order to control and develop new and improved structures and properties (Öchsner, Ahmed, and Ali 2009).

Montmorillonite and kaolinite clays show good potential and novel carbon-based graphene nanoplates are highly promising as nanocomposites (Arora and Padua 2010). When incorporated into polymer matrices, nanomaterials interact with the food and/or its surrounding environment, thus providing active or 'smart' properties to packaging systems. Such properties, when present in food packaging systems, are usually related either to improvements in food safety/stability or information about the safety/stability status of a product (Azeredo, Mattoso, and McHugh 2011). Natural biopolymer bio-nanocomposites-based packaging materials have great potential for enhancing food quality, safety, and stability as an innovative packaging and processing technology (Neethirajan and Jayas 2011). Plantic Technologies Ltd, Altona, Australia has manufactured and is selling biodegradable and fully compostable bioplastics packaging (Taylor and Thyer 2006). This is constructed from organic corn starch using nanotechnology (Neethirajan and Jayas 2011). Bio-degradable bio-nanocomposites prepared from natural biopolymers such as starch and protein exhibit advantages as a food packaging material by providing enhanced organoleptic characteristics such as appearance, odour, and flavour (Zhao, Torley, and Halley 2008). The unique advantages of natural biopolymer packaging include their ability to handle particulate foods, act as carriers for functionally active substances, and provide nutritional supplements (Rhim and Ng 2007).

Nanomaterials offer an opportunity to enhance the mechanical and thermal properties of packaging to improve the protection of foods from undesirable mechanical, thermal, chemical, or

microbiological effects. For instance, nanoparticles bonded in polymers can enhance material properties such as reducing weight, increasing recyclability, lessening spoilage and loss of and cross-contamination of flavors. Nanocor®, a global supplier of nanoclays, has developed Imperm®. Described as a gas barrier resin, Imperm® is a nanocomposite containing nanoclay particles, which restricts gas permeation, reducing the loss of carbon dioxide and impeding the ingress of oxygen, which, when used in the manufacture of beer bottles, maintains the freshness of the beer, giving it a six-month shelf-life (Asadi and Mousavi. 2006). In addition the bottles are stronger and lighter and less likely to shatter. Similar technology is also being developed for the US Government as a bio-security application which may be capable of detecting possible terrorist attacks on the US food supply (Ravichandran 2010; Nanotechnology 2011; Dingman 2008). Another everyday application is the detection of the molecular changes as milk begins to spoil. These changes could be used to trigger a reaction with nanoparticles embedded in the milk cartons, resulting in the carton changing colour indicating a deterioration in the milk quality. This would provide a visual sign to retailers and consumers about the “freshness” of the milk (Nanotechnology 2011; Dingman 2008).

Kriegel et al (2009) have developed a methodology which uses an electrospinning technique to make biodegradable “green” food packaging from chitin. Chitin is a natural polymer and one of the main components of lobster shells. The electrospinning technique used involves dissolving chitin in a solvent and drawing it through a tiny hole with applied electricity to produce nanoslim fibre spins. These strong and naturally antimicrobial nanofibres have been used for developing the “green” food packaging (Neethirajan and Jayas 2011). Many companies are creating a competitive advantage by producing food packaging bags and sachets from biodegradable polylactic acid and polycaprolactone obtained from the polymer nanocomposites of the corn plant (Bordes, Pollet, and Avérous 2009; Neethirajan and Jayas 2011).

Polymer nanocomposite technology holds the key to future advances in flexible, intelligent, and active packaging. Once production and material costs decrease, companies will be able to use this technology to increase their products’ stability and survivability through the supply chain to deliver higher quality to their customers while reducing costs (Mohan 2005). However, further work is required in the development of more compatible filler-polymer systems, better processing technologies, and a systems approach to the design of polymer-plasticizer-fillers (Magnuson, Jonaitis, and Card 2011).

Antimicrobial Packaging

Microorganisms are the most common cause of food poisoning and cause food spoilage, rendering food unfit for human consumption. Antimicrobial packaging systems can extend a product’s shelf life and maintain food safety by reducing the growth rate of microorganisms. This is of obvious benefit to the food industry and consumers. Anti-microbial nanoparticle coatings in the matrix of the packaging material can reduce the development of bacteria on or near the food product, inhibiting microbial growth on non-sterilized foods and maintaining the sterility of pasteurized foods by preventing post-production contamination.

Antimicrobial packaging systems include the addition of an antimicrobial nanoparticle sachet to the package, dispersing bioactive agents in the packaging; coating bioactive agents on the surface

of the packaging material, and utilizing antimicrobial macromolecules with film-forming properties or edible matrices (Coma 2008). Applications of packaging nanotechnologies have been shown to increase the safety of food by reducing material toxicity, controlling the flow of gases and moisture, and increasing shelf life (Watson, Gergely, and Janus 2011).

There is a broad range of antimicrobial nanoparticles that have been synthesized and tested for applications in antimicrobial packaging and food storage boxes; these include silver oxide nanoparticles (Sondi and Salopek-Sondi 2004), zinc oxide, and magnesium oxide nanoparticles (Jones et al. 2008) and nisin particles produced from the fermentation of bacteria (Gadang et al. 2008).

Foods that are prone to spoiling on the surface, such as cheese, sliced meat, and bakery products, can be protected by contact packaging imbued with antimicrobial nanoparticles. Rodriguez, Nerin, and Batlle (2008) developed an antifungal active-paper packaging, incorporating cinnamon oil with solid wax paraffin using nanotechnology as an active coating; this proved to be an effective packaging material for bakery products. Working with oregano oil and apple puree, Rojas-Grau et al. (2006) created edible food films that are able to kill *Escherichia coli* bacteria (Neethirajan and Jayas 2011).

CTC Nanotechnology GmbH, Merzig, Germany has manufactured and is now selling a nanoscale dirt-repellent coating to create self-cleaning surfaces for use in food packages and meat-processing plants. This concept is based on a sol-gel process in which nanoparticles are suspended in a fluid medium. By the action of nanohydrophobisation, the absorbency of the surfaces to be treated is eliminated so that they remain resistant to environmental factors after cleaning, with the added advantage that this product is biodegradable and approved and certified for use with food (Neethirajan and Jayas 2011).

Intelligent Packaging Concepts Based on Nanosensors

Nanosensors in intelligent packaging can be designed to indicate the freshness of food, reduce spoilage by releasing preservatives and, based on the consumer's preferences or needs, adjust the sensory appeal and/or nutritional value by secreting colors, flavors or supplements. The use of nanotechnology can, for example, modify the permeation behavior of foils, increase barrier properties (mechanical, thermal, chemical, and microbial), improve mechanical and heat-resistance properties, develop active antimicrobial and antifungal surfaces, and sense as well as signal microbiological and biochemical changes (Tiju and Morrison 2006; Neethirajan and Jayas 2011; Brody 2003; Chaudhry et al. 2008).

One innovative deployment of nanotechnologies in packaging solutions is the reduction of spoilage through deployment of sensors built into food packages (Busch 2008). Nanosensors have been developed which can be applied as labels or coatings to add an intelligent function to food packaging in terms of ensuring the integrity of the package through detection of leaks (for foodstuffs packed under vacuum or inert atmosphere), indications of time-temperature variations (e.g., freeze-thaw-refreezing), and microbial safety (deterioration of foodstuffs) (FAO/WHO 2010; Mahalik and Nambiar 2010; Watson, Gergely, and Janus 2011). Intelligent food packaging can sense when contents are spoiling, and alert the retailer and consumer. Furthermore

production, processing, and shipment of food products could be made more secure through the use of nanosensors for pathogen and contaminant detection (Dingman 2008).

Food safety requires confirmation of the provenance and authenticity of a product. Nanobarcodes incorporated into printing inks or coatings show excellent potential for the management of product tracing and the authenticity of the packaged product (Han et al. 2001). Food quality indicators have also been developed to provide visual indications to the consumer of when a packaged foodstuff starts to deteriorate. Used for meat, a nanosilver layer is opaque light brown initially, but if the meat starts to deteriorate, silver sulphide is formed and the layer becomes transparent, indicating that the food may be unsafe to consume (FAO/WHO 2010). In addition, spoilage can be revealed, for example, by an indicator that turns from transparent to blue, informing the consumer that air has entered the modified atmosphere of the packaged materials. For this type of application, nanotechnology-derived printable inks have been developed. An oxygen-detecting ink containing light-sensitive (TiO₂) nanoparticles detects only oxygen when 'switched on' with UV light (Park et al. 2007). Other conductive inks for ink jet printing based on copper nanoparticles have also been developed (Park et al. 2007; FAO/WHO 2010).

One of the most promising innovations in smart packaging being pursued by many companies has been the use of nanotechnologies to develop antimicrobial packaging to prolong product shelf-life (Meetoo 2011) and reduce the need for man-made preservatives (Sekhon 2010). One material developed for potential food packaging applications is based on nanostructured silicon with nanopores. The potential application includes detection of pathogens in food and variations of temperature during food storage. Another relevant development is aimed at providing a basis for intelligent preservative packaging technology that will release a preservative only when the packaged food begins to spoil (ETC-Group 2004; FAO/WHO 2010).

The apparent benefits of substituting active ingredients or carriers with nanosized equivalents has also opened the door to research into the potential applications of nanotechnology to pesticides, veterinary medicines and other agrochemicals such as fertilizers and plant-growth regulators. The anticipated benefits, which are driving current R&D in these areas, include a potential reduction in the use of certain agrochemicals (such as pesticides) and an increased ability to control the application and dosage of active ingredients in the field. Despite a great deal of industrial interest in this area, research is still in an embryonic stage. Although most developments are currently at a developmental stage, it is likely that the agriculture sector will see some large-scale applications of nanotechnologies in the next decade that will alert the consumer to the agrochemicals currently being used in the agriculture production (MacKenzie 2007; FAO/WHO 2010).

There are many other research initiatives exploring more complex, smarter packaging. These include the use of an array of nanosensors which are sensitive to gases released by food as it spoils, indicating if it is no longer 'fresh' (Meetoo, 2011) or triggering the release of preservatives to extend the life of the food (Ravichandran 2010). Kraft Foods is also engaged in producing products which incorporate nanosensors that detect a consumer's food profile of likes and dislikes, allergies and the person's nutritional deficiencies. Nanotechnologies could then respond by releasing accurately controlled amounts of suitable molecules to tailor the smell, taste

and nutritional value of the product to match the personal preferences of an individual consumer (Meetoo 2011)..

Nanocoated Films

Nanofilms have the virtue of keeping unwanted materials or contaminants out of food, as well as improving the protection of food sealed inside the package. Nanocoated films are usually composed of layers of polymers that are designed as barriers to flavour, water, and/or gas. Studies have shown that layers of nanoparticles imbedded within a single polymeric film (nanocomposites) improve upon a previous layer polymeric film's barrier and protection properties (Kuzma, Romanchek, and Kokotovich 2008; Meetoo 2011).

A wide number of nanoparticles, including silica, silicate, clay, organomontmorillonite, and calcium carbonate, are used in nanocomposites for food packaging (Chu, Keung, and Su 2003; Lagaron et al. 2005; Kuzma, Romanchek, and Kokotovich 2008). These particles fall under the more general category of clay nanoparticles, or 'nanoclays'. Clays exist in a structure held together in crystalline form. By breaking the crystal structure leaving only the platelets, a nanoclay is created (Frazer 2004). The high aspect ratio (width divided by height) and the large surface area create desirable barrier properties, reinforcing efficiency, and improving thermal stability (Zeng et al. 2003). The nanoclays are then imbedded into a polymer film to create a nanocomposite. These nanocomposites decrease the diffusion of oxygen and carbon dioxide in and out of packaging material, keeping food fresher for longer periods of time. They also help reduce the health risks associated with bacterial growth in food i.e., lower oxygen for growth (Kuzma, Romanchek, and Kokotovich 2008).

Many recent developments are extending even further the potential for nanocoated films to enhance the safety and quality of food supply (Magnuson, Jonaitis, and Card 2011). The foundations of the current research can be found in a study by De Moura et al. (2008), that showed how the tensile, water vapour, and oxygen-permeable properties of edible films could be significantly improved through the application of nanoscience. Azeredo et al. (2010) described the use of cellulose nanofibers and glycerol as a plasticizer to improve the mechanical and water-vapour barrier properties of edible chitosan films. They reported that nanocomposite film with 15% of cellulose nanofibers and plasticized with 18% glycerol was not only comparable in strength and stiffness to some synthetic polymers, albeit with poorer elongation and water vapour barrier properties, but was also extremely environmentally friendly. In 2011, Dobon et al. (2011) outlined the potential cost savings from deployment of a new smart-packaging concept with a communication capability embedded in a device. This allows the expiry date of the product to change as a function of temperature during transport and storage; in effect a flexible best-before-date (FBBD).

Nanotechnology in Tracking and Tracing

Nanotechnology can enhance agricultural SCM by improving supply chain visibility, food authenticity, tracking and traceability and ultimately food security through features that assist avoid counterfeiting, product adulteration and diversion (Neethirajan and Jayas 2011; FAO/WHO 2010). Radio Frequency Identification (RFID) technology is widely deployed and

globally appreciated as a major technological enhancement to the management of tracking, information collection and reporting within a supply chain. However, the advantage of enhancing RFID with nanotechnology is still emerging. Through experimentation and analysis of results using multiple variables, Mapa, Aryal et al. (2010) confirmed the improved readability of RFID tags in the presence of various nanofluids at different concentrations on a conveyor belt, an example of a typical packaging environment.

Watson Gergely and Janus (2011) concluded that refinements to the use of RFID tags with nanotechnologies used on agricultural products gave government and industry greater supply chain and product traceability in the event of a food recall. RFID tags or 'smart' labels are being developed with displays that enable rapid and accurate distribution of a wide range of products (including foodstuffs) that have a limited shelf-life. RFIDs incorporating polymeric transistors that use nanoscale organic thin-film technology are under development. The smart tag system will be designed to operate automatically providing exception reports for anomalies in temperature and other factors that affect the quality and safety of perishable foods products and products with a short life span (Garland 2004).

To help in the tracking and tracing, nanotechnology provides complex invisible nanobarcodes with batch information which can be encrypted directly onto the food products and packaging. This nanobarcode technology offers food safety by allowing the brand owners to monitor their supply chains without having to share company information with distributors and wholesalers (Neethirajan and Jayas 2011). It is interesting that nanotechnology can provide not just security but also the enforcement of brand-protection. Nanotechnologies can be embedded in a product to enable brand owners to assure customers of its authenticity and for investigators to identify genuine goods, making it very difficult for counterfeiters to imitate. Using nanotechnology, companies can encrypt unique product information such as data about growing conditions — climate and soil — collected from on-farm sensors. This can not only inform buyers about food quality, but also confirm product pricing and, very importantly, assure greater security and safety if a product recall requires data relating to product origins. Nanotechnology can also be encrypted with logistics information, such as processing or batch information, directly onto the product or packaging (Roberts 2007). Oxonica in the United Kingdom offers solutions for food product identification and brand authenticity whereby the nanobarcodes become a biological fingerprint created by nanoparticles which generate unique reading strips for every food item (Neethirajan and Jayas 2011).

In order to allow better information delivery in tracking and tracing, some nano-based products may be able to encrypt information technology in the form of nanodisks functionalized with dye molecules to emit a unique light spectrum when illuminated with a laser beam, so that they can be used as tags for tracking food products (Nam, Thaxton, and Mirkin 2003). A nanobarcode detection system is being developed that fluoresces under ultraviolet light in a combination of colours that can be read by a computer scanner (Li, Cu, and Luo 2005). Dip Pen Nanolithography involves using a scanning probe with a molecule-coated tip to deposit a chemically engineered ink material to create nanolithographic patterns on the food surface (Zhang et al. 2009).

Roehrig and Spieker (2008) present a technique to monitor the manual transportation processes of goods in a warehouse, in order to update the database automatically. In the proposed scenario, transport vehicles such as forklift trucks or pallet jacks would be equipped with wireless sensor nodes and every storage and retrieval activity would be reported to the warehouse management system. Tracking of transport vehicles is performed with nanoLOC sensor nodes, which offer range measurement capabilities. This radio positioning system determines the range between two devices by measuring the signal propagation delay. The tracking of transport vehicles with range measurements and trilateration could be carried out by using the Extended Kalman Filter. Experimental results were presented of tracking a forklift truck in a warehouse.

Due to the cost of introduction and user acceptance of such applications, nanotechnology in tracking and tracing within agricultural supply chains is still in the experimental stage, although there is a considerable amount of research being undertaken. It should be noted that there are some applications of nanotechnology already introduced into industry supply chains; early success of such applications suggests they could be introduced into the supply chain of agricultural products with positive effect.

Nanotechnology in Storage and Distribution

The quality of goods in storage and distribution can be adversely affected by changes in the storage environment, such as temperature, humidity and odour. Nanotechnology can be applied to agri-food SCM track and report these changes.

Packaging that incorporates nanomaterials can respond to environmental conditions to self-repair or alert the consumer to contamination and/or the presence of pathogens (Baumner 2004). Such packaging enhances information collection and product management in relation to environmental conditions relating to such factors as temperature and moisture during storage and distribution. In providing solutions for these problems, nanotechnologies can modify the permeation behaviour of foils, increasing barrier properties; for example, mechanical, thermal, chemical and microbial, improving mechanical and heat-resistance properties, developing active anti-microbial and anti-fungal surfaces and sensing as well as signalling microbiological and biochemical changes (Meetoo 2011).

Active packaging films for selective control of oxygen transmission and aroma affecting enzymes have been developed based on the nanotechnology approach. Modification of the surface of nanosized materials by dispersing agents can act as substrates for oxidoreductase enzymes (Neethirajan and Jayas 2011). Nanocomposite film can be enriched with an enormous number of silicate nanoparticles that reduce the entry of oxygen and other gases and the exit of moisture, thus preventing food from spoiling (Scheffler et al. 2010). Nanocrystals have been developed that can be used in nanocomposite plastic bottles. This material minimizes the loss of carbon dioxide and the entry of oxygen into beer bottles (Sekhon 2010). Smart-sensor technology could be very useful for monitoring the quality of grain, dairy products, fruit and vegetables in a storage environment in order to detect the source and the type of spoilage (EduTransfer Design Associates 2007).

Liu et al (2011) report that a water quality monitoring sensor composed of single-walled carbon nanotubes has been developed. It can be integrated inside microfluidic channels and on-chip testing components with a wireless transmission board. This nanosensor should be useful for sensing and reporting real time information regarding the product from production through to delivery to the consumer.

Nanotechnology also has shown remarkable properties applicable to other aspects of storage and agri-food distribution. For example:

- Nanoencapsulation offers numerous benefits including ease of handling, enhanced stability, protection against oxidation, retention of volatile ingredients, taste masking, moisture-triggered controlled release, pH-triggered controlled release, consecutive distribution of multiple active ingredients, changes in flavour, long lasting organoleptic perception, and enhanced bioavailability and efficacy (Shefer 2012).
- Nanomaterials with food and bioprocessing applications can be produced from engineered plants or microbes from waste materials such as stalks and other cellulosic materials (Robinson and Morrison 2009).
- Single-walled carbon nanotubes form a nanosensor which, in addition to use in water quality monitoring and fresh fish storage and distribution, can be integrated inside microfluidic channels and on-chip testing components with a wireless transmission board (Liu et al. 2011).

