

Understanding Organic Prices: An Analysis of Organic Price Risk and Premiums

Sarah Michele McKay

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State
University in partial fulfillment of the requirements for the degree of

Master of Science

In

Agricultural and Applied Economics

Kimberly L. Morgan

Olga Isengildina Massa

Gustavo F.C. Ferreira

April 22, 2016

Blacksburg, Virginia

Keywords: organic, premiums, risk, volatility, price, grains, commodity, oilseed

Understanding Organic Prices: An Analysis of Organic Price Risk and Premiums

Sarah Michele McKay

SCHOLARLY ABSTRACT

The organic food sector has been growing rapidly over the past several decades. Traditionally, this growth has taken place in the produce category, but as consumers demand more organic products, the organic grain and meat sectors have been emerging. Currently, there is a shortage of organic grains, specifically corn, soybeans, wheat, oats and barley, to feed organic livestock. In addition, there is limited studies and understanding of organic price premiums. Therefore, the purpose of this study is to extend existing literature on organic price behavior and factors affecting the organic premium.

The agriculture and food industry has undergone many changes over the past several decades as consumers continue to demand increased transparency and sustainability from the U.S. food system; most notably, the rise of organic food consumption. Food processors and retailers have contributed to this growth as they expand their number and variety of organic product offerings, and have contributed to the increased demand for organic grains, soybeans, milk and meats. Within the last year, major food companies, such as Kroger, Target, McDonald's and Wal-Mart have made commitments to sell more organic food—including grains, milk, and meat. Domestic organic food production increased by 240 percent from 2002-2011 versus three percent in non-organic food. In 2015, there were 21,781 USDA certified organic operations in the United States, representing an increase of 250 percent from 2002. Despite increases in organic production, there are still major shortages on the supply side of organic feed grains and soybeans. This has resulted in increased imports of organic grain from Canada, Eastern Europe and South Africa in response to the organic grain and soybean demand from the animal feed markets. Under these market conditions, there is room for expansion in the organic grain and oilseed markets, yet low levels of adoption of organic production among U.S. field crop producers persist.

Part I of this study provides new insight into the price risk exposure of organic grain and oilseed commodities as compared to their conventional counterparts by analyzing price levels and volatility over time. Organic corn, soybeans, and oat market prices were less volatile during the 2007-15 time period, whereas organic wheat and barley market prices were more volatile than their conventional counterparts. Organic prices collapsed during the recession and remained low one year following the recession. The volatility of organic and conventional prices was significantly different pre-, during, and post-recession for all commodities except soybeans and wheat pre-recession.

In Part II, organic price premiums are explored through identification of key variables expected to influence production and market conditions for corn, soybeans, wheat, barley, and oats. Using an OLS model, lagged premiums were significant for corn, soybeans, and oats, but at varying lags and levels. Oil price was positively significant for all commodities except barley premiums and personal income was only significant for corn, soybeans, and oats. The model was re-estimated using first differences and run with the stationary data, revealing significant variables including lagged premiums, oil price, and the FAO Cereal Index.

Study findings are expected to benefit organic and conventional farmers by providing new information useful for planting decisions. Results are also expected to better inform

consumers of these organic commodities, such as livestock producers and food manufacturing firms, who seek to more fully understand the price risk exposure of their organic commodity inputs. Lastly, policy makers and the USDA can help organic producers by collecting more accurate and frequent data on organics, especially with regards to planted and harvested acreage, yields, stocks, imports, exports, and use.

Understanding Organic Prices: An Analysis of Organic Price Risk and Premiums

Sarah Michele McKay

GENERAL AUDIENCE ABSTRACT

Organic food products are produced without synthetic chemicals, including herbicides, pesticides, and fertilizers. Food grown in organic systems that are certified organic by the United States Department of Agriculture command a price premium, whether it is direct to consumer via farmers markets or in conventional grocery stores. Organic food and food products are representing a relatively larger portion of overall food sales in recent years, and the demand for organic meat has also increased. However, there is a lack of available U.S.-grown organic grains and soybeans to feed the growing number of organic certified livestock to produce organic meat to meet