Other Applications in Agri-SCM

Nanotechnology in Supply Chain Safety

Quality assurance in the food supply chain is of the utmost significance, not just because of the legal implications for the producer and supplier, but also because of the importance of satisfying increased demand from consumers for safe and quality food and to meet stringent government food safety regulations. Nanotechnology has shown significant promise in the enhancement of sensors able to detect spoilage or changes to product quality. To ensure food safety, EU researchers in the Good Food Project have developed a portable nanosensor to detect chemicals, pathogens and toxins in food (Tiju and Morrison 2006). This circumvents the very time consuming and expensive alternative of sending samples to laboratories. Food can be analysed for safety and quality at control points in the supply chain; for instance at the farm, abattoir, during shipping, at the warehouse or storage depot, and at the processing or packaging plant. They are also developing a device which uses DNA biochips to detect pathogens - a technique that can also be applied to determine the presence of different kinds of harmful bacteria in meat or fish, or fungi affecting fruit. In addition there are plans to develop microarray sensors that can be used to identify pesticides in fruit and vegetables as well as those which will monitor

environmental conditions at the farm. These have been called ‘Good Food Sensors’ (Tiju and Morrison 2006).

Nanosensors are far from being just a passive, information-receiving device. They can receive information from immediate and remote contexts and can analyse, record and report data. They can be designed to do this at critical control points in the supply chain over the period of time from the point food is produced or packaged, through to the time it is consumed. The latest developments have resulted in nanosensors able to provide quality assurance by tracking microbes, toxins and contaminants through the food processing chain by using data capture for automatic control functions and documentation.

Advances in miniaturized instrumentation have also resulted in the development of biosensors capable of integrating bio-recognition and spectroscopy tools to support pathogen detection, thus addressing safety concerns in the food supply chain. The development of smart and robust sample preparation methods can lead to the effective incorporation of similar strategies over a wide array of currently available mid-IR technologies that can be used in field at sites-of contamination as portable sensors (Ravindranath 2009). In another development, a direct-charge transfer (DCT) biosensor has been created that uses antibodies as sensing elements and polyaniline nanowire as a molecular electrical transducer (Pal, Alocilja, and Downes 2007). The resulting biosensor could be used for the detection of the foodborne pathogen, *Bacillus cereus*.

Nanotechnology in Supply Chain Efficiency

Smart sensors, that is sensors which have “intelligence” capabilities are likely to revolutionise agriculture supply chain management in the near future (5-8 years). Smart sensing is mostly applicable to micro-electromechanical systems (MEMS) technology, which integrates mechanical elements, sensor material and electronics on a common silicon chip through microfabrication techniques. Initial work by the Intermec Technologies Corp. to use MEMS-based technology in supply-chain data collection equipment has confirmed it is possible to produce laser data collection scanners that are significantly faster, smaller, lighter and more efficient than today's legacy scanners (Anon 2005). Subsequent tests confirm that MEMS-based laser scanners are able to read bar codes up to 40 times faster with more accuracy; a massive advancement over existing scanner technologies that highlights the need for even better information management technologies to be developed before improvements to supply chain visibility can be fully realised (Anon 2005). Later developments have therefore moved into a field related to smart sensing - smart decision analytics. This is based on a the capture, analysis and reporting of the data obtained from the smart sensors (Tien 2011). Due to the superiority of nanotechnology, it will soon be possible to embed the present technology in the SCM to improve the efficiency of the supply chain.

Discussion and Conclusions

Agricultural and food supply chain management is complex due to the diverse characteristics of agricultural products. There are numerous types of agricultural products, many of which are

perishable. In addition, the degree of standardization of some kinds of agricultural products and their management is still low. Furthermore, agricultural production sites are still very fragmented and often highly dispersed. Because of the inherent complexity of agricultural products, the deployment of technology in the agricultural supply chain has the potential to provide more significant and far-reaching benefits compared to other industries. For example, the tracking and tracing of perishable food products in the supply chain can be more precise than in a manufacturing supply chain. New technology once deployed in the agricultural and food supply chain can be targeted to known problems in order to profoundly improve visibility, promote ubiquitous access to data, promote even higher efficiency and lower costs (Ward, Woods, and Wysocki 2011; Amanor-Boadu, Marletta, and Biere 2009).

As one of the fastest growing areas of research and technology, which is being heralded as the basis of the next industrial revolution (Marchant 2009), nanotechnology offers the potential to make most products lighter, stronger, cleaner, less expensive and more precise. Nanotechnology has the potential to fundamentally alter the way people live, by providing new drug delivery systems, faster and cheaper manufacturing processes, cleaner and more efficient energy generation, new materials, clean water and the next generation of computing devices. In fact, nanotechnology is already having a profound impact on major industries worldwide, including electronics, computers, communications, national defense, energy, biomedical, transport and manufacturing. Nanotechnologies such as nanosensors are sufficiently robust and developed to a point where they can radically reshape supply chains across all locations and types of industries, modes of transport or goods. However, although nanotechnologies can have significant potential to remove complexity and manage variables in the agri-food supply chains, they have not yet been adopted on a large scale.

Nano and nano-intelligent technologies have a wide application to the process of supply chain (e.g. sensors, buy and sell intelligent agents or quality, security and safety control through nano materials in and on food, goods, packaging and freight). For instance nano-sensors can be used in the determination of the ripeness and freshness of packaged produce, and in the detection of pathogens in animal food production systems (e.g. detection of harmful viruses which infect cattle) and in farm, food and environmental samples before they can contaminate the food.

Investigation confirms that incremental application of nanotechnology in the agricultural supply chain, first in the food packaging, and later in other areas such as tracking and tracing and storage and distribution, is occurring. Currently, most nanotechnology applications in the agricultural supply chain are concentrated in packaging, mainly in the improvement of packaging materials for product security, quality and safety. From the point of view of the supply chain, the logical extension is the application of intelligent packaging based on nanosensors with a view to promoting information and management across all elements of an agricultural supply chain. Compared with traditional sensors and their shortcomings, nanosensors have several

advantageous properties, such as high sensitivity and selectivity, near real-time detection, and low cost and portability.

Existing nanotechnologies can radically reshape supply chains across all locations and types of industries, modes of transport or goods. The benefits for the agricultural supply chain are equally exciting. Beyond the next phase of development - extending nanotechnology from packaging to nanosensors - there seems to be every reason to examine nanotechnology deployed not as a product specific packaging enhancement, but as an intentional and controlled exercise intent in constructing a 'Smart Supply Chain', in which nanotechnologies are deployed to deliberately improve the level of product visibility, security, quality, safety and introduce efficiencies across an entire agricultural supply chain. Nanotechnologies permit such deployment because they are autonomous, permit a two-way data flow, can be oriented towards human goals and can permit communities of people to work together in more powerful ways than previously conceived of. They remove unnecessary complexity in variables such as diversity of products, locations and characteristics of each product type that have been impeding the positive transformation of the management of agri-food supply chains. Smart Supply Chains in agriculture, as foreshadowed by this review, can leverage existing advancements in nanotechnologies in order to enable supply chain efficiencies only possible through ensuring that product-level data collection is more detailed, more accurate and available almost in real time.

From this review, we can see that nanotechnology has potential applications in every aspect of the agricultural and food supply chain, although some of the specific applications are still slowly transitioning from research into wide-scale, commercial deployment. Given nanotechnologies have been developed to a point where their significant contribution to competitive advantage in agriculture supply chains is known, the gap between technology R&D and adoption by potential businesses remains stark. Despite the overwhelming possibilities demonstrated by scientific research, levels of adoption of the technology within the agricultural supply chain remain relatively low. Furthermore the application of nanotechnologies to agricultural supply chains raises concerns about serious ethical arguments, regulatory and broader human and environmental health issues (European Food Safety Authority 2012; EFSA Scientific Committee 2011; Scientific Opinion of the Scientific Committee 2009).

The economics of nanotechnology application in the agricultural supply chain is no different to the application of other new technologies. Initially, the outlay is relatively high, which impedes uptake of the new technology. Although the cost of some nano packaging materials has been reduced, the price of nano-sensors is relatively high. In the short to medium term, with large-scale applications, as well as the improvement of production technology, nano-technology costs will decrease significantly. In the long term, with the popularity of nanotechnology, the cost of the application of nanotechnology in the agricultural supply chain will become cost effective.

Just as early ICT brought a technological revolution to food and agribusiness industry, nanotechnology will bring revolutionary improvements to the agricultural supply chain. It is imperative that the food and agribusiness industry is aware of and understands the opportunities and challenges that nanotechnology offers. Future technological and managerial innovations should take full advantage of nanotechnology, thus improving the efficiency, food safety, compliance, eco-friendliness, and competitiveness of and realizing the economic benefits for individual producers, companies and the sector in the long term.

Although a large amount of information is now available about the advantages of nanotechnology for agricultural supply chains, further research is needed to realize fully the potential of nanotechnology within the industry. Can the resistance of elements within agricultural supply chains be overcome by simply the knowledge of nanotechnological advances and benefits? Is this knowledge sufficient in itself to accelerate the adoption of these technologies by industry, and lead to improved product visibility and food safety, quality and security? The answers to these questions are of critical importance, not just for those seeking to develop the nano-technology but also for those employing the technologies.

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Analysis of Differences in Meat Consumption Patterns

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Abstract

Even though nowadays meat is affordable for nearly everyone in western societies, demand has been decreasing in Germany. Thus, not only income, which is the dominant determinant in emerging economies, but also other factors seem to affect meat consumption.

With an a-priori segmentation and a multiple group comparison of “low”, “average” and “heavy” meat consumers, this paper analyzes in which attitudes towards meat “Low Meat Consumers” differ from typical consumer behavior. The results show that “Low Meat Consumers” generally are more concerned about individual and ethical issues of meat consumption.

Keywords: attitudes, consumer, meat, multiple group comparison

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Introduction

In emerging economies, the per capita meat consumption increases with the per capita Gross Domestic Product (GDP), whereas the curve stagnates or even declines for countries with a GDP of more than about 25,000 US\$ PPP (Purchasing Power Parity) (FAO 2009). In Germany for instance, a fall in demand has been observed since the 1990s. Whereas at the beginning of the 1990s the average per capita consumption of meat was about 65 kg per year, today this has been reduced to about 60 kg (Gurath 2008). If this trend continues, the per capita meat consumption will decrease to about 53 kg per year in 2030 (Spiller et al. 2010), which would have a serious impact on the German meat market.

Nevertheless, meat consumption will, in line with the economic development and the growing world population, grow worldwide. The increase is highest in poultry consumption, lower in pork and beef. Overall, the demand for grain and other traditional food will decrease in favor of animal foods (DBV 2012).

Interestingly, in this context, it can be stated, that the reduction of meat consumption in Germany does likewise not include all meat types. Whereas the consumption of pork and beef declines, the per capita consumption of poultry is rising (DBV 2010, Spiller et al. 2010).

Thus, not only income, but also other factors seem to affect meat consumption. A multitude of attributes and beliefs, such as animal welfare, health or environmental effects concerning the consumption of meat are discussed in this context (e.g. Richardson et al. 1993; Lea & Worsley 2001; Guenther et al. 2005; De Boer et al. 2007).

In order to gain detailed insights into the multiple attitudes and the social environment that might have impact on the amount of meat consumed, a consumer survey was undertaken in this study. Most studies use regression models to explain meat consumption, whereas in the present analysis participants are a-priori segmented in “low”, “average” and “heavy” consumption patterns. This simplifies the understanding for managers. The study thereby focuses on attitudes that are distinguished as most influential according to the literature and expert discussions. In addition, socio-demographic factors, such as age or income, are considered.

The results of the analysis are not solely interesting from a scientific point of view, but also important for decision makers of the meat chain, who are confronted with new challenges caused by societal and demographic changes.

Theoretical Background

As mentioned above, a multitude of studies deal with consumer attitudes towards meat and meat consumption in developed countries (e.g. Woodward 1988; Richardson et al. 1994; Verbeke and Viaene 1999; Grunert 2006; Verbeke et al. 2010). These studies regard various attitudes as

relevant for building an image of meat in general or of special meat types or product variations. Likewise, the impact of attitudes on meat consumption has been analyzed, particularly since a reduction of meat consumption in western populations is occurring (FAO 2009).

To some extent, changes and differences in meat consumption can be explained by socio-demographic dimensions. Particularly gender has a strong influence on attitudes towards meat and meat consumption. Following the literature it can be stated that men generally consume more meat than women and that women are more concerned about a healthy diet and about food choices in general (Beardsworth & Bryman 1999, 2004; Lea & Worsley 2001; Gossard & York 2003; Praet et al. 2006). A negative determinant of meat consumption can be seen in the age of consumers (Gossard & York 2003; De Boer et al. 2007). Gossard and York (2003) also found that social class has substantial impacts on beef and total meat consumption. In their study, those in laborer occupations and people with a low level of education ate more beef and meat in general than people in service or professional occupations and people with a higher level of education. Furthermore, beef consumption increased with higher income, whereas the total meat consumed was not affected by income. Consumers with medium and high income are also a target group for premium beef (Kim & Boyd 2004). In Germany, the comprehensive National Nutrition Survey II revealed that men belonging to the lower class ate 20% more meat and meat products than men belonging to the upper class. For women, there is a minimal difference of 7 grams per diem between upper and lower class (MRI 2008). By contrast, Beardsworth and Bryman (1999, 2004) found no association between the respondents' social class and their food choices. Since they conducted an eleven year longitudinal study with undergraduate students in the UK, a certain class position bias may be pre-sent in their findings. Further socio-demographic impacts on meat consumption can be seen in race, ethnicity, location of residence and religion (Beardsworth & Bryman 1999; Gossard & York 2003).

These social structural dimensions can be seen as the context in which psychological factors operate. So even if their impact on meat consumption in developed countries is smaller than the influence of psychographic determinants, they play an important role in shaping individual attitudes (Gossard & York 2003).

As described above, the focus of this study lies on these psychographic factors.

The main reasons given by consumers for reducing their meat consumption or avoiding meat completely seem to be health and diet related. The nutritional awareness of meat, the perceived unhealthiness, concerns about additives or the perceived fat content can be mentioned in this context (Woodward 1988; Beardsworth & Keil 1991; Richardson et al. 1993, 1994; Verbeke & Viaene 2000; Lea & Worsley 2001). The aspect of health plays an important role concerning the consumption of meat. Especially red meat is associated with a higher risk of health complaints like coronary heart disease (Huijbregts et al. 1995; Mahley et al. 1995), Type 2 Diabetes (Song et

al. 2004; van Dam et al. 2002) and different types of cancer (Chao et al. 2005; Tavani et al. 2000).

Besides health, Woodward (1988) evaluated individual price considerations as main reason for eating less meat.

Ethical factors or outcomes as external effects of meat production and consumption have also been discussed as main forces determining attitudes towards meat and meat consumption. Primarily animal welfare concerns are considered to result in a reduction of meat consumption (Woodward 1988; Beardsworth & Keil 1991; Richardson et al. 1993, 1994; Verbeke & Viaene 1999; Lea & Worsley 2001; Guenther et al. 2005; De Boer et al. 2007). The good treatment of animals is one of the future lifestyle trends concerning meat consumption (Grunert 2006). Sustainable consumers prefer animal-friendly produced meat (Harper & Henson 2001).

The role of environmental awareness in this respect is controversial. While De Boer et al. (2007) found a negative influence (of universal values) on reported meat consumption, Richardson et al. (1993) found by contrast no influence of environmental awareness, whereas Lea and Worsley (2001) only found impacts of universal values on women's meat consumption. According to McCarty et al. (2003, 2004) environmental concerns had no significant influence on the attitude towards meat.

Further aspects affecting meat consumption are seen in the influence of reference groups (Richardson et al. 1994; Lea & Worsley 2001) and in a lack of trust in the product or information sources (Richardson 1994; Verbeke & Viaene 2000; Lea & Worsley 2001). Also, the negative image of meat (Andersen et al. 2005) and the bad reputation of the agri-food industry (Albersmeier & Spiller 2010) are considered responsible for decreasing meat consumption. Especially meat scandals contribute to consumer uncertainty (Saghaian & Reed 2007; Verbeke et al. 1999), associated with mistrust against food safety in meat industry (Goldsmith et al. 2003; Latvala & Kola 2003).

In contrast to the traditional view of meat as being tasty (Richardson et al. 1994), a dislike of the taste of meat and the disgust of preparing a dead animal are seen as factors leading to a reduction or avoidance of meat (Woodward 1988; Beardsworth & Keil 1991; Richardson et al. 1993, 1994).

However, according to Richardson et al. (1994) meat choice or avoidance motives are often multi-layered and therefore no single issue should be considered separately: "Views might be classed as ethical, philosophical, aesthetic, psychological, political, economic, cultural, ecological, nutritional, medical, and countless ways besides. Which influences are of primary relevance, and how they are categorized, depends largely on context and orientation of the research."

Sample Description and Research Design

In the present study, 990 consumers were interviewed online with a standardized (identical) questionnaire in the spring of 2011. The respondents were recruited with the help of a private market research provider. In order to draw conclusions about the German population from the sample, the participants were selected by socio-demographic quota specifications. The gender ratio in the sample is 48.8% men and 51.2% women. The respondents (30.7%) are 18 to 39 years old; 36.9% are between 40 and 60 years old and 32.4% are older than 60 years. Sixteen percent of the respondents live in Northern Germany, 27.5% in Southern Germany, 20.5% in Eastern Germany and 36.1% in the Western part of Germany. The largest group—41.7% of the participants—live in villages with fewer than 20,000 inhabitants. Of these, 27.6% live in a city with 20,000 to 100,000 inhabitants and 30.7% in a large city with more than 100,000 inhabitants. Thereby, the sample approximates a small-scale representation of the German population (Statistisches Bundesamt 2009).

Regarding further characteristics not included in the selection, such as marital status, household size and available income, good conformances with the German average were found, whereas higher educational levels are overrepresented.

Thirty four individuals identified themselves as vegetarian and were therefore excluded from the analysis, since the motives of vegetarianism were not subject of this study. Hence, 956 respondents were taken into consideration for the present analysis.

In order to prevent the risk of common method bias (cf. Soehnchen 2009), the statements and attributes of the questionnaire were retrieved from various scales (Likert scale, ranking, percentages, slider). However, predominantly five-point Likert scales from -2 to +2 were used (cf. Weijters et al. 2010).

The statements were constructed based on a literature study and expert discussions and pre-tested with 66 respondents. The questionnaire developed subsequently contains several questions concerning attitudes towards meat and meat products, eating, buying and cooking habits as well as socio-demographic variables. Missing values were replaced by an expectation-maximization algorithm (cf. Dempster et al. 1977).

Data analysis was conducted with the statistical program SPSS (IBM SPSS Statistics 19) by means of uni-, bi- and multivariate methods (cf. Backhaus et al. 2008).

The respondents were grouped according to the proportion of meat in their total diet. Trying to divide the sample into almost equal subsamples, the group of “Low Meat Consumers” (32.6% of the respondents) is characterized by a proportion of meat less than 12% of the total diet; the “Average Meat Consumer” (34.5%) eats between 13% and 23% meat and the “Heavy Meat Consumer” (32.8%) more than 24%.

In order to explore group differences, an analysis of variance (ANOVA) was undertaken, comparing attitudes concerning meat (factors) that can be regarded as relevant according to the literature study (e.g. Richardson et al. 1993, Lea & Worsley 2001, Guenther et al. 2005, De Boer et al. 2007) and expert discussions. These factors were established by a confirmatory principal component analysis respecting the common quality values (Backhaus et al. 2008, Field 2009) (see Table 1, see Appendix). The reliabilities (Cronbach's Alpha) of the scales (factors) ranged from 0.553 to 0.805. Although the reliability of the factor "Figure awareness" did not reach the value of 0.6, it was integrated in further analysis. On early stages of research, Alpha-values between 0.5 and 0.6 are acceptable (Nunnally 1978).

Likewise the proportion of the different meat types (beef, pork, poultry, and other meat) in the total meat consumption was analyzed. Furthermore, socio-demographic variables were included in the comparison of means. The Levene-Test shows that homogeneity of variances cannot be assumed; hence the T2 test (Tamhane) was chosen for a post-hoc multiple group comparison. This test offers the same results as the conservative Bonferroni-Test if the variances are homogeneous and enables pair-wise comparisons on the grounds of a t-test (cf. Backhaus et al. 2008, SPSS 2003).

Results of the Analysis

The results (see Table 2) show that "Low Meat Consumers" (LMC) have an average proportion of 7.12% of meat of their total diet, the "Average Meat Consumers" (AMC) 19.00% and the "Heavy Meat Consumer" (HMC) 38.31% on average.

Regarding the meat types separately, it can be stated that with a proportion of 39.59%, the "Low Meat Consumers" eat relatively more poultry than the other two patterns (AMC: 32.52%, HMC: 32.28%), which distinguish themselves by a significantly higher consumption of pork (LMC: 33.76%, AMC: 40.96%, HMC: 42.01%). In contrast, the proportions of beef (LMC: 19.32%, AMC: 19.31%, HMC: 18.63%) and other meat (e.g. lamb, game) (LMC: 5.17%, AMC: 5.47%, HMC: 6.29%) do not differ significantly among the three groups.

Concerning the attitudes, it can be observed that the group of "Low Meat Consumers" is generally characterized by the highest concerns related to the effects of meat consumption. They show significantly higher health (LMC: 0.28, AMC: -0.09, HMC: -0.20), figure (LMC: 0.18, AMC: -0.02, HMC: -0.15) and particularly higher environmental (LMC: 0.31, AMC: -0.05, HMC: -0.24) and animal welfare awareness (LMC: 0.34, AMC: -0.10, HMC: -0.23) than those of the other two patterns.

Likewise, with a value of 0.20, they have more problems with the concept of eating animals than the "Average Meat Consumers" (-0.08) and the "Heavy Meat Consumers" (-0.11). Furthermore they are more influenced by their environment (LMC: 0.16, AMC: -0.03, HMC: -0.13). Strikingly, the "Low Meat Consumer" group has significantly less trust (-0.26) in the agri-food industry compared to the "average" (0.06) and the "heavy" (0.21) meat consumer. As expected, the general preference for meat increases from the "Low Meat Consumer" (-0.58) to the "Heavy Meat Consumer" (0.40, AMC: 0.16).

By contrast, the chosen socio-demographic variables age (LMC: 46.88 years on average, AMC: 47.75, HMC: 48.53), occupation (index from 1= pupil, unemployed to 6= executive manager, LMC: 3.39, AMC: 3.45, HMC: 3.54) and personal income (index from 1= under 1,000€ to 5= more than 4,000€ LMC: 1.87, AMC: 2.04, HMC: 2.05) do not display significant differences between the three groups. Only the level of education differs significantly between the respondents (index from 1= no degree to 4= A level, LMC: 3.44, AMC: 3.31, HMC: 3.19).

Table 2. Results of the ANOVA

	Low Meat Consumer (a)	Average Meat Consumer (b)	Heavy Meat Consumer (c)	Total
N	312 (32.6%)	330 (34.5%)	314 (32.8%)	956 (100%)
¹ Proportion of meat in the total diet ***	7.12^{bc}	19.00^{ac}	38.31^{ab}	21.49
<i>Consumption of Meat Types</i>				
¹ Proportion of pork in the total meat consumption***	33.76 ^{bc}	40.96 ^a	42.01 ^a	38.96
¹ Proportion of poultry in the total meat consumption ***	39.59 ^{bc}	32.52 ^a	32.28 ^a	34.75
¹ Proportion of beef in the total meat consumption ^{n.s.}	19.32	19.31	18.63	19.09
¹ Proportion of other meat (e.g. lamb, game) in the total meat consumption ^{n.s.}	5.17	5.47	6.29	5.64
<i>Attitudes towards meat</i>				
² General preference for meat***	-0.58 ^{bc}	0.16 ^{ac}	0.40 ^{ab}	0.00
² Trust in the agri-food sector***	-0.26 ^{bc}	0.06 ^a	0.21 ^a	0.00
² Environmental awareness***	0.31 ^{bc}	-0.05 ^{ac}	-0.24 ^{ab}	0.00
² Health awareness***	0.28 ^{bc}	-0.09 ^a	-0.20 ^a	0.00
² Figure awareness***	0.18 ^{bc}	-0.02 ^a	-0.15 ^a	0.00
² Eating of animals***	0.20 ^{bc}	-0.08 ^a	-0.11 ^a	0.00
² Normative influence**	0.16 ^{bc}	-0.03 ^a	-0.13 ^a	0.00
² Animal welfare awareness***	0.34 ^{bc}	-0.10 ^a	-0.23 ^a	0.00
<i>Socio-demographic variables</i>				
Age ^{n.s.}	46.88	47.75	48.53	47.72
³ Education (index)***	3.44 ^{bc}	3.31 ^a	3.19 ^a	3.31
⁴ Occupation (index) ^{n.s.}	3.39	3.45	3.54	3.46
⁵ Personal income (index)*	1.87	2.04	2.05	1.99

N= number of respondents, significance level: * = $p \leq 0.05$, **= $p \leq 0.01$, ***= $p \leq 0.001$, n.s.= not significant, letters indicate significant difference to the specified class (post-hoc test T2 after Tamhane on the significance level 0.05)), bold= cluster-forming variable, ¹percentage, ²factor, ³index from 1= no degree to 4= A level, ⁴index from 1= pupil, unemployed to 6= executive manager, ⁵index from 1= under 1,000€ to 5= more than 4,000€

Furthermore, based on cross-classified tables with standardized residuals (sr) (interpretation like z-values with $\pm 1.96 = p \leq 0.05$; $\pm 2.58 = p \leq 0.01$; $\pm 3.29 = p \leq 0.001$) (Field 2009), it can be said that more women belong to the “Low Meat Consumers” (women sr: 5.3; men sr: -5.4) whereas men are overrepresented in the group of “Average Meat Consumers” (women sr: -2.7; men sr: 2.8) and in the group of “Heavy Meat Consumers” (women sr: -2.5; men sr: 2.5).

In summary, the “Average Meat Consumers” who generally display indifferent views, show more similarities to the “Heavy Meat Consumers” than to the “Low Meat Consumers”. The

differences between the “Average Meat Consumers” and the “Heavy Meat Consumers” are in most cases not significant, however the difference between the “Low Meat Consumers” and both of these groups concerning attitude towards meat differs significantly in all dimensions examined.

Discussion and Limitations

Considered as a whole, the present study indicates that the per capita meat consumption in western countries, such as Germany, does not reflect class position, in contrast to emerging economies (FAO 2009). Instead, various attitudes, and in particular those concerning external effects of meat production and consumption, lead to a stagnation or even decrease in meat consumption.

In the study it becomes obvious that consumers with a low consumption of meat are concerned about personal factors, such as their health and their figure, but more than that about the treatment of animals and about environmental consequences of meat production. Interestingly they show a lack of trust in the agri-food sector, but the preferred meat seems to be poultry, even though the poultry production chain has the highest degree of vertical integration and industrialized structures in Germany. In this context, the disgust of eating animals might have an impact since the preparation of poultry is less bloody than the preparation of other types of meat.

What limits the results of this study is the fact that even though the sample is, with 990 participants, of a satisfactory size and most socio-demographic variables comply with the German population, it is still a convenience sample. Particularly the fact that higher educated people are overrepresented in this study may have an impact on the results. As Gossard and York (2003) found out that people in laborer occupations and people with a low level of education ate more beef and meat in general, especially the results of the “Heavy Meat Consumers” could vary from the true results.

Furthermore, the estimation of consumed meat is a self-estimation in this study and therefore might deviate from the true values.

Further research especially focusing on the group of “Low Meat Consumers” might be interesting, in order to identify possible shifts towards vegetarianism. In this context a more differentiated classification with more groups might allow deeper insights.

Since, as seen in this study, psychographic determinants seem to explain differences in meat consumption better than socio-demographic dimensions, life style approaches, such as the food-related life style (e.g. Grunert et al. 1993, Grunert 2006), might be appropriate to explain meat consumption in western societies.

Management Implications

For the meat industry the results offer the possibility to gain more information about their customers and to develop or adapt marketing and communication strategies accordingly. With a focus on the poultry chain, it can be stated that this supply chain has a high segment of critical

“Low Meat Consumers” and therefore has to intensify its efforts with regard to health and sustainability issues. A communication strategy combining sustainable management and emotional marketing, which distances the end products from the raw products seems to be appropriate to attract this critical consumer segment.

Likewise the pork and the beef chain could benefit from product quality differentiation. Next to standard quality products, which might be sufficient for individuals with a generally high preference for meat, specific product qualities might lead to more demand. Especially the proportion of consumed pork is significantly low in the segment of “Low Meat Consumers”. Intensified efforts of the industry to produce and to market differentiated meat due to special process qualities should help developing new marketing segments.

Overall, the retrieval of consumers’ trust seems to be a major component in order to increase meat consumption. Therefore, marketing or communication strategies should truthfully advertise the products and their processes. Private or public certification systems might be helpful in this context (Albersmeier et al. 2009). Also an implementation or intensification of a reputation management might lead to more consumers’ trust. In this context a structural discussion with critical stakeholders such as NGOs (Non-Governmental Organizations) should be taken into consideration.

In general, the paper reveals that health and sustainability issues are the most important drivers of the changing meat consumption behavior in some developed countries. Considering the growing world population and limited resources, this development has positive implications for world food security and climate change.

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Appendix

Table 1. Results of the principal component analysis

General preference for meat (CA: 0.791, MSA: 0.783, TVE: 55.05%)	
Variables	Loadings
Meat is a source of vitality.	0.772
Meat always tastes good.	0.754
I can never have enough meat in a meal.	0.754
A juicy steak is better than anything else.	0.751
Meat is essential for a balanced diet.	0.675
Trust in the agri-food sector (CA: 0.779, MSA: 0.660, TVE: 69.38%)	
Variables	Loadings
I have a great deal of trust in the meat sector.	0.886
The information provided by meat producers is reliable.	0.839
I am certain that the majority of farmers look after their animals well.	0.770
Environmental awareness (CA: 0.805, MSA: 0.714, TVE: 63.13%)	
Variables	Loadings
Eating a lot of meat and sausage is very bad for the climate.	0.890
I restrict my meat consumption to protect the climate.	0.831
Animal husbandry pollutes the environment.	0.812
Living sustainably is important to me.	0.619

Table 1. Continued

Health awareness (CA: 0.668, MSA: 0.622, TVE: 50.19%)	
Variables	Loadings
People who do not eat meat are healthier.	0.761
People who eat a lot of meat are damaging their body.	0.756
A balanced diet is more important to me than taste.	0.655
I am very health-conscious in what I eat.	0.654
Figure awareness (CA: 0.553, MSA: 0.570, TVE: 52.84%)	
Variables	Loadings
I look for low calorie food products.	0.816
I am very conscious of my figure.	0.729
I find meat too fatty.	0.623
Eating of animals (CA: 0.723, MSA: 0.739, TVE: 54.70%)	
Variables	Loadings
I can't bear the sight of dead animals.	0.779
If I'm going to eat meat products, I'd at least rather not be able to see that it was once an animal.	0.758
I find raw meat disgusting.	0.723
I avoid eating meat as much as possible because it means that an animal must be killed.	0.696
Normative influence (CA: 0.679, MSA: 0.691, TVE: 51.82%)	
Variables	Loadings
I adjust what I eat at a restaurant according to what the others at my table are eating.	0.671
Eating meat is out of fashion.	0.795
Whether I eat meat depends on what my family thinks about it.	0.761
When the media reports about scandals such as the dioxin contamination, this influences my eating behavior.	0.641
Animal welfare awareness (CA: 0.706, MSA: 0.741, TVE: 54.00%)	
Variables	Loadings
Recorded: I find meat and sausage from factory farming ok.	0.788
Recorded: To be honest, I don't think much about animal welfare.	0.773
I have often thought about eating less meat because I feel so sorry for the animals.	0.709
Animals should be kept in accordance with their natural needs.	0.663

Note. CA= Cronbach's alpha, MSA= Measure of sampling adequacy, TV = Total variance explained



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Diversification Decisions in Agriculture: The Case of Agritourism in Kansas

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Abstract

The thesis of this paper is that diversification decisions may be described by a three-stage sequential framework. The framework begins with the choice between on-farm and off-farm investments and ends with the selection of activities that decision-makers believe would be more effective in addressing their needs. The paper tests this thesis using data collected from participants in an agritourism workshop in Kansas. The test begins at the framework's second stage, where decision-makers decide between intensifying current operations to take advantage of scale and/or size economies, and diversifying to deploy slack resources in other businesses. The third stage involves the selection of alternative enterprises to meet decision-makers' desired objectives. It is hypothesized that the second stage decision choice is defined by decision-makers' demographic characteristics and their motivational factors. Demographic characteristics, such as age and education, also serve as proxies for decision-makers' embedded capabilities. The results show that for this case study, all demographic characteristics but gender are statistically significant, with education exhibiting the highest positive impact on the decision to diversify at the second stage. Economics was also determined to be a positive motivating factor in the intention to choose marketing, tourism and fishing and hunting enterprises at the third stage. However, personal satisfaction was a positive motivating factor for all enterprises except fishing and hunting. The impact of community as a motivation for any of these enterprises was split. It was negative for marketing and positive for accommodation and food service and statistically insignificant for tourism and fishing and hunting. The study provides an empirical foundation for exploring the diversification decision process and choices among smallholder producers as well as challenging policymakers to carefully determine how these decisions and choices actually get made given people's situations and characteristics. .

Keywords: diversification, agritourism, value-added agriculture, agricultural entrepreneurship

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Introduction

The 2007 Census of Agriculture (NASS/USDA, 2010) indicated that while 54.4 percent of agricultural producers in the U.S. considered farming/ranching as their primary occupation in 1987, only 45.1 percent do so three decades later. The share of farm income emanating from farm operations has also been declining. For instance, it averaged 41.6 percent between 1960 and 1969 and only 10.8 percent between 2000 and 2009 (Economic Research Service/USD, 2011). Another interesting observation is that although average farm household incomes increased through the decades, they did so at a decreasing rate; from 142 percent between the average in the 1960s and 1970s to 58.57 percent between 1990s and the 2000s in nominal terms.

Some producers have responded to the prevailing income challenges by expanding their operations to gain scale and/or size economies while others have sought off-farm employment. Unfortunately, other producers are unable, for one reason or another, to do either. For them, policymakers have tried to encourage them to diversify their operations into on-farm ventures (Morehardt et al. 2004). These ventures encompass value addition, farmers' market, agritourism and other similar ventures. Bernardo et al. (2004) note that the attractiveness of agritourism to producers rests on its potential to increase farm incomes and enhance utilization of farm resources. Agritourism has also been found to have the potential to enhance local communities when visitors purchase goods and services beyond those they find on the destination farm (Hamzah et al., 2012). Compared to Europe, however, agritourism is still a fringe activity in the U.S. For example, while it contributes to the incomes of nearly a third of British farmers and even higher in France and Italy (Bernardo, 2004), only about 2.5 percent of U.S. farmers receive income from agritourism activities (Brown and Reader, 2007). The offerings of these farms are defined to a large extent by their location. For example, farms offering recreation agritourism tend to be located closer to cities in order to leverage the large human population while those offering hunting and similar products tend to be in rural areas.

The agritourism participation rate in Kansas is lower than the national average, estimated at about 1.4 percent in 2007 (NASS, 2010). However, the proportion of farms receiving \$5,000 or more from agritourism activities increased from 9 percent in 2002 to 21 percent by 2007. What is more remarkable is the change in the distribution of total revenue from agritourism activities. Total revenue from agritourism activities in Kansas was about \$2.9 million in 2002 and farms receiving less than \$5,000 from these activities accounted for about 40.6 percent of this amount. By 2007, the total revenue from agritourism in Kansas had increased to about \$8.1 million and the share of those receiving less than \$5,000 had declined to about 12.2 percent. Thus, while relative participation may be declining, the contribution to agritourism to the incomes of participating farms is increasing.

It is hypothesized that producers choosing to adopt agritourism and other on-farm ventures exhibit certain characteristics, and these characteristics influence their diversification decisions. This research develops a framework and tests this hypothesis using a target group of Kansas producers with particular interest in agritourism. The size and localized nature of the sample suggests that the results must be interpreted as insights that could contribute to the development of the appropriate strategies to help producers and policymakers considering agritourism as vehicles for addressing smallholder producers' income challenges in regions resembling Kansas.

Literature Review

The results from studies on diversification generally point to improved performance when firms diversify into related businesses and decreased performance when firms diversify into unrelated businesses (Stern and Henderson 2004; Bowman and Helfat 2001). For small businesses, the rationale for diversification may be more nuanced than strict profitability. It may be a decision-maker's last ditch effort to ensure survival or maintain a particular way of life. This is particularly true in small agricultural businesses where the business contributes significantly to its owner's economic and social identities.

Agritourism has been seen as one opportunity offering producers a significant opportunity to differentiate themselves, and in so doing, build and sustain a competitive advantage in their chosen markets (Colton and Bissix 2005). Various public policies, including grants and education programs, have contributed to a boom in agritourism and other diversification initiatives in Europe (Walford 2003; Morgan et al. 2010), North America (Nickerson et al. 2001; McGehee 2007; Leroux 2001), and Australia (Ollenburg and Buckley 2007). There are also signs of an emergence of agritourism initiatives in Africa (van der Merwe 2012) and Asia (Kumbhar, 2011). Additionally, value-added initiatives are emerging as alternative business opportunities for small producers in both developed and developing countries. For example, Lawal et al. (2011) report that Nigerian cashew producers who processed their cashews into juice had incomes that were significantly higher than those who did not. Likewise, Biarari et al. (2006) show higher economic value for turmeric producers in India who produced consumer-ready products. These initiatives are seen as not only helping the farm families involved in them but also contributing towards local and regional economic development (Brenes et al. 2011).

While the decision to embark on value addition is often straight-forward, i.e., increasing the value producers get from their production, the decision to pursue agritourism is often more complex. As a result, factors motivating agritourism ventures have dominated the literature (Nickerson et al. 2001; Mace 2004; McGehee and Kim 2004; Ollenburg and Buckley 2007). Nickerson et al. for example, identify three motivating factors for agritourism ventures in Montana: economic; social; and external. Economic factors included income generation and minimization of income variability while social factors encompassed meeting new people and building new relationships. External factors were defined to include concerns about loss of government subsidies to agriculture and a desire to educate consumers about agriculture. The study showed that economic factors were the primary motivators for Montana producers to diversify into agritourism and social factors were secondary. Contrarily, Ollenburg and Buckley (2007) show that social factors were marginally more important than economic factors in Australia. Their results on Australian producers were similar to those of McGehee and Kim (2004) who replicated the Montana study by Nickerson and his colleagues in Virginia. McGehee and Kim conclude that diversification decisions are hardly motivated by a single factor and that any attempt to categorize motivating factors into one or another category is not only inaccurate in context but also in fact.

Conceptual Framework

A producer's decision to diversify, like all human actions, is triggered by the recognition of an untenable situation (von Mises 1966). The diversification decision may be structured into a number of distinct steps, as described by the human action literature (von Mises 1966). First, the producer must be able to conceive of at least one alternative solution that is believed to have the potential to address the current untenable situation. Second, the producer must have access to or control over resources that are required to implement the preferred alternative solution. Finally, the producer must believe in his capability to create the preferred situation by using available resources. The foregoing process has been discussed extensively in the literature (von Mises 1966).

Suppose now that a producer's household income is decreasing and suppose the producer decides to do something about this observation. Figure 1 illustrates the alternative decision paths that may be pursued by the producer after this recognition. The first decision (Stage I) involves a consideration of on-farm versus off-farm solutions. It is assumed from here on that the producer has both tangible and intangible resources – such as labor, land, equipment, knowledge and creativity—which may be deployed in any chosen enterprise. Choosing the off-farm solution path directs the producer towards securing off-farm employment and deploying at least some of current labor away from the farm, as seen in the 54 percent of producers who have off-farm employment as their primary occupation (Economic Research Service 2011). An on-farm solution will be based on an expectation that deploying labor and other resources on-farm would provide higher benefits given the producer's realities and other constraints.

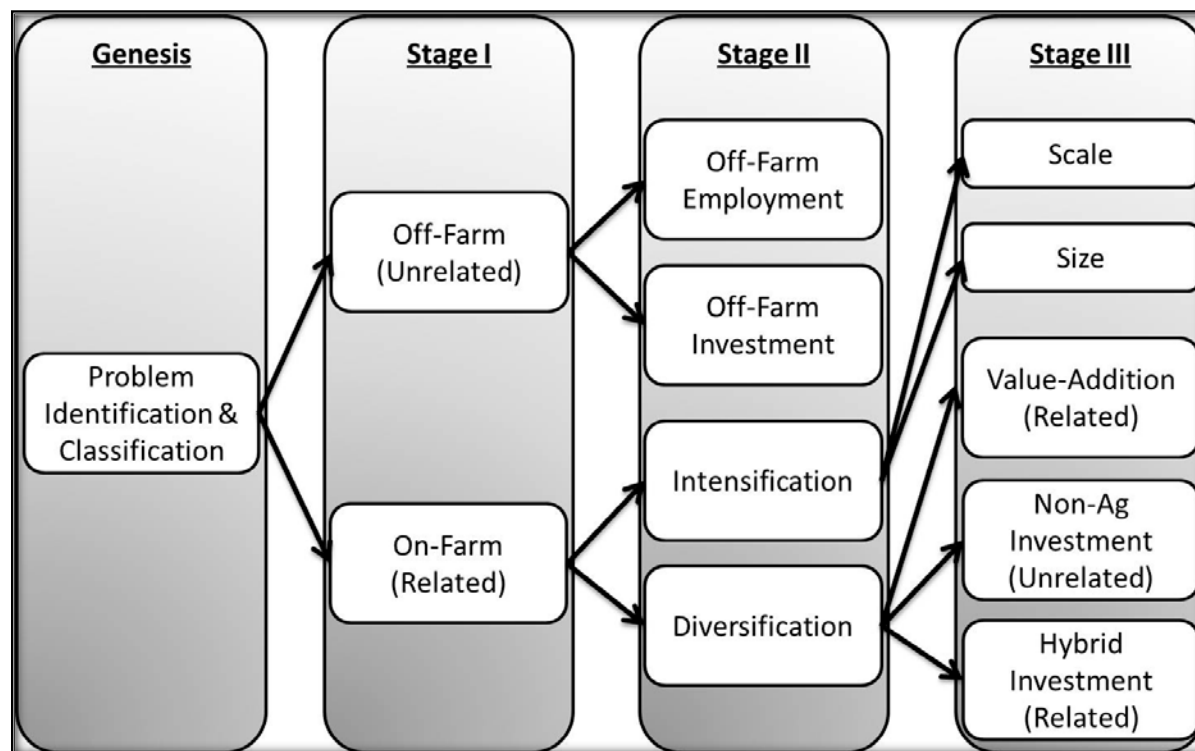


Figure 1. Conceptual Framework of Decision Paths to Diversification Investments

Selecting an on-farm solution engenders a dichotomous decision rule in the second stage of the decision-making process: diversification or intensification solution. Under intensification, the producer would choose to intensify resource utilization in current activities, hoping to increase efficiency through scale and/or size economies. Under diversification, the decision-maker chooses instead to invest available slack resources in farm-related or non-farm-related enterprises with an expectation for higher monetary and/or non-monetary benefits. Stage III involves that selection of specific activities or enterprises to invest in to achieve the desired results.

Assuming resources as given and capabilities as embedded in an individual's characteristics (Wagle 2009), a producer's path selection process is modeled as a function of his demographic characteristics and motivational factors. Demographic characteristics include age, education, family situation, and income. Berglann et al. (2011), in exploring the origins of entrepreneurial action in Norway, showed that gender, income, children and education all mattered. Similarly, Nga and Shamuganathan (2010) report the importance of demographic factors in influencing entrepreneurs' start-up intentions. These variables have also been found to be true in agricultural diversification decisions (McElwee and Bosworth 2010).

Motivational factors are often invisible external and internal antecedents defining intent and action (Deci 2000; Locke and Latham 2004; Carsrud and Brannback 2011). Motivation for entrepreneurial action may exhibit social embeddedness and the search for personal satisfaction that may be stronger than economic motivations, such as income (Langevang et al. 2012). Nickerson et al. (2001) and McGehee (2007) as well as a few others have explored the role of motivation in starting new non-traditional agricultural ventures, such as agritourism. These studies show that motivation variables do influence decisions and economic motivations are not always the primary drivers (McGehee and Kim 2004).

Data and Methods

The early 2000s were one of the toughest periods in U.S. production agriculture in recent memory. It prompted various government agencies and land grant universities to embark on finding innovative approaches to help producers deal with declining incomes. Kansas Department of Commerce collaborated with the Ag Innovation Center at Kansas State University to offer business development education workshops and one-on-one consulting services to Kansas producers interested in diversifying their operations. The data for the research were collected using a structured questionnaire at one of these workshops in 2004. The questionnaire had been tested for reliability and validity at two earlier workshops. Workshop participants received a survey questionnaire in their registration packet and were instructed to complete the questionnaire and return it to the registration desk before the end of the conference. A total of 120 out of the 187 distributed questionnaires were turned in, implying a response rate of 64.2 percent. Eight questionnaires were discarded for incompleteness, leaving 112 for analysis.

It is important to acknowledge the limited nature of the data because all participants were Kansas producers. Additionally, by choosing to attend an agritourism workshop, these respondents had revealed their bias towards a diversification strategy. As a result, the ensuing results must be interpreted carefully as a special case study of Kansas agricultural producers with specific

interest in agritourism. Applications of these results must be within the context of providing insights into the role and effects of the explanatory variables in determining choices and the importance of evaluating local conditions to ensure accuracy.

The study was designed to test the conceptual process underlying the diversification decision model presented in Figure 1. Because the respondents had chosen to attend a business development workshop, their implicit recognition of the untenable situation in which they find themselves may be assumed. Furthermore, because the workshop was advertised as an agritourism workshop, it is fair to assume participants' interest in exploring on-farm diversification opportunities, such as agritourism. The analyses, therefore, begin at Stage II of the model.

Any respondent's Stage II decision is treated as a binary choice, D_i , with diversification as the outcome of interest. Hence, the probability, p_i , that a decision-maker chooses to diversify may be defined as a function of the decision-maker's demographic characteristics, X_i , with coefficient estimates β , presented as follows:

$$(1) \quad p_i = \Pr(D_i = 1) = F(x_i'\beta) = \frac{e^{x_i'\beta}}{1 + e^{x_i'\beta}}$$

The demographic characteristics included here are gender, family income, number of children in the household, adults in the household, respondent's age and education level attained and the extent to which the respondent considers him or herself an entrepreneur. All the variables, with the exception of age and education level, are categorical.

Stage III decision choices have been studied extensively (Brandth, 2010; Barbieri and Mshenga, 2008; Bowen et al. 1991). In this research, Stage III analyses focused on determining the effect of demographic and motivation variables on the probability that a decision-maker would select a particular enterprise type as a diversification solution. The choice problem is modeled as a binomial logistic problem for each of the identified enterprises emanating from the survey.

The relevant summary statistics are presented in Table 1. It shows that about 63.4 percent of respondents were male and respondents' average age was about 49.4 years. Not all respondents identified agricultural production as their primary occupation because only 73.2 percent identified themselves as producers. Also, while 33.9 percent indicated they were currently operating an agritourism venture, 61.6 percent of respondents indicated an intention to embark on an agritourism venture. The average contribution of agritourism to the household income of those currently operating agritourism ventures was 17.7 percent. However, the average expected contribution of agritourism to household income of those intending to operate an agritourism venture was 26.62 percent. That those intending to diversify expect higher contributions to income than incumbents' realized is consistent with earlier findings that show entrepreneurs' expectations consistently exceed realized performance (Lowe and Ziedonis 2006).

The average years of formal education was approximately 13.7 years, with a standard deviation of about 3.2 years. This implied that the average education was a year or so above high school, suggesting some college. About 33.9 percent had one or more children younger than 18 years in

the household. Contrarily, 64.3 percent of respondents indicated having two adults in their household, including themselves while only about 8.9 percent indicated having three or more adults in the household. This implied that about 26.8 percent of respondents had only one adult in the household. The average household income – includes off-farm incomes – was \$74,828. The annual household income of about 22 percent of respondents was \$35,000 or less even though 77.7 percent of respondents had incomes in excess of \$35,000. These income characteristics of the sample suggest that the majority of respondents were essentially small producers. Respondents' entrepreneurial bend was determined using their response to the question: "How strongly do you agree with the statement 'I see myself as an entrepreneur?'" on a scale of 1 (strongly disagree) to 5 (strongly agree). The distribution of the responses led to developing entrepreneurial bend in a binary variable, with about 81.25 percent of respondents suggesting they lean entrepreneurial.

Table 1. Summary Demographic Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Producer	112	0.732	0.445	0	1
Gender (1 = Male)	112	0.634	0.484	0	1
Intention to Diversify	112	0.616	0.489	0	1
Current Agritourism Operator	112	0.339	0.476	0	1
Operating Duration	37	8.482	7.329	0.67	32.00
Agritourism contribution to household Income	37	0.177	0.154	0	0.55
Expected contribution of Agritourism to Household Income	92	0.266	0.169	0	1
Education (Years)	112	13.696	3.424	6	18
Income (0 = \$35,000 max; 1 = More than \$35,000)	112	0.777	0.418	0	1
Children (0 = None ; 1 = At least one child)	112	0.339	0.476	0	1
Adults (Reference = 1)					
2 Adults	112	0.643	0.481	0	1
3+ Adults	112	0.089	0.286	0	1
Age (Years)	112	49.402	9.738	23.0	73.0
Entrepreneurial Bend (0 = No; 1 = Yes)	112	0.813	0.392	0	1
Marketing	112	0.384	0.489	0	1
Accommodation	112	0.473	0.502	0	1
Tourism	112	0.563	0.498	0	1
Food Service	112	0.205	0.406	0	1
Fishing & Hunting	112	0.196	0.399	0	1

To arrive at respondents' enterprise intentions, the survey asked them to identify the specific enterprises they were considering. Their responses were organized into the five enterprise groups presented in Table 1. Marketing enterprise covers activities selling farm produce or value-added products on farm, in road-side stalls and/or at farmers' markets while the accommodation enterprise encompasses the provision of on-farm accommodation, such as bed and breakfast inns or campgrounds. On-farm tourism involves providing experience, entertainment and/or education for visitors to the farm property, including visitors participating in farming and ranching activities, hay rides, horseback riding, petting zoo, or corn mazes. Food service involves the preparation and serving of food for consumption in a restaurant-style format on the farm property while fishing and hunting activities provides guests with access to the farm

property to fish and hunt in natural and/or created environments. The results show that about 38.4 percent indicated an intention to embark on marketing enterprises compared with 56.3 percent who indicated an intention to invest in on-farm tourism activities. While 47.3 percent indicated an intention to pursue an accommodation enterprise, food service and fishing and hunting enterprises were the intentions of about one-fifth each of respondents. That the sum of these distributions exceeds unity implies that respondents selected more than one enterprise as their intentions in some cases.

Stage II Results and Discussion

The probability of choosing to diversify ($D = 1$) in the Stage II of the conceptual framework is modeled thus:

$$(2) \quad \Pr(D = 1) = \Pr(\beta_0 + \beta_g Gen + \beta_i Inc + \beta_c Chd + \beta_a Adult + \beta_{ed} Ed + \beta_{ag} Age + \beta_{ent} Ent + \varepsilon)$$

where *Gen*, *Inc*, *Chd*, *Adult*, *Ed*, *Age* and *Ent* represent a respondent's gender, household income, number of children under 18 years in the household, number of adults in the household, respondent's age, and the respondent's self-described entrepreneurial bend. The regression error term is defined by ε . The logit regression routines in STATA/IC 12 were used to determine the estimates, conduct related tests and calculate the marginal effects of the covariates.

The dependent variable of Equation (2) defines those intending to diversify their operations as $D = 1$ and those who do not intend to diversify as $D = 0$.¹ It is hypothesized that the likelihood of males diversifying will be no different from that of females because the challenges facing farm household are not differentiated by gender. On the other hand, higher income earners are hypothesized to be more likely to consider diversification because of their presumptions about their capabilities. The likelihood of diversification is hypothesized to decline with an increasing number of adults in the household because of the potential for adults to earn off-farm income to supplement farm income. Contrarily, the presence of children in the household may be considered another chore that needs to be undertaken, making the likelihood of diversifying less likely. Finally, it is hypothesized that education, age and entrepreneurial bend would all increase the likelihood of diversification.

Table 2 presents the binary logit model regression results, reporting the odds ratio of the covariates on the probability of choosing to diversify. The estimated overall model described in Equation (2) is significant at the 1 percent level ($F(8, 103) = 48.79$, $\text{Prob} > F = 0.000$). Its Pearson goodness-of-fit test was significant at the 1 percent level ($F(9, 102) = 151.77$) while its Wald test of overall significance of included variables was also significant at the 1 percent level ($F(8, 110) = 52.11$, $\text{Prob} > F = 0.000$), suggesting that none of the variables needed to be excluded. This is supported by the model's mean variance inflation factor (VIF) was 1.29 and its

¹ Respondents who are currently operating an agritourism enterprise but indicated an intention to diversify their operations are included in $D = 1$. However, those who did not indicate an intention to diversify were not.

condition number was 24.03. The rules of thumb are that VIF of less than 10 and condition numbers of less than 30 indicate the non-existence of multicollinearity problems.

Table 2 shows that all variables are statistically significant at the 1 percent level except entrepreneurial bend, which was significant at the 5 percent level, and gender, which was not significant. This implies that respondents intending to diversify were significantly different from those who were not intending to diversify in all situations except with respect to gender. This result is in line with the expected result hypothesized above. The point estimates in the table show that the odds ratio of households with income in excess of \$35,000 choosing to diversify is about 1.68 times higher than that of households with no more than \$35,000. Similarly, the odds of diversifying for respondents who indicated they were entrepreneurial are about 1.41 times higher than that of those who indicated that they were not entrepreneurial. For every year's increase in a respondent's age, the odds ratio of diversification increases by about 9 percent while every year's increase in a respondent's education increases the odds ratio of diversification by 23.48 percent. Thus, as hypothesized, these demographic characteristics, which also capture respondents' embedded capabilities, increase the probability of diversifying. With respect to adults in the household, the results indicate that the odds of diversifying when there are two adults is 2.32 times higher than when there is only one adult in the household. However, the odds of diversifying when there is only one adult in the household 2.09 times higher than when there are three or more adults in the household. This again confirms the hypothesis that increasing number of adults in the household reduced the probability of diversification. Likewise, the hypothesis that having children in the household would adversely affect the probability to diversify was confirmed because the odds of diversification when there were no children in the household was about 1.35 times higher than the odds of having children. In other words, households without children are more likely to diversify than those with children, an outcome that is statistically significant at the 5 percent level.

Table 2. Logit Results for the Intention to Diversify into Agritourism (N = 112)

Variables	Odds Ratio	Linearized Std. Err.	t	P>t
Gender (1 = Female)	1.036	0.12	z	0.76
Income (0 = \$35,000 max; 1 = More than \$35,000)	1.685***	0.22	3.94	0.00
Children (0 = None ; 1 = At least one child)	0.742**	0.09	-2.36	0.02
Adults (Reference = 1)				
2 Adults	2.327***	0.30	6.57	0.00
3+ Adults	0.479***	0.11	-3.14	0.00
Education (Years)	1.235***	0.02	11.18	0.00
Age (Years)	1.091***	0.01	13.96	0.00
Entrepreneurial Bend (0 = No; 1 = Yes)	1.412**	0.21	2.35	0.02
Intercept	0.000***	0.00	-16.75	0.00

Note. *** = 1 percent level of significance; ** = 5 percent level of significance.

Stage III Results and Discussion

It was argued from Figure 1 that after Stage II (when producers choose between diversification and intensification), producers proceed to select enterprises from available alternatives. It has hitherto been argued that the enterprise choices available in a producer's opportunity scope are determined by their demographic characteristics and their motivating factors. Because motivations tend to be invisible, a Likert approach was used to elicit them from respondents using the extent to which they agreed with 12 statements about their reasons for diversifying on a scale of 1 (totally disagree) to 5 (totally agree). These 12 indicators of motivating factors for agritourism were reduced to three factors using principal component analysis by setting the maximum Eigenvalue for inclusion as unity. A summary of the variables and the factor loadings generating orthogonality are presented in Table 3. These three components had an orthogonal Varimax rho of 0.685, implying that they explained about 68.8 percent of the variance in the 12 variables. The overall scale reliability coefficient was 0.883 and the overall Kaiser-Mayer-Olkin measure of sampling adequacy was 0.849, described as "meritorious" by STATA (2009, 309).

Table 3. Principal Component Loadings after Varimax Rotation for Components with Minimum Eigenvalues = 1

Statement	Mean	S.E.	Component Factors		
			Community	Economics	Personal Satisfaction
1 Contribute to community survival	4.02	0.10	<u>0.51</u> *	-0.01	-0.20
2 Preserve my culture	3.88	0.09	<u>0.37</u>	-0.05	0.12
3 Ensure own economic survival	3.24	0.10	-0.15	<u>0.56</u>	0.06
4 Generate new income	3.55	0.11	0.02	<u>0.58</u>	-0.09
5 Help community prosper	3.86	0.09	<u>0.44</u>	-0.16	0.01
6 Preserve agriculture	4.21	0.09	<u>0.37</u>	0.06	0.08
7 Personal satisfaction	3.62	0.09	0.00	-0.05	<u>0.60</u>
8 Not enough agricultural income	3.99	0.10	0.25	<u>0.39</u>	-0.15
9 Work at home instead	3.74	0.10	0.05	<u>0.38</u>	0.16
10 Get more family time	3.90	0.09	0.15	0.15	<u>0.33</u>
11 Meet new people	3.57	0.09	-0.05	0.00	<u>0.63</u>
12 Exploit an opportunity	4.15	0.09	<u>0.39</u>	0.01	0.12

Note.* Bold and underlined loadings indicate the statements that are loading specific component variables.

Setting the absolute principal component loadings threshold at 0.30, the 12 variables were used to classify the components as follows: Community Survival, Personal Economic Well-Being, and Personal Satisfaction. Table 3 shows that Community loaded Statements 1, 2, 5, 6 and 12 while Personal Economic Well-Being loaded Statements 3, 4, 8 and 9. Finally, Personal Satisfaction loaded 7, 10 and 11. These three components defined the motivation variables used as predictors of enterprise choices in Stage III.

The third stage of the diversification framework involves the selection of enterprises that are expected to satisfy the decision-maker's objective. Recall that the survey revealed five major enterprise groups: Marketing; Accommodation; On-farm Tourism; Food Service; and Fishing

and Hunting. Marketing enterprises, accommodation enterprises and On-farm tourism may all be executed with resources that are already available as slack resources on the farm given its current production activities. This commonality allows the modeling of these three enterprises with the same right-hand side variables. To operate a food service venture, on the other hand, requires investment in kitchen equipment that are often unavailable in a domestic kitchen and the procurement of license that ensures specified food safety protocols are followed. These potential costs suggest that decision-makers are likely to consider the potential contribution of these ventures explicitly in their choice to embark on a food service venture. Thus, the food service venture choice is modeled with expected contribution to household income from the venture instead of income as an explanatory variable. Finally, the hunting and fishing enterprise differs from all the others because it is the only one that has to be completely outdoors and unrelated to the primary functions of the farm. Thus, while tourism may be outdoors, it always involves the normal operations of the farm – planting corn mazes, providing horseback riding, petting farm animals, etc. Preliminary analysis of the data revealed the special role gender played in the selection of fishing and hunting enterprise and this is recognized in the modeling process.

Enterprise choice in each case is modeled as a dichotomized decision. Missing responses to these options were treated as 0 on the assumption that the decision-maker would have selected it if the choice had been attractive. Table 4 shows the results for Marketing, Accommodation and On-Farm Tourism enterprises. Among this study's participants, the results show that the odds ratio of a male choosing any of these enterprises is lower than a female choosing them. For example, the odds ratio of females choosing to embark on a marketing venture is only about 1.52 times higher than the odds ratio of males doing same. Similarly, the odds ratio of females choosing a tourism venture is 1.75 times higher than the odds ratio of males choosing a tourism venture. Both estimates are statistically significant at the 1 percent level. A unit increase in the economic motivation factor increases the odds ratio of choosing to start a marketing enterprise by 1.16 times more than choosing not to start a marketing enterprise. Similarly, the odds ratio of choosing to start a tourism enterprise is 1.21 times higher than choosing not to with a unit increase in the economic motivation factor. However, the odds ratio of not choosing an accommodation venture is about 1.53 times higher than the odds of choosing it with a unit increase in the economic motivation factor. While this is statistically significant at 1 percent, the former ones are both significant only at the 5 percent level. Being in the higher income category instead of the lower one increases the odds ratio of starting a tourism enterprise by 1.84 times. However, the odds ratio of not starting an accommodation venture is about 1.81 times higher than the odds ratio of starting one when the decision-maker is in the higher income category.

Are those in the higher income category more or less likely to be motivated by economics? This question is explored by constructing an interaction variable between income and the economic motivational factor. It is driven by the hypothesis that people in the higher income category would be less likely to be motivated by economics. Thus, the coefficient on the interaction variable is expected to be less than unity. The results show that the odds ratio of this interaction is less than unity and statistically significant for both marketing and tourism and positive but not statistically significant for accommodation. This means that increasing economic motivation decreased the odds of people in the higher income category embarking on either marketing or tourism enterprises vis-à-vis not embarking on either of these enterprises. The hypothesis that

the interaction between income and economic motivation will be less than unity cannot be rejected in the case of marketing and tourism.

The odds ratio of a unit increase in the satisfaction motivation factor is positive for all three enterprises at the 1 percent level of significance. For example, its effect on selecting accommodation is about 1.35 times higher than the odds ratio of not selecting accommodation. The effect of the community motivation factor is positive and statistically significant for accommodation at the 1 percent level and negative and significant at the 5 percent level for marketing. It is positive but not statistically significant for tourism. The table also shows that having three adults in the household instead of one increases the odds of choosing to start any of these enterprises. Age has a negative effect on developing any of these businesses, even though it was not significant in the case of marketing. Also, having children in the household does not statistically alter the odds of launching any of these businesses compared to not having children. All three models fit well, with F values that are significant at the 1 percent level. Also, testing misspecification using the Linktest routine in STATA suggested that there was no misspecification in all three cases considered here.

Table 4. Logit Model Results for Marketing, Accommodation and Tourism Enterprises

Odds Ratio	Marketing	t-value	Accommodation	t-value	Tourism	t-value
Gender (1 = Male)	0.659***	-4.04	0.783**	-2.25	0.571***	-5.26
Economic	1.156**	2.00	0.651***	-3.34	1.206***	2.53
Income (0 = \$35,000 max; 1 = More than \$35,000)	0.937	-0.51	0.552***	-3.99	1.843***	4.85
Economic # Income	0.805***	-2.83	1.026	0.20	0.764***	-3.18
Children (0 = None ; 1 = At least one child)	0.880	-1.03	1.064	0.51	0.851	-1.30
Adults (Reference = 1)						
2 Adults	0.940	-0.48	0.977	-0.18	1.145	1.12
3+ Adults	4.548***	7.14	3.438***	6.13	7.654***	7.15
Age (Years)	0.992	-1.40	0.945***	-7.62	0.988**	-2.03
Education (Years)	1.000	-0.01	0.827***	-10.69	1.010	0.55
Satisfaction	1.141***	2.95	1.348***	6.22	1.121***	2.89
Community	0.904**	-2.48	1.224***	5.53	1.045	1.16
Intercept	1.195	0.41	317.348	10.33	1.523	0.97
F(11, 100)		9.01		20.59		10.19
P > t		0.00		0.00		0.00

Note. *** = 1 percent level of significance; ** = 5 percent level of significance.

Table 5 presents the results of the logit regression for the intention to embark on a food service enterprise. As seen in the previous results, the odds ratio of males is less than unity, implying that males are less likely than females to embark on tourism enterprises. Although the economic motivation factor has a negative effect on the intention to develop a food service enterprise, it was not significant. Likewise, while the expected contribution of the venture to household income presents a positive effect, it was not statistically significant. However, the interaction between these two variables has a negative effect on the intention to embark on a food service enterprise, and its coefficient is statistically significant at the 1 percent level. The odds ratio of

having one or more children in the household on the intention to develop a food service enterprise is more than twice higher than that of having no children in the household and significant at the 1 percent level. The odds ratio of intending to develop a food service enterprise when there one adult instead of two in the household is more than two time higher than that of not intending to develop a food service enterprise. This was significant at the 1 percent level. Contrarily, the odds ratio of having three or more adults in the household is not different from the odds of having only a single adult when deciding to start a food service business. Age and education both have negative effects on the intention to develop a food service enterprise, and are both significant at the 1 and 5 percent levels respectively. What is most revealing is that the odds ratio of both satisfaction and community motivation factors are positive and significant. This would suggest that for the survey participants with intentions to develop a food service enterprise, personal satisfaction and community are the motivating factors, not personal economic wellbeing. The overall model was significant at the 1 percent level and the Linktest routine in STATA indicated that it was not misspecified.

Table 5. Logit Model Results for Food Service Enterprise

Odds Ratio	Food Service	t-value
Gender (1 = Male)	0.558***	-4.46
Economic	0.980	-0.28
Expectation	1.963	1.56
Economic # Expectation	0.511***	-2.92
Children (0 = None ; 1 = At least one child)	2.064***	4.67
Adults (Reference = 1)		
2 Adults	0.480***	-5.00
3+ Adults	1.400	1.31
Age (Years)	0.976***	-3.3
Education (Years)	0.951**	-2.39
Satisfaction	1.354***	5.39
Community	1.155***	3.1
Intercept	2.236	1.44
F(11, 100)		16.59
P > t		0.00

Note. *** = 1 percent level of significance; ** = 5 percent level of significance.

The final enterprise considered was fishing and hunting and the results of the logit estimation of the model are presented in Table 6. The table shows that the odds ratio of the intention to develop a fishing and hunting enterprise for males is about 1.6 times higher than that of females. This estimate is significant at the 1 percent level. This enterprise is the only one for which the odds of males is higher than that of females for this sample of respondents. The results also show that the economic motivation factor and its interaction with the income are both statistically significant but income by itself is not. Thus, unlike the previous results, people in the higher income category are positively affected by economic motivation. Having at least one child in the household yields an odds ratio of the intent to develop a fishing and hunting enterprise of 1.81 times higher than having no child in the household, significant at the 1 percent level. This result is different from those obtained for the first three enterprises but similar to that for food service

enterprise. Unlike the other enterprises though, satisfaction and community are not motivating factors for the fishing and hunting enterprise. Similarly, unlike the other enterprises, age has a positive, small, 3.8 percent—but statistically significant impact on the intention to establish a fishing and hunting enterprise. The odds ratio of developing a fishing and hunting enterprise resulting from a unit increase in education years is about 91.2 percent of the odds ratio of not developing a fishing and hunting enterprise. This estimate is determined to be statistically significant at the 1 percent level. Again, the odds ratio of embarking on a fishing and hunting enterprise when there are two adults in the household is estimated to be 1.57 times higher than the odds ratio of having only one adult in the household, significant at 1 percent. However, the odds ratio of doing the same when there are three or more adults is about 1.22 times higher but not statistically significant from the odds ratio of having only a single adult. The estimated model was found to be significant at the 1 percent level and was determined not to suffer from misspecification.

Table 6. Results of Logit Model Estimation for Fishing and Hunting Enterprise

Odds Ratio	Odds Ratio	t-value
Gender (1 = Male)	1.600***	3.46
Economic	1.289***	2.76
Economic # Income	0.630***	-4.28
Income (0 = \$35,000 max; 1 = More than \$35,000)	0.861	-0.96
Children (0 = None ; 1 = At least one child)	1.810***	3.80
Adults (Reference = 1)		
2 Adults	1.573***	3.30
3+ Adults	1.218	0.81
Age (Years)	1.038***	5.84
Education (Years)	0.912***	-4.49
Satisfaction	0.999	-0.02
Community	0.954	-1.01
Intercept	0.062	-5.81
F(11, 100)		10.50
P > t		0.00

Note. *** = 0.01 level of significance

Conclusion

The paper sought to contribute to the literature on diversification decision-making. It developed a three-stage decision framework that was assumed to be predicated on the recognition of an untenable situation by a decision-maker. That untenable situation in this paper was declining farm incomes in the United States, especially among smallholder producers. Finding themselves in this situation, the first stage decision these producers have to make is between taking off-farm employment and looking for on-farm opportunities. If they choose the on-farm option, then the second stage decision is about intensifying their traditional agricultural production to gain size and/or scale economies or diversify by investing available slack resources in non-traditional activities, such as agritourism. If they choose to diversify, then the third stage decision is selecting among alternative enterprises the ones they believe would produce the highest net benefit—both pecuniary and non-pecuniary—for them.

Using data from participants at a business development workshop on agritourism, this paper tests the factors that influence the choices that are made at the second and third stages of the diversification model presented here. It was assumed that the presence of these respondents at a workshop on agritourism in Kansas suggests they have already made their Stage I choice of considering on-farm investments to address their identified problem. However, because of this characteristic of the participants in the research and the smallness of the data, the results must be interpreted more as a case study providing insights into the effectiveness of the diversification model and a foundation for broader research to test its veracity and broader application.

The study's results indicate that with the exception of gender, Stage II decision to diversify is influenced by the demographic characteristics of the decision-maker and their perception of their entrepreneurial bend. That gender was not significant at this stage was expected because the decision to intensify or diversify was hypothesized to be independent of gender. The results, however, also suggest that having more than two adults in the household reduced the likelihood of diversifying. This is because the opportunity for off-farm income increases under this situation, reducing the odds of diversification. For this group of respondents, perceiving themselves to be entrepreneurial increases the odds ratio of diversifying.

Stage III results indicated that the factors influencing the intention to invest in specific enterprises differed across enterprises for this group of respondents. For example, while females were more likely to indicate an intention to invest in marketing, accommodation, tourism and food service enterprises, the odds of males indicating an interest in fishing and hunting enterprises was higher. Also, having three or more adults in the household positively influenced the intention to invest in marketing, accommodation and tourism ventures but not food service and fishing and hunting. Economics was a motivating factor in the intention to invest in all enterprises with the exception of food service. However, its impact on accommodation was negative. Personal satisfaction was also a motivating factor for all enterprises except fishing and hunting. Community as a motivation factor was for all enterprises except tourism and fishing and hunting. These results support previous ones in the reviewed literature. However, they also show that diversification decisions are influenced by numerous factors, internal and external to the decision-maker. As such, they provide further evidence of the complexity of the role of motivation in entrepreneurial action (Langevang et al. 2012). Thus, it is critical to carefully determine how these factors act independently and together to influence decisions and choices in specific situations and circumstances. It is crucial to appreciate how the effects change given location and available options in order to effectively develop strategies with high probabilities of success.

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Multiplex Uses of Food-Product Standards

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Abstract

Food-product traceability systems have been developed to achieve seamless electronic connectivity to assure food safety through the use of information technology. This is determined by legislation. While achieving customer value through quality, food supply is the core logistical purpose. Food-product traceability as such is seldom regarded as a core purpose. Food-product standards are a key resource in developing connectivity between information systems operated by different firms in a supply network using numerical product codes. This study couples the technical characteristics of a food-product standard with the organizational characteristics of a supply network. The common purpose is to achieve customer value in the supply network. Alderson's (1965) marketing-channels (transvection) model of product supply is applied to analyze potential multiple uses of the TraceFish product standard in its supply network. The case study of North Sea herring supply involves following raw material from in Norway to finished product in the Netherlands. Analysis of this empirical data exposed variation in TraceFish standard use, including coupling it with GTIN product codes. This facilitated seamless electronic information exchange between firms for a range of supply-network purposes, including tracing food. This perspective is possible when multiple functions and professions that are equally involved in operating and managing business processes are allowed to handle not only operation, but also develop information systems.

Keywords: seafood product standards, transvection, product traceability, multiplex resource use, food product value, supply networks.

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Background and Introduction

Food-product traceability is a global issue, as seen by the growing number of legislative measures in different countries. Product traceability requires that businesses have the expertise to retrieve product history in a complex, often long, food-product flow from raw material to consumption. Product traceability is an organizational competence. One major technical and economic challenge is developing information systems that support traceability. These are often called traceability systems. Swaroop et al. (2010) showed how experts view traceability as a vital component in improving safety and consumer confidence in food products. On the other hand, food-product traceability remains theoretically and practically underdeveloped (ibid. 2010). Canavari et al. (2010) examined traceability in relation to competitiveness. Traceability may also be an organizational resource, since it solves a range of a company's societal and business needs. This evokes many useful facets regarding competence. This variation in traceability usage represents the foundation of this study. The research focuses on a specific technological component, which is a system of food-product standards called TraceFish.

Efforts toward developing food-product traceability primarily come from a technical angle aimed at automating and tracing information processes that register transformations from raw material to finished product. Information technology (IT) professionals have dominated many research and developmental projects involved in food-product traceability. This IT dominance in developing food-product traceability should be weighed against food supply as a collective responsibility of business actors that are networked to ensure food safety and quality (Engelseth 2009, Engelseth et al. 2009). The result of this unbalanced involvement of IT professionals is that companies with tacit knowledge of supply processes and a good perception of customer value are rendered passive partners in traceability-system development. This is partially due to IT project control and that IT is outside the companies' realm of proficiency.

Implementation of TraceFish has also proven challenging due to high investment costs, coupled with organizational inexperience in securing electronic traceability and a general lack of inter-organizational thinking. As a result, implementing electronic traceability has been slow (Engelseth and Nordli 2006). This resulted in research switching focus from implementing food-product traceability systems to developing trust as a foundation for cooperation in the supply network (Fritz 2008; Canavari et al. 2009; Hofstede et al. 2010). However, Canavari et al. (2010) noted that tracing products is one of many informational processes supporting an overall aim of a safe and quality food supply. This brings up the concept that tracing processes are interlinked with other processes involved in food supply. This also indicates that resources for tracing foods may have other uses in the supply network. The term multiplex is used to describe a form of complexity involving interaction between the TraceFish product-standard and other information resources in a relatively wide food-supply network organizational context. For analytical purposes, embedding TraceFish in an organizational context shows how this it can be interlinked with various purposes in a supply network normally characterized as a conglomerate of heterogeneous actors and processes.

Alternatively, information system (IS) development may provide technical efficiencies by widening the perspective of traceability development and implementation, thereby avoiding IS myopia. Investments in electronic traceability systems can also not be limited to just product

traceability. When different IS system components are difficult to integrate, information processes may be duplicated. This is a form of waste that operates in parallel to satisfy the technical requirements of incompatible IS. This line of thought is in accordance with Engelseth and Nordli (2006). They proposed TraceFish as an economizing resource not solely as a means to facilitate a higher degree of automated product traceability, but to also include other potential societal and business uses in a supply network environment.

From a total cost perspective investment costs include other factors than a contracted price. A total cost of a purchase encompasses lifecycle costs as well as a range of “hidden” costs. This involves a mix of adapting the invested resource to business processes and adapting business processes to the resource. Finding the right balance between these adaptations in IT investment is never straightforward. Some help is found in that the aim of such adaptation should be functional; aligned with, if existent, an explicitly formulated business objective of securing customer value. The basic idea set forth in this paper is that food producers and distributors through investing in and implementing a potentially costly seafood product standard like TraceFish may increase the return on this IT investment by invoking uses in addition to those for which the standard was originally designed. Often understanding diverse use opportunities emerge over time among practitioners in organizations including both labor and management. Through this study we illustrate, however, in a proactive manner the multiplex use potential of the TraceFish seafood product standard. The concept of “multiplex” is used in this paper as an eye-opener; to evoke and underpin the potential of more than one use of the studied TraceFish seafood product standard. This approach to IT investment in food chains, searching for uses other than what the IT resource was originally designed for, is applicable to a range of business cases concerning IT investment in different types of food industry and in different stages of the chain, from raw-material production (agriculture/aquaculture/wild catch), through processing, distribution, and ultimately reaching businesses serving the end-user (retail/restaurant/catering). A focused study is provided here for illustrative purposes providing experiences of TraceFish implementation and use in a specific seafood supply network. The case study illustrates a food chain including product traceability issues from a starting point of fishing herring off the coast of Norway, through production in Norway and then export to The Netherlands for further processing and retail purposes. This provides an inter-organizational, and therefore realistic setting for considering food product traceability issues. The supply network is a complex conglomerate of interconnected actors. Given that product supply is a collective responsibility and that traceability involves all actors who are stakeholders in product transformation and use, an end-to-end (or complete) supply-network analytical framework was used. In Alderson’s (1965) analytical approach, a end-to-end, systems-oriented, marketing-channels model (transvection) is discussed and applied to analyze the potential for multiplex benefits of using the TraceFish standard in an IS.

The TraceFish Standard

The unit of analysis in this study is the supply network. The TraceFish standard is an artifact in relation to its multiplex, technical potential in a predominately managerial organizational context. In exploring this use potential, it is vital to picture various features of this informational resource. The EU concerted action QLK1-2000-00164, “Traceability of fish products” (finalized

in 2003), represents the foundation for developing the TraceFish CEN (European Committee for Standardization: www.cenorm.be) standard. This standard enables precise classification of fish products through a complete supply network.

Studies regarding product traceability have cited a range of issues, including: litigation and economic risk, supply-chain integration, information connectivity, consumer perceptions of product quality, safety and traceability, inter-organizational information system compatibility, the relationship with tracking goods, and product and industry features (Florence and Queree 1993; Töyrylä 1999; Kees 2002; Van der Vorst et al. 2002; Bourlakis and Allison 2003; Senneset et al. 2006; Folinas et al. 2006; Van Rijswijk and Frewer 2008). These studies share a mainly technical focus on resources such as food characteristics and IS.

A product standard is one of a conglomerate of resources in an information flow in a supply network. The product standard is at the microlevel. Information flow is a logistical term, indicating purposeful information transformation in relation to time, place, and form to support goods transformations and product utility, measured from an end-user perspective (Heskett et al. 1973; Engelseth 2012b). More specifically, a product standard is a classification of product types. The level of detail is determined by the people developing the standard. The standard is usually administered by an organization that sets rules for standardization practice. TraceFish is administered by CEN, which classifies fish species, weight groups, fat content, and other potential indicators (depending on the product). This differentiates a seafood product at a generic (non-branded) level. This classification is mainly verbal and facilitates numerical coding. The purpose of any product standard is to secure quality in product registration, identification, and communication. It efficiently links a material product artifact to its representation within an information system.

TraceFish was adapted to facilitate numerical product classification through the Global Trade Item Number (GTIN) in the GS1 (www.gs1.org) system. The GTIN is an open (nonproprietary) classification system that uses bar codes. TraceFish is also adapted through the TraceCore extensible mark-up language (XML) standard to support communication of document information types between IS, using the internet. XML is an electronic data interchange (EDI) type that provides a cost-efficient way to communicate documents, since it considerably reduces information system investment costs, compared to proprietary EDI solutions. The TraceFish standard provides a common numerical language that electronically links heterogeneous firms' information system. TraceFish contains three, voluntary, consensus-based standards for recording and exchanging traceability information in the seafood chains:

- The farmed fish standard for full-chain traceability determines which data should be recorded in the captured fish chain, as well as how and where the data is recorded. This is distributed through CEN (CWA 14659:2003, Traceability of fishery products - Specification of the information to be recorded in farmed-fish distribution chains).
- The captured fish standard for full-chain traceability determines which data should be recorded in the captured fish chain, as well as how and where the data is recorded.. This is distributed through CEN (CWA 14660:2003, Traceability of fishery products - Specification on the information to be recorded in captured-fish distribution chains).
- A technical standard regarding how the data should be coded, transmitted, or made available in electronic form, including which existing electronic standard will disseminate data.

Several research projects in Norway are seeking to implement TraceFish to secure efficiency in traceability routines by integrating IS on fishing vessels, the pelagic seafood auctions administered by Norges Sildesalgslag (the Norwegian Fishermen's Sales Organization for Pelagic Fish), and industrial producers of pelagic fish products. Another project was concerned with developing an IS using TraceFish (as a GTIN code) to create bar-coded labels/markings on distribution packages. Developing the TraceFish standard is a continuous task, as new product classification needs and uses emerge (www.tracefish.org). This case study was part of one such research project.

Information system development involves a single firm investing in a mixture of information resources, including IT hardware/software and people operating these systems. Traceability systems are generally no different from other types of information systems. However, securing traceability is almost always an inter-organizational challenge. It involves developing information flows across company borders. Investments encompass traceability-system development and integration in several supply networks. IT is usually an outsourced, external competence. A traceability system is often an individually developed information system component. After implementation, the system is coupled with other information system components (such as human resources, supply-chain management, and accounting). This view of information system as a combination of components is embodied in enterprise resource planning (ERP) systems marketed by information system suppliers. An ERP system is a development of materials-requirement planning systems that is widened to encompass a range of business enterprise information systems. However, it may prove technically and organizationally challenging to secure a fit between various functional information system components developed at different stages of time and in different organizational contexts. Current ERP systems usually encompass traceability functionality and are in widespread use within larger food-production and distribution enterprises.

A Transvection Approach to Product Standards and Traceability

The preceding sections examined how TraceFish is implemented and used in a complex seafood-supply network. This part presents an approach to examine the multiplex potential for TraceFish use, based on a marketing-channels model. Transvection, although largely unknown today, should be regarded as a classical management model (Alderson 1965), given its conceptual interlinking of customer value and value creation. This model was used to create a framework to study and analyze end-to-end food-value networks (Engelseth 2007; Engelseth 2009; Engelseth and Felzensztein 2012; Engelseth 2012a; Engelseth 2012b). Alderson (1965) proposed that the concept of transactions be complemented by transvection to fully understand and develop customer-oriented product supply. While transactions are concerned with sales and purchasing activities, transvection is predominately a logistical concept found in publications usually classified as marketing literature. This provides a cross-functional approach, from a time in management literature when logistics and supply-chain management were emerging as academic disciplines with unclear borders with marketing theory. Early marketing-channel models (e.g., Alderson 1965) provided the basis for cross-functional analysis by interconnecting a marketing and logistics perspective of supply efficiencies. An interesting aspect is that this logistical model enhances what is now known as customer value, which is; an increasingly prevalent concept in business research and practice. In business practice the transvection model may be applied as a powerful tool in drawing an end-to-end picture, a mental model, of the inherently complex food supply network. This perspective is especially important in regards to food product traceability since occurrence of food product discrepancies through flows of food transformations must be accountable from “sea or farm” to “plate and fork”. The transvection is accordingly a functional food chain development tool that helps to cure managerial myopia through providing a complete picture of how goods and information are transformed the supply network. This end-to-end chain knowledge empowers managers through increasing understanding of how value is created in the supply network when seeking to develop product traceability systems in an obscure sea of IT potential.

Marketing-channels literature highlights the number and roles of intermediaries involved in product supply to an end-user (Rosenbloom 1995). These supply roles depend on characteristics of these individual firms and their organizational role or position in a supply chain. Alderson (1965) explained that product supply involves a complete, multi-tiered channel, consisting of a heterogeneous set of actors. He also included technical logistics of supply. The transvection model provides an end-to-end view of product supply and encompasses both a marketing focus on transactions, as well as a logistics focus on value creation by transforming goods. Product-transforming activities are carried out in accordance with the step-by-step transvection model, creating a cumulative whole that can be measured in relation to customer value upon receiving the product. Figure 1 shows the transvection model.

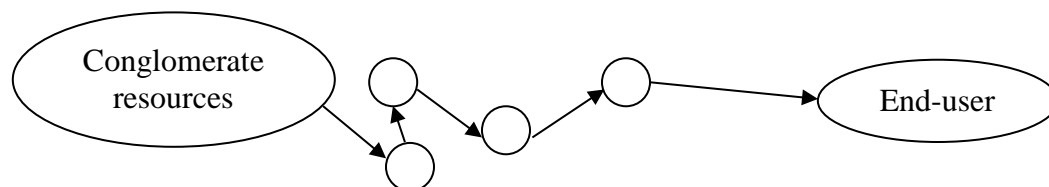


Figure 1. The transvection model (circles indicate sorts, and arrows indicate transformations).

Technical product transformation can be measured in terms of time, place, and form. This shows sequential product dependencies. Thompson (1967) labeled this form of product supply as “long-linked technologies,” which represents an industrial classification. Because this term may not be very clear to the reader, we will attempt to show a picture of prolonged time and distance in physical distribution and sequentially dependent food transformation.

In Thompson’s (1967) view, these different technologies are sequentially dependent. In the food industry, value creation depends on transformation. This is not the case in service and handicraft value networks, where the fundamental forms of dependency are reciprocal (Stabell and Fjeldstad 1998).

In addition, sequential dependencies may vary between different physical distribution forms. For example, manufacturing does not involve prolonged farming, which is a heavily culturally embedded industry in very small firms. This shows the potential for more precise classification of sequential dependencies found in physical distribution. Evoking the core importance of sequential dependencies in food supply also provides a foundation for analyzing creation and use of information resources, including product standards. As products are transformed, information about them also changes. A product standard helps visualize and communicate information about transformation.

The TraceFish standard simplifies comparison between identical products or combines transformed components in relation to time, place and form in the flow of goods. TraceFish provides information about seafood, which is a biological artifact. They may efficiently provide information about raw material for processing or link the final seafood product with where it was slaughtered and packed.

Conceptions of customer value are interlinked with product transformations. The transvection model depicts piecemeal transformation of goods through a series of complementary activities that provide time, place, and utility of products. Utility can be interpreted as customer value, while the provision of utility can be called value creation. This long linking of value generation and value realization encompasses customer responsiveness. This can be modeled as technical linkage between the end-user, intermediaries, supporting actors, and initial suppliers. From a multistage, food-supply viewpoint, matching value generation with realization occurs in sequences of events involving different supply-network actors. One important feature of TraceFish’s utility is how it realizes customer value. This is true for value creation from a supply side, as well as perceptions of supply quality from the customer side.

Transvection (Alderson 1965) provides a way to model the piecemeal, sequential nature of seafood-product transformation, which generates customer value by a series of intermittent decision-making events that Alderson termed sorts. The TraceFish standard facilitates this process by contributing to information-flow efficiency, as well as in interactions with the flows of goods. These two efficiency aspects affect goods transformation. TraceFish has an indirect impact on efficiencies in the flow of goods. Since value is created through product transformation, product information is an important boundary-spanning resource that links various local and event-specific customer perceptions of product features as they are identified in product flow. Because supply-network actors sequentially transform the product, the end-user registers these transformations and perceives responsibility in securing safe, quality food. Accordingly, the information flow is sequential when focusing on how product information reflects the product itself. This product flow, embedded in the supply network or chain, is the organizational context for providing utility through transformations of product “time, place and form features” (Alderson 1965).

Decision-makers in the supply network are influenced by the degree of integration between firms in multiple tiers. However, product information is more intricate than the product itself. Products have past, present, and future states that may be seen through orders, forecasts, tracking, and tracing (Engelseth 2007). The same information about a specific product can be duplicated and transmitted to different recipients. Therefore, the IS is more complex than the logistical product-flow system.

Product flow is the key value driver in the supply chain. People (labor), competence, information, IS, the focal product, other products, packaging, facilities, and equipment are used to make decisions regarding product flow. In accordance with Alderson’s (1965) transvection model, a sort represents a local and event-specific arena for supply-chain actors to combine people, knowledge, products, facilities, and information into a dynamic resource. By focusing on customer value as the prime indicator of supply purpose, it is natural to term TraceFish’s organizational context as a value network, rather than a supply network. This paper applies the transvection model to approach the “value network” (Engelseth 2012a). It retains the original logistical focus on the flow of goods to evoke the multiplex use of the TraceFish product standard. We generated the research question: “What benefits may product standards, specifically the TraceFish standard, provide from a transvection-model approach?” The case narrative provides a basis for analyzing how the TraceFish standard may support value creation in an industrial network.

Method

The empirical data was collected for a research project called TraceFish Use, financed by the Norwegian Research Council. The project leader was an IT company that specialized in package-labeling systems. The research consortium also comprised a Norwegian pelagic (herring and mackerel) seafood-processing firm and its main logistics supplier for shipping goods to the Netherlands. This project aimed at implementing the TraceFish standard at one of three seafood-processing factories and linking it with the existing ERP system. Operationally, the project involved implementing a package-labeling system using the TraceFish standard as a central information component with other information systems to support fully inter-organizational,

electronic traceability. The data in this study was presented with a preliminary analysis as a conference paper (Engelseth and Nordli 2006).

The data is further analyzed in this study with the transvection model discussed in the previous section. This case study was driven by the project's need to embed the package-labeling system in a wider, inter-organizational context. It focused on the TraceFish product standard as the unit of analysis. However, this standard is hard to follow in an empirical setting. It was more practical to use Alderson's (1965) transvection model as a research guideline to trace the product (particularly product information) back from finished state to raw material. This was in accordance with the transvection model of studying it in an upstream pattern.

For practical reasons, the initial interviews were conducted with the seafood producer's marketing organization to gain an initial overview of end-to-end product transformation. Interviews were then conducted to describe the flow from raw materials to finished product. In the initial interview, we got a relatively clear concept of the final product state to which we wished to relate the raw material. Subsequent interviews provided detailed descriptions of information and product transformations, as well as different perceptions of supply propose in the network. Interviews did not strictly follow an upstream pattern, especially since informants were geographically dispersed. Some interviews were conducted with informants in Norway, while other interviews were conducted in the Netherlands.

This is a case study that explores the complex, embedded nature of product information. Ellram (1996) stated that case studies provide "depth and richness, allowing the researcher to really probe the how and why questions." In accordance with this statement, the case-study research strategy was chosen to capture the details and complexities of using GTIN TraceFish in the diverse settings of a supply network. While the unit of analysis in this study is the supply network, the unit of analysis, while conducting the case study was product information. Product information involves different rules that may be explicit, including using standards. TraceFish was not yet implemented throughout the supply network. This meant that the study aimed at accounting different forms of product standards and their interlinking use in goods identification. Data was collected on goods identification and descriptions of actual product-tracing incidents.

Since this was an exploratory investigation, the case study encompassed an iterative inductive method. Iterative methodology is inspired by dialectic epistemology. Each interview involving analysis directed the next stage of inquiry to find new understanding and conceptualization. This is a common feature of case studies, according to Eisenhardt (1989). Research follows an emergent design, including continuous iterations between theory and empirical findings that involved adductive reasoning through trial and error (Kovács and Spens 2005). Findings are progressively noted in a research protocol and new empirical findings with theory are explored. Theoretical understanding gradually develops.

Since this study was rooted in a relatively postmodern ontological stance, validity and reliability were considered with alternative terms (Lincoln and Guba 1985). Taped and transcribed interviews, together with additional observation notes, were provided to ensure an audit trail, which is a vital component in establishing credibility and trustworthiness (Erlandsson et al.

1993). Informants were also allowed to inspect interview transcripts to ensure accuracy and provide additional comments.

From a vague initial understanding of the research problem concerning the TraceFish standard, more specific research issues became evident. This may be compared to hypothesis formulation based on empirical data that further steers the research process (Eisenhardt 1989). Because this is a single case study, there may be limitations on the degree to which findings may be applied in other industrial settings. Theoretic generalizability (Merideth 1998) and transferability (Lincoln and Guba 1985; Erlandson et Al. 1993) are terms used in a non-positivist, qualitative research tradition to address the question of generalizing empirical findings. This study aimed for analysis of empirical findings to generate theory that may be used in different settings. This transfer must be done with caution, adhering to a range of empirical particularities. Since this material is published, analysis is also subject for debate also contributing to theoretical development.

Informants all had key roles in their firms and were chosen to provide different perspectives of TraceFish use in the supply network. They were briefed that this was a case study aiming to describe information and product transformations, with an overall goal of better understanding how to improve product traceability through electronic interlinking of information flows between firms. Informants provided described the logistics processes, as well as marketing-channel roles, in the supply network. We avoided conflicts of interest because this case study represented research, rather than process development.

The 15 semi-structured interviews involved open-ended questions provided as a guide. Each interview guide was created specifically for each informant. Guides were influenced by preceding interviews, along with preliminary analysis noted in the research protocol. The research design was flexible. Ad-hoc questions were often formulated when fruitful issues arose during interviews. Each interview created a foundation for a following interview. This was part of the research's emergent and iterative nature to develop new understanding regarding TraceFish use. Interviews were sequentially dependent on each other in developing the research protocol and theoretical understandings regarding TraceFish use.

Case Narrative

The Product Flow

The product flow follows a specific path chosen for research purposes. This path is one flow of goods in the complete supply network. This structure of the case narrative was chosen to reduce the complexity of this text. Figure 2 shows the flow of North Sea herring from Norway, to a specific producer of finished goods, and then to retailers.

Fish bound for the Dutch market mainly consists of small herring filets caught during a short season in the spring. Fish quality and size categories for herring are: over 300 g; 200 to 300 g; and 150 to 200 g. Large fishing vessels use nets mounted on the side of the ship to catch fish. Catches vary from day to day. Fish are hauled into ships' refrigerated holding rooms, where they are kept up to 48 hours before delivery to the land-based processing facility. The fish-processing

plant receives the goods at port through a device that sucks the fish through a funnel from the fishing vessel. Semi-automatic production lines fillet the fish before they are packed.

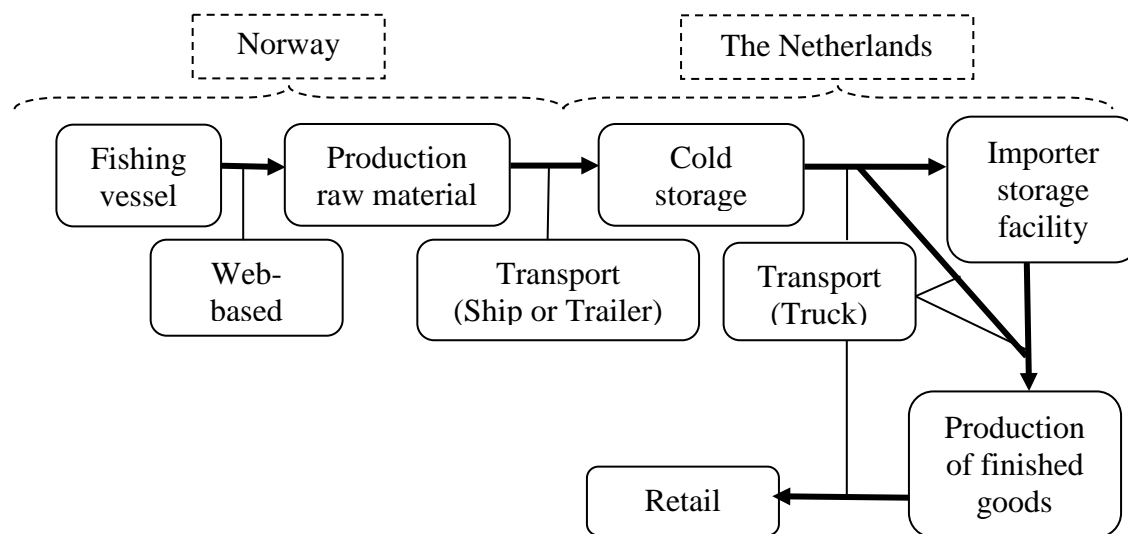


Figure 2. Flow of North Sea herring through different principal (marketing-channel actors) and supporting facilities from Norway to the Netherlands.

The Norwegian producer distributes most of the fish products sent to the Netherlands. The package is an innovative foil pouch that vacuum-seals the goods, thereby increasing durability. Approximately 20 kilo of goods are contained in one automatically labeled package. Pallets of packages undergo a 10- to 12-hour freezing process to -25°C . A forklift then moves the pallets of goods to the storage facility in the production plant. The product may be stored for up to a year, depending on market features.

Reefer (cold-storage) ships or containers placed on ships transport goods. The frozen goods are sturdy, reducing damage. Most goods are loaded directly onto a truck for a short trip to the importer's storage facility on the other side of the harbor. Goods can also be transported directly to the finished-goods producer. A forklift unloads goods off the truck into the customer's cold-storage facility. The goods remain there until they are sold, primarily to other Northern European customers.

The Flow of Information

Personnel on the fishing vessel register in the ship's log the size and quality of the catch. The vessels vary greatly in size. In parts of the season, as many as 50 vessels will be in the same location. Norges Sildesalgslag receives this information by radio or mobile phone. A blind auction sets the price of the fish. There are four to five Web-based electronic daily auctions. Each purchaser (the raw-material producer in Norway) bids on the catch of a chosen fishing vessel located near their processing plant. After each auction, the purchaser can get an idea of who won the bid and use this information on subsequent bids. Purchasers are informed about the size of the catch, measurements of the fish's fat content and the general appearance of the goods.

When the purchasing contract has been agreed upon through the auction, the boat communicates the anticipated time of arrival at the production facility. Upon delivery, the processing facility carries out quality control and certifies the supplied batch. A batch comprises the catch of one boat from a single day. Catches from two different days are kept in separate tanks on the vessel and registered as separate batches. The producer classifies the batch in accordance with three size categories. Fish size is used as basis to classify different product types. The producer's IS then registers size group and fat content.

Goods are packed into distribution-level packages, most often containing 20 kg of fish. The producer then labels the distribution packages with a GS1 standard transport label containing information about the batch, production date, best-before date, and information classification, in accordance with the TraceFish standard. The TraceFish classification is also printed in numerical and bar-code form on the transport label. The producer scans packed goods and registers the volume placed in cold storage. When orders are received from customers, the volume is scanned when goods leave the storage facility. Goods are tallied by scanning as they are loaded on the truck or ship. This tally is used in the bill of lading sent to the customer and the transport company. The producer's sales representative uses this updated inventory information registered in their ERP system as a basis to promote its products.

The Dutch producer informs the transport vessel, customer, and cold-storage/transit facility of the vessel's expected docking time at its destination in the Netherlands. The sales office informs the operator of the transport ship and registers this agreement in the ERP system. Invoice documents are sent as email attachments to the Dutch importer, and a packing list is sent to the transport company by fax or email. The transport company verifies the goods' arrival to the cold-storage/transit facility by faxing a transport document to that facility. The different actors in the supply chain log product temperature during transport and storage. Customers demand this information when they detect product discrepancies. Providing "cold trail" information is a highly manual process. When goods arrive in the Netherlands, the cold-storage/transit facility and the vessel operator do a tally control by manually counting pallets. Tally discrepancies are the responsibility of the transport operator and are financed by transport insurance. The cold-storage/transit facility operates an IS that is well-adapted to GS1 standards. On the other hand, the Dutch importer uses a small IS with a three-digit proprietary code to register and monitor inventory. The Dutch producer uses the ERP system to support automated ordering systems with its retail customers.

Roles of the TraceFish Standard in the Supply Network

Overall, pelagic fish is a high-volume, low-value product. The Norwegian producers are squeezed between profitable catches and profitable retail. Although frozen fish can be stored for many months, producers are forced to sell as quickly as possible on the market. This economic situation also affects investments in the supply network, including developing IS, supply-network connectivity, and seamless electronic traceability. The few reported incidents of product tracing involved a simple form of manual tracing. The foreign customer phoned the Norwegian producer, who then checked production records on their intra-firm IS. There was no automated information connectivity between the different supply-network companies. On one occasion, the source of the discrepancy was already detected through control routines carried out by the

producer. On another occasion, the grounds for tracing the product may have been to negotiate a lower price. TraceFish is thereby an element in a system to secure product traceability. The producer is the sole user of TraceFish to label goods.

Analysis

According to the transvection model, the crucial location of product-value is found in relation to end-use. This was also starting point of analysis. Customer value, based on the transvection model, is result of a set of sequentially dependent decision-making events (sorts). The transvection shows how sequential dependencies in the product flow also affect information flow. Product history embodies past sequentially dependent product transformations in a supply network.

From Alderson's (1965) perspective, the studied supply network has an important technical aspect that involves sets of sequentially ordered decision-making events. This is in line with Thompson (1967), who highlighted how different industries have different resource-dependency patterns. Since transvection predominately illustrates sequential dependencies, it is well-adapted to analyzing various forms of food distribution.

Supply-network integration involves more than developing trust and actor relationships. It is also a technical imperative. Business relationships constitute decision-making events combined with knowledge of product value objectives. These objectives are affected by how to attain value through technical product and information transformations. In other words, value creation meets value realization. Supply network integration provides guidance on how to integrate customer value into the value creating processes that transform food products.

Decision-making events (sorts) represent a meeting place between the technical and organizational realms. Product-supply information is predominately technical and chronologically measured. Time may be either relational or chronological (Hedaa and Törnroos 2002). The transvection sort involves combining two levels of time: the past, present and future states of products along with the preceding and following operational sorts carried out at a specific time at the organizational level. The technical level involves creating value, while organization involves decision-making to support operations. Figure 3 models TraceFish as an integrator between a product standard and product transformation.

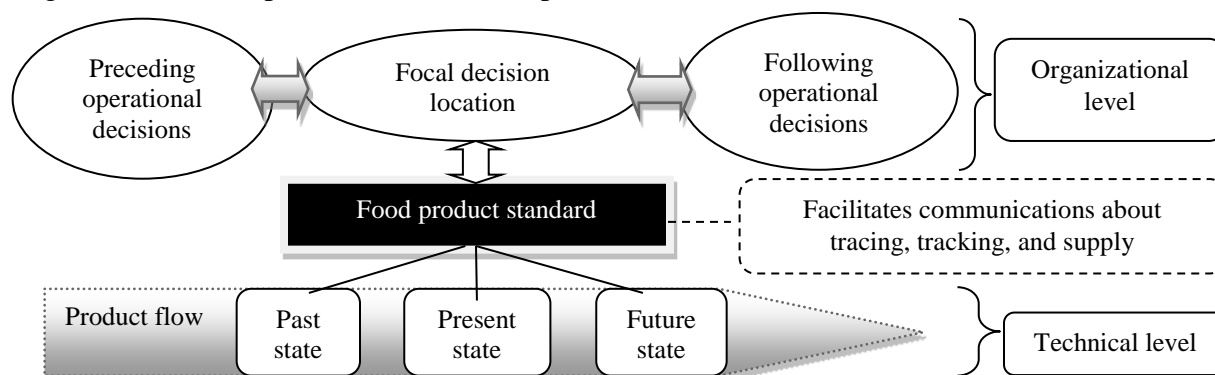


Figure 3. The product standard as integrator between organizational and technical activities.

Figure 3 shows the core of a product standard integrating organizational decision-making (sorts) and technical components. The model shows how product information is intertwined with time. The time factor is also associated with activities. Combining time aspects of product supply evokes how timing involves relative time (“before”-“now”-after”) and chronological time (numerical variable) (Hedaa and Törnroos 2002). These aspects of time and timing are associated with different activities. Timing is also associated with supply purpose.

The TraceFish standard interlinks supply purpose with the product flow. There is no demand that product standards be used, especially not from a complete food chain perspective. The demand in most countries is related to product traceability leaving it to practitioners to find out how to meet this product information demand. The TraceFish seafood product standard simplifies designing and organizing the information flow thereby supporting information flow quality. TraceFish is an information resource that increases information quality when supply network actors jointly invest in its implementation and use. The multiplex use of this standard involves potentially a higher investment cost and later economizing this use in relation to multiple informational functions classified in Figure 3 as tracking, tracing, and logistical product supply.

Food-product standards improve connectivity since they also facilitate standardized terminology regarding product features. The open TraceFish standard is a low-investment, modular (interacting with other heterogeneous resources) resource that supports connectivity and transparency in the information flow by interlinking the past, present and future states of products in relation to different actors. Information distortion is reduced by using a product standard that automates goods identification and seamless communication between operational decision-making events.

Furthermore the product standard facilitates viewing information as a set of components where features of product time may easily be seen and compared with each other. Given the centrality of products in generating value, the standard is a simple central resource that potentially drives supply-network integration efforts. This involves a wider range of uses than the traceability function for which the standard initially was developed. Accordingly, TraceFish may facilitate value-network integration.

Based on an assumption of economizing by uncovering potentials for multiplex use of the TraceFish standard, different actors may develop information flows to explicitly seek to uncover its complexity. This modular approach in which information-flow resource components are designed to function together for different purposes simplifies developing information exchange in a complex food supply network setting. This regards designing new information systems, implementing them as well as use and later further development. In an initial development phase, TraceFish laid the foundation for automating informational processes for connectivity between information systems. However, information system strategy should not stop at initial usage (such as product standards explicitly designed to support traceability), but instead seek a wider range

of uses not necessarily explicitly found in the core resource's development process. TraceFish is a generic information resource that can support daily supply activities by enhancing goods identification and communication. Improved goods identification and communication may better support activities such as production, logistics, purchasing, and sales.

The TraceFish standard may also support process automation when used with GTIN numerical standards so that a product document can be seamlessly communicated from seller to customer and numerous logistics providers. This will reduce administrative costs and potential errors associated with manual document handling. Most important, using a product standard to facilitate seamless information exchange is a tool to secure customer value.

Supply-network integration may be classified in relation to different measurable variables, including access to inter-organizational information systems (Frohlich and Westbrook 2001). Since many food-supply networks remain a conglomerate of loosely integrated actors managing their internal processes, weak supply-network integration is accountable as manual operations in the information flow. Litigation associated with traceability requirements thus influenced supply-chain integration efforts and increased motivation to develop end-to-end information transparency.

In practice, manual solutions are preferred, since this reduces investment risk. Although trust is fundamental in integrating supply networks, the case narrative did not find lack of trust to be a fundamental obstacle to integration, other than limiting investment in traceability systems. The total cost issue related to information system investment is vital. Although smarter, hi-tech solutions encouraging supply-network integration are available at a relatively high investment cost, simple and safe solutions are preferred when the product information flow spans inter-organizational boundaries. Manual product tracing is also understandable since tracing is seldom required and plays a relatively peripheral role in relation to daily value generation through product transformation. Information transparency is achieved with minimal investment.

The case narrative shows that business actors usually navigate the supply network by interacting with their first-tier partners. An alternative view of supply integration is achieved through evoking the complete supply network by highlighting the transvection model. This view involves interdependencies between multiple tiers of actors, including both vertical (organizing complementary activities) and horizontal (organizing similar or alternative activities) aspects of integration. From a business perspective, traceability implementation demands applying a complete, multi-tiered, end-to-end scope to analyze product supply. It should also include internal integration. Information systems cross the functional borders found in firms. Different functions should therefore take part in information system development. In addition, IT enabled process development should utilize labor as well as management. Labor, being close to operations, sees problems to which management may be blind. Without coaching, labor may not be motivated to see nor report potential for information system development.

Concluding Remarks

The linkage between the information system and IT capabilities should also be considered when IT suppliers promote and sell their traceability solutions. There is no limit to how wide this perspective may be, from an internal-firm and a supply-network perspective. Within the firm, product traceability may be linked with existing information systems for a range of uses. There is a need for product traceability from an inter-organizational perspective, since tracing products inherently concerns following goods identifications and registrations through the product history in its flow toward the end-user. However, developing information connectivity between firms is more challenging than within firms, due to trust, power, and conflict issues in the supply chains.

TraceFish is an informational resource with a range of divergent potential uses to explore a wider range of economies related to information system investment. The standard is a fixed resource to which other information system components must relate. In this manner, the standard is the glue in supply-network integration efforts. To support this development, actors need to move toward a common supply-network mindset when business managers seek to develop product traceability. Information system development involves people and decision-making. The product information standard is merely a standardized facilitator. For business practitioners this evokes an understanding regarding how a technical artifact, a food product standard, is a tool that supports integration necessary for achieving successful information system development.

Information systems are explored through the literature review and the case narrative as conglomerates of information-resource components. Managers should seek microlevel solutions, without forgetting the broad picture of what information systems can do as a unified mix of heterogeneous components. TraceFish can be used to develop seamless product traceability through the use of GTIN-based numerical product standards.

However, a greater potential for investing in traceability systems should be considered. Traceability is designed into the overall inter-organizational food-distribution system. The transvection model shows a piecemeal picture of product supply. This should also stimulate a more piecemeal perception of information flows and how interactions between companies involve boundary-spanning that need not require expensive, proprietary-system investments. Rather, the use of standard open systems should enable boundary-spanning in a simpler and less costly manner.

While the TraceFish standard was developed to make seafood traceability more efficient, its main usefulness is found in supporting decision-making to direct product flow. This study reveals a simple truth that may be forgotten when different professions, functions, and companies inter-mingle. This mingling may hide obvious facts, such as that a resource has several potential uses, which may not always coincide with the original design. This indicates opportunities for economizing value-creating operations.

This has clear implications when evaluating risk in regards to investments. This is illustrated by the case regarding IS development to support product traceability. Tracing products is not a core business activity and is seldom carried out. Food-product traceability is required by law. Not having full information about a product's history creates concern among the public. The seeming hassle of investing in traceability systems may be rendered null when considering multiple uses. This study focused on how a product standard facilitates supply-network integration of different IS components to achieve product-supply objectives.

Since customer value is the driving force in achieving information connectivity, further research may look at detecting new aspects of product-value perceptions and their measurement in relation to operational decision-making, and how these perceptions may support supply-network integration. Research may also examine the development of actor perceptions regarding product value, based on efficient product-transformation measurement at different "sort" stages and communication of these measurements. Product and information transformations represent a meeting of two complex systems of combined and transforming resources to create customer value. This is a prime motivator toward designing improved overall food product supply.

For business practice, developing this understanding of multiplex use will enhance information system development with potential for securing customer value objectives. This, is revealed as a continuous (possibly Kaizen type) process involving understandings of product supply; something that not easily achieved. Also markets, technologies and environments change. The path to understanding how to develop information systems is inherently continuous in nature. It is not necessarily simple to grasp how product standards at an operational level function as informational resources with multiplex use and how multiplex may aid the development of efficient customer value-oriented information systems. Furthermore, each food chain must create adapted information systems that support the flow of foods through facilitating tracking, tracing and logistics activities. The good news is that knowledge that takes time to develop, so-called "sticky information" (Von Hippel 1994), is also difficult to copy by competitors.

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California Water Wars: Tough Choices at Woolf Farming

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Abstract

This case explores the challenges facing a large family farming operation in the fertile San Joaquin Valley of California. Woolf Farming and Processing, a diversified farming and processing operation, has faced reduced water allocations resulting in the removal of permanent crops and the fallowing of some of their land. The case challenges students to develop and analyze alternatives that will allow the company to continue to thrive under uncertain future water allocations.

Keywords: water policy, irrigated agriculture, farm management

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IFAMA Agribusiness Case 16.2 A

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Introduction

In August 2009, Stuart Woolf, President of Woolf Farming and Processing, watched as fruitful almond trees were fed into an industrial grinder that transformed them into woodchips in a matter of seconds. Woolf Farming, a privately held, diversified, family farming business, and one of the most productive farming operations in California's San Joaquin Valley, was pulling up their valuable almond trees, not because of low product prices or lack of productivity, but because they lacked sufficient water to keep the trees alive. Throughout the state of California, fields have been fallowed and orchards removed because water allocations to farmers have been cut.

The development of water resources, funded by the federal and state governments, was instrumental to the development of California's economy. Competition for scarce water resources has ebbed and flowed, but it has been especially intense over the last 40 or so years since the advent of landmark environmental legislation. Farmers have been pitted against environmentalists in a battle that has been dubbed "fish versus farms." In some cases farmers from the north have clashed with farmers from the south in an attempt to stop the export of water from north to south. In recent years, farmers have suffered severe cutbacks due to decreased water availability and the EPA's mandates to increase allocations to environmental uses to protect threatened and endangered species.

Woolf Farming responded to the water cuts by reducing some of their farmed acreage, but, as Stuart admits, this is a short-term solution to a long-term problem. Furthermore, it is not sustainable from a business perspective. The Woolf family has been in the business since 1974, growing their operation by focusing on crop diversification and investment in conservation technologies. In addition to almonds, Woolf Farming cultivates other crops including grains, garlic, onions, pistachios, tomatoes, wine grapes, and roses. They own several processing plants where they produce value-added products, primarily processed almonds and tomato paste. Woolf Farming's profitability is highly dependent upon a steady and reliable flow of water for crop irrigation and production purposes; lack of water compromises its ability to stay in business as a family farm. It is evident that the current water situation will necessitate some significant changes, but what is the best course of action for Woolf Farming to follow in the midst of uncertainty?

Farming in California

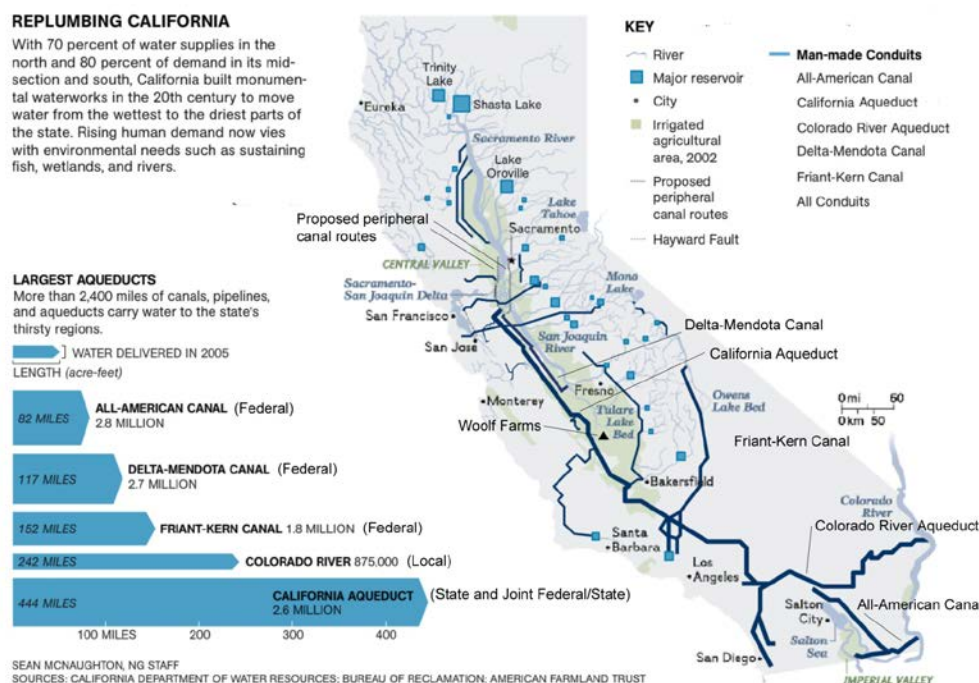
Agriculture makes a significant contribution to the California economy. Direct farm sales totaled approximately \$37 billion in 2008 with exports totaling about \$11 billion (California Department of Food and Agriculture 2009). California's 75,000 farms and ranches (which account for only 4% of the nation's farms), produced 12.8% of the nation's total agricultural value. Moreover, of the top ten most productive agriculture counties in the U.S., nine are located in California and more than 14 California counties record upwards of \$1 billion in agricultural production (California Department of Food and Agriculture 2009). California products have a reputation for quality and are distributed throughout the U.S. and world.

California's agricultural prominence has been attributed to rich topsoil, an extended growing season, an abundance of sunshine... and, of course, water. Intensive farming began in the 1850's when miners drawn to California during the Gold Rush sought out alternative means of making a living through cattle ranching after the gold ran out. Gradually, farmers began dry land farming wheat and barley crops, eventually cultivating more water-intensive crops by drawing on ancient aquifers to meet the water demand. Subsequent large-scale agricultural production was made possible by investment in a complex water storage and delivery system, which allowed for the irrigation of the arid Central Valley.

The access to land, water, labor, and California's unique climate has provided California farmers with a comparative advantage in the agricultural marketplace. In 2007, California farmers produced over 400 crops and agricultural products, valued at \$36 billion and representing more than half of all U.S. grown fruits, tree nuts, and vegetables, making the state a prominent producer of high-value agricultural products on a national and global scale (California Department of Food and Agriculture 2009). California is the nation's sole producer (99% or more) of a large array of specialty crops including almonds, artichokes, clingstone peaches, figs, almonds, pomegranates, raisins, and walnuts.

The Central Valley (Exhibit 1), a large flat valley that stretches over 450 miles from north to south and over 80 miles from east to west, is the state's most important agricultural region. Some crops, such as almonds, are grown almost exclusively in this region (California Department of Food and Agriculture 2009). The northern portion of the Central Valley is drained by the Sacramento River and is known as the Sacramento Valley. Likewise, the southern portion of the Central Valley, drained by the San Joaquin River, is known as the San Joaquin Valley.

Exhibit 1. Map of California and Major Water Storage and Delivery Systems



Note. Adapted from National Geographic, California's Pipe Dream (Bourne 2010). Used with permission.

Water Availability and Use in California

Approximately 70 percent of all available water falls in the form of rain or snow in the northern, less populated region of California. Much of the moisture occurs as snow in the Sierra Nevada mountain range (eastern portion of the state) and flows into rivers and reservoirs when the snow melts in the spring. The greatest demand, for both agriculture and urban uses, lies in the southern two-thirds of the state (which includes much of the farmland and the large population centers of Los Angeles and San Diego), which receives only about 12 inches (30.48 cm) of rain annually. By comparison, many other important agricultural states and regions, such as Florida, receive over four times the amount of rainfall annually (NOAA 2010). When local surface water and underground aquifers were no longer able to meet farmers' demand for water, the state and federal governments built an elaborate system of water storage and conveyance mechanisms to deliver water to urban and agricultural users (Exhibit 1). The 1930's saw the construction of the Central Valley Project (CVP), a federally funded venture that delivers water from the Sacramento-San Joaquin River Delta to the dry south through pumping stations in the Delta. The CVP provides water for over 3 million acres (over 10 percent of the U.S.'s irrigated farmland) and includes 22 dams and reservoirs, 11 hydroelectric power-plants and 500 miles of canals and aqueducts (Bourne 2010). In 1960 the State Water Project (SWP) was built. The principal conduit for this system is a 444-mile concrete-lined canal, the California Aqueduct, which runs the length of the Central Valley. The SWP delivers water to over 23 million residents and irrigates over 600,000 acres of cropland (Bourne 2010).

The Colorado River Aqueduct is an example of local and federal cooperation. The Metropolitan Water District, which serves several southern California counties and includes the cities of Los Angeles and San Diego, operates the aqueduct. The aqueduct carries Colorado River water from Parker Dam (constructed by the federal government) to residential and commercial users in a six-county area and serves almost 20 million people.

In recent years, approximately 41 percent of California's developed water supply has been allocated to agriculture with approximately 48 percent allocated to environmental uses, and 11 percent going to urban users (Department of Water Resources 2010a).

The Water Crisis: Changes in the Market for Water

In recent years, droughts and federal enforcement of environmental regulations have led to reduced water allocations to agriculture. Since 2007, California has experienced below average levels of rain and snowfall, which has contributed to lower water levels in both natural and man-made water reservoirs. Water allocations from the SWP are shown in Exhibit 2. See Bourne (2010) and Paul (2009) for more information on California's water system and the impact of the drought.

Population pressures are expected to further exacerbate the situation. Continued population growth and the consequent demand for water in urban areas are expected to increase. The state currently has 38 million residents and is expected to reach 50 to 60 million people by 2050. The water system was designed for a population of 16 million. Moreover, climate change predictions forecast more variable weather with intensified droughts and less water available to be captured

in lakes and reservoirs in the coming years. The major water providers, including the state and federal governments, make allocations based on a complex set of rules and priorities. These include available supply, contractual obligations with farmers, cities, and other users, and legislative and judicial mandates. A reduced and more variable water supply coupled with the increased pressure on water demand from urban areas is expected to further exacerbate the conflict between urban and agricultural use of this limiting resource. While agricultural users have not yet seen their allocations reduced based on urban demand, agricultural water use is a frequent target for criticism given the high percentage of the developed water supply allocated to agriculture. Farmers have strong contractual and historical rights to their water allocations. However, it is not inconceivable that these allocations might be targeted by other groups through legislative action, judicial challenges, or California's ballot proposition process, which allows voters to make changes to the state's constitution and laws.

Year	Percent Allocation
2006	100
2007	60
2008	35
2009	40
2010	50
2011	80
2012	65

Exhibit 2. State Water Project Allocations, 2007-12

Source. Association of California Water Agencies 2012.

Endangered Species Act (ESA) & the Delta Smelt

Further confounding the issue, litigation regarding the 1973 Endangered Species Act (ESA) has limited the amount of water that is actually delivered to farmers via the SWP and the CVP. A decline in the delta smelt population, a threatened, three inch-long silver fish, indigenous to the Sacramento-San Joaquin River Delta has led U.S. district judges to limit the amount of water pumped out of the Delta for agricultural uses. Scientists have found that the smelt are threatened by fluctuating salinity levels resulting from the movement of fresh water through the Delta and are killed by being drawn directly into pumps that move the water. In 2007, a federal court order cut the amount of water pumped out of the Delta, increasing water allocations to the environment, in an effort to protect the fish. For farmers, this has meant lower water allocations. In 2009, many farmers received less than half of their historical, average contractual water allocations. While some in the agricultural community view this as a "fish versus farmers" debate, environmentalists and many scientists believe that the decline in smelt populations points to a larger problem of a collapsing delta ecosystem.

New Developments

In 2009, the state of California passed a comprehensive Water Package creating a "framework for water managers, legislators and the public to consider options and make decisions regarding California's water future" (Department of Water Resources 2010a). The primary goals of the package were to ensure "a reliable water supply for future generations" and to restore "the

Sacramento-San Joaquin Delta and other ecologically sensitive areas” (Department of Water Resources 2010b). The plan has set the stage for the possible development of an alternative conveyance system, sometimes known as the Peripheral Canal, which would reroute water around the Delta’s winding waterways. While several proposals have been discussed, one alternative would provide 50 miles of canals at a 2012 cost of nearly \$11-13 billion. Ultimately, the goal of the Peripheral Canal would be to provide greater water reliability and improve environmental conditions in the Delta by rerouting fresh water flows around the environmentally sensitive areas. Plans to build the Peripheral Canal, the so-called final link in California’s water system, were defeated once before in 1982 when the state ran out of money to fund the project, the federal government relinquished its support, and political support diminished with increasing public attention on the mounting environmental toll of big water projects. While the state’s current water problems have generated renewed support for the Peripheral Canal, the \$11-13 billion price tag is a formidable obstacle in the context of the multi-billion dollar budget deficits the state has faced in recent years.

Woolf Farming

With over 35 years in business, Woolf Farming has established itself as a leader in California agriculture, employing over 75 full-time workers on the farm and 800 employees in processing operations. Woolf Farming prides itself in running a highly efficient operation. They plant a diversified array of crops selected to yield the highest returns and to provide the flexibility needed to address fluctuations in market prices and water supply. It has been a leader in pursuing water-saving technologies such as drip irrigation. Permanent crops include almonds and pistachios, while annual plantings include cotton, tomatoes, garlic, and onions. Their value-added operations include an almond processing plant where 40-50 million pounds of almonds are handled and distributed annually and a tomato processing plant that produces 3 million pounds of tomato paste per day. Additionally, Woolf Farming recently acquired two frozen vegetable processing companies that supply private label and industrial products. Exhibit 3 includes information on the major crops grown by Woolf Farming.

Additional information regarding water usage, cost, and returns for selected crops grown in the San Joaquin Valley is presented in Exhibit 4. This information is developed by the Cooperative Extension Service and includes most of the major crops grown by Woolf Farming as well as alternative crops grown in the San Joaquin Valley. The information provided by the Extension Service is generally consistent with the crop information for Woolf Farming. Taken together, Exhibits 3 and 4 present a fairly complete picture of the agricultural crop production opportunities for Woolf Farming. Although a crop budget is not available for garlic, water usage, cost, and returns are similar to that of onions.

Exhibit 3. Woolf Farming, Selected Information, 2009

Crop	Acres Planted (percent)^a	Price Per Pound	Yield in Pounds Per Acre	Gross Revenue Per Acre	Gross Margin Per Acre
Almonds	19.0	\$1.85	2,750	\$5,088	\$1,372
Pistachios	16.3	\$2.25	3,500	\$7,875	\$5,715
Onions	2.6	\$0.65	4,000	\$2,600	\$670
Tomatoes, processing	33.0	\$0.33	96,000	\$2,120	\$405
Garlic	1.8	\$0.13	20,000	\$2,600	\$770
Fallow	27.3	-	-	-	-

^aTotal acres planted is shown as a percent of Woolf Farming's principal crops, not total acres planted.

Exhibit 4. Selected Central Valley Crop Production Cost & Return Studies

Crop	Irrigation System	Unit Water Usage	Unit Water Cost^a	Total Water Cost	Total Operating Costs^b	Net Returns Above Op. Cost
		<i>acre-ft.</i>	<i>acre-ft.</i>	<i>per acre</i>	<i>\$/acre</i>	<i>\$/acre</i>
Almonds	Flood (canal)	4.25	\$110	\$468	\$2,154	\$1,847
Almonds	Micro-sprinkler	3.50	\$110	\$385	\$2,391	\$461
Pistachios	Drip (canal)	3.92	\$110	\$431	\$1,593	\$2,443
Wine grapes	Drip (well)	1.33	\$110	\$147	\$3,069	(\$144)
Onions	Drip (canal)	3.33	\$110	\$367	\$3,987	\$1,213
Tomatoes, fresh	Furrow (canal)	3.00	\$110	\$330	\$5,668	\$1,092
Wheat	Surface (canal)	1.67	\$110	\$183	\$579	\$76
Cotton	Furrow (canal)	2.50	\$110	\$275	\$796	\$266
Corn ^c	Furrow (well/canal)	3.67	\$110	\$404	\$1,204	(\$133)

Source. Agriculture and Resource Economics Various Years.

^aThe various water costs per acre-foot used in the studies are amended to reflect Westland Water District fees of \$110/acre-foot. ^bOperating Cost figures exclude overhead and investment costs, which are higher for perennial crops (grapes, nut trees). ^cThe corn study is amended to include a CA corn price of \$6.00/bushel, instead of the low \$4.20/bushel assumed in the study.

Note. Canal indicates that surface water is the source and well indicates that the water is pumped from underground wells. The method of application is indicated as: flood, where the whole field is flooded; furrow, where water flows through trenches in the field; micro-sprinkler, where small sprinklers attached to a hose spray water, and drip, where small emitters attached to a hose drip water. Surface irrigation for wheat is typically with either sprinkler, where sprinklers spray water over a wide area, or furrow.

Historically, Woolf Farming has relied on its water allocation through the Westlands Water District for water to irrigate its crops. The surface water allocation from the Westlands Water District, priced at \$110 per acre-foot, is the least expensive source of water. In years when water is plentiful, a full allocation provides Woolf Farming with 2.65 acre-feet (an acre-foot equals 325,851 gallons) per acre to the entire farm.

To close the water gap, Woolf Farming uses groundwater pumped from their land to supplement surface water. Groundwater costs about \$130 per acre-foot to pump and Woolf Farming has the capacity to pump approximately 1 acre-foot of water per acre across the entire ranch. However, water in the local wells contains levels of dissolved salts that are much higher than that of surface water from the delta, resulting in a toxic build up of salts in the soil. Moreover, removing too much groundwater without replacing it can result in land subsidence (sinking of the land resulting in a permanent loss of underground water storage capacity). Pumping ground water has provided short-term relief, but it ultimately compromises the health of crops and the soil quality. Any use of well water will increase the salt load. Therefore a greater reliance on well water will result in a larger impact on crop quality and yields, although some crops, such as cotton tend to tolerate higher concentrations of salt.

To fully utilize its farmland in the best of years, Woolf Farming needs to supplement its surface water and ground water sources by purchasing water from those entities that do not use their entire allocation. This has been the case in recent years as water allocations have been declining. Allocations from the Westlands Water District were 50 percent in 2007, 40 percent in 2008, and 10 percent in 2009. The company has also made supplemental water purchases in recent years directly from the district. Purchased water is used as a last resort, since the cost is about \$260 per acre-foot.

Woolf Farming has managed its water by giving permanent plantings priority since no water means losing the trees and a loss of the investment in the plantings valued at thousands of dollars per acre. In short water years, the first step has been to reduce the land planted to annual crops. However, in recent years, the outlook for future allocations of water has been so dire, that Stuart made the decision to remove over 1,200 acres of mature almond trees.

Complicating matters further, agricultural users typically do not know what their allocations will be until after the planting decision is made. Preliminary allocations are made based on estimates of the available water supply, which in turn is based largely on estimates of the winter snowpack. These estimates are updated as the snowpack melts and better information becomes available. However, final allocations are not made until later in the spring. According to Stuart, the uncertainty surrounding how much water they will receive results in the inefficient use of resources and makes planning difficult. Moreover, Woolf Farming is a vertically integrated operation, with almonds and tomatoes being processed in their company-owned processing facilities. For most commodities, the price will not be known until close to harvest. In what has become a family mantra, Stuart says that they “plan for the worst and hope for the best.”

The impact of reducing the number of acres farmed has been felt throughout the company. Total returns to the ranch have declined somewhat, but the decline in acres farmed has been offset by higher prices due to acreage reductions throughout the state. It has been particularly hard on the labor force as both the full-time and seasonal labor force has declined. However, Stuart has told his foremen and key managers that they will survive and prosper by focusing on the right crops with the best returns.

The Challenge

Stuart contemplated an uncertain future for Woolf Farming that revolved largely on the water situation in California. Climate change, increased urban pressures, and environmental restrictions all pointed to lower and more variable water supplies for agriculture than that which farmers had relied on in the past. He felt that all options should be on the table and he believed that the company may have to pursue unconventional strategies, including alternative investments outside of the Central Valley to strategically meet these new realities.

1. What do you see as the major issues for Woolf Farming regarding water and the long-term success of its farming operation? How would you approach the problem?
2. Conduct an analysis of Woolf Farming's enterprises and make a recommendation as to how they should proceed given the future water outlook.
3. What alternatives or programs should Woolf Farming support that have the potential to positively impact the availability of water and the continued profitability of farming in the San Joaquin Valley?

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The Global Competition for Talented People

Industry Speaks

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Abstract

This article discusses “people challenges,” and is gathered from the authors own research working with both public and private sector businesses. It is divided in two sections: the first addresses the new environment of “doing more with less” and how this affects labor. The second part focuses on the personal and professional characteristics valued by public and private organizations. These characteristics include: tuned, simplified, adaptive, innovative, investor, related, broad, dreamer, results-driven and communicative. A brief description follows.

Keywords: talents, labor, self-improvement, education

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Introduction

The business of agriculture is entering a new era which requires a different type of human resource management and skill development. To meet the challenge, how do we attract people who possess the talents needed to fill the food and agribusiness jobs of the future?

Several factors are driving growth in the food and agro sector. It's forecasted that the world population will reach 9 billion people by 2050. As urbanization in Asia and Africa rise, economic development and income distribution in highly populated countries is creating new tensions on finite resources. This coupled with new public policies for food distribution and competing interests for land usage for other non- food items such as: fuel, plastics and electricity are providing a setting for a perfect storm.

If 1.27 billion tons of grains and 258 million tons of meat were produced in 2006, its projected we will need almost 1.6 billion tons of grains and 460 million tons of meat to feed the world population by 2050 (Mano and Ikeda 2013).

As consumption rises, more pressure will strain local and regional governments as they seek to manage land (soil) use, water usage, energy (sun and power), and agricultural inputs. These decisions made by local institutions and governments, require manpower, new technologies, education, credit, storage capacity, transport, connectivity, logistics, and finally, management capabilities.

Societies that are better able to manage their resources now will be better able to capture this food and agro related market growth and promote its development in the future.

In the last five years, we've seen a dramatic change in two of these resources: people and management. In Brazil, we've moved from a period of unemployment with plentiful labor for the food and agribusiness production to an era where there is a shortage of available workers. Additionally, they are both expensive and low-skilled. This is threatening the ability of food and agribusiness to thrive and is one of the biggest challenges in Brazil—a country that has greatly benefited from of this demand-growth period due to the richness of resources.

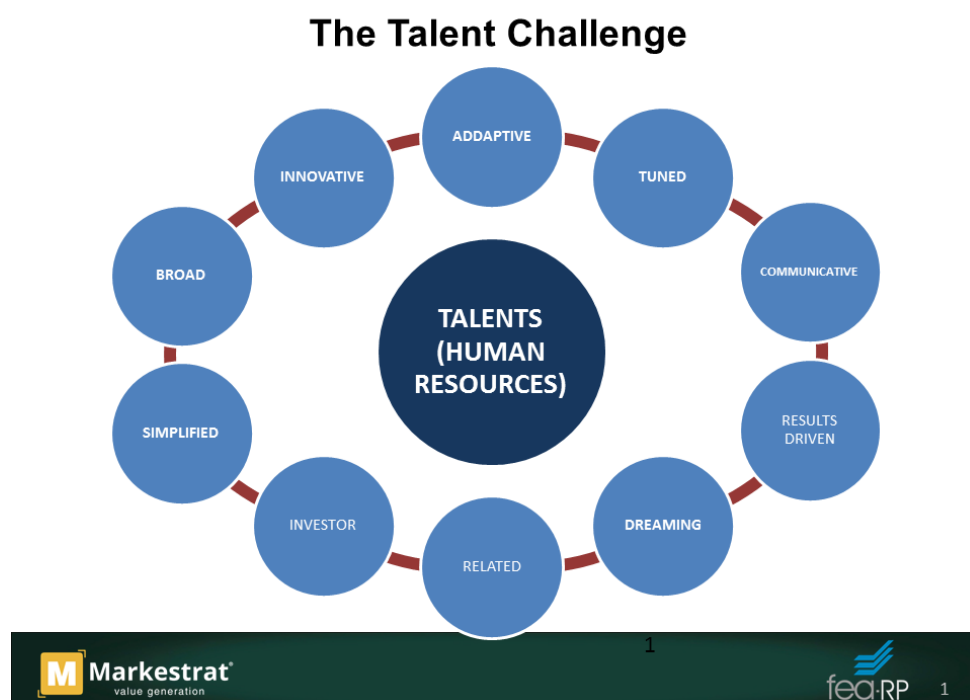
Massive education is necessary in order to create the talent necessary for the future. This is something that takes time and is not easily solved. Countries which have made a strategic investment in education are now reaping the rewards. For example, in Russia and Chile, 24% of the population between ages 25 to 34 years have attended universities, while in Brazil and South Africa its remains closer to 7% (Mano and Ikeda 2013).

China has 194,000 people currently studying in US universities, while India has 107,000 and Brazil has only 9,000. Forty percent of the researchers working in the US are foreigners. In Brazil, only 7% are foreigners. Brazil has 9% of its researchers living abroad while India has 40%. It's estimated that today, Brazil lacks 150,000 engineers for its companies (Mano and Ikeda 2013).

In the past, 12% of the jobs in developed countries required a university degree, today its 25%. In emerging economies, this figure grew from 4 to 10% in the same period. McKinsey & Company estimates that we will have a deficit of 40 million professionals with a university degree in the world by 2020 (Baily and Manyka 2013).

We are moving to an era of talent scarcity—urgency even more pronounced in the food and agribusiness sector because highly skilled young people often find other industries more exciting. The task of finding, localizing and attracting qualified people is becoming increasingly important to each country's operating policy. Some countries are actively pursuing this strategy, while others, like Brazil, have bureaucratic processes that make it extremely difficult to simply secure a work visa.

The second part of this article reflects discussions we've had with employers, farmers, and government agencies in several countries. It also reflects our own feelings as employers. Based on these discussions, we offer a list of special characteristics needed by governmental officials and food and agribusiness corporations to become and remain competitive:



TUNED TALENTS: stay tuned to the macro-environment (politics, economics, socio-cultural and technology), by reading, watching, listening and paying attention. Develop a global view, with cultural sensitivity.

SIMPLIFIED TALENTS: learn how to simplify processes, be practical, search for basic and faster solutions to problems.

ADAPTIVE TALENTS: the capacity to adapt in a fast changing environment is one of the most important characteristics and solutions for change.

INNOVATIVE TALENTS: innovate and create your own businesses and find your own solutions, differentiating, getting away from the basic.

INVESTOR TALENTS: never stop studying, advancing your knowledge and desire to learn more. Status quo is one of the worst characteristics in a workforce.

RELATED TALENTS: interact well with others, build teams, work in groups, and; share knowledge and solutions. Respect differences and assign people to duties that best use their skill-sets. Motivate and encourage them to be competitive. By including them in the process they take ownership and feel valued. It improves confidence.

BROAD TALENTS: provide feedback and respect differing opinions. Have constructive arguments and reflect as to why opinions vary. Read editorials, opinion pieces and learn always to see the facts through different lens.

DREAMING TALENTS: keep dreaming that the targets, results and desired outcomes are possible. Search for excellence, dream more. People that don't dream tend also to flatten out.

RESULTS DRIVEN TALENT: deliver results. Manage your head, health and happiness. Develop a passion for efficient planning and become results oriented. Stay present and available.

COMMUNICATIVE TALENTS: communicate efficiently. Not excessively, trying to sell yourself, but neither remaining silent towards the tasks at-hand. Search for balance and elegance by sharing the major achievements with your team.

For those of us involved in education, it's imperative that our universities provide dense theory founded on global business models and methods, while strongly linking to markets, and practical application. Our roles as educators are not only to produce good technicians, but also instill strong character and further global citizenship, through promoting social and environmental causes as well as community development.

People are probably the most challenging resource for the food and agricultural sector in the coming years. But when a challenge exists, it is followed by an opportunity, and this is the way we like to treat it.

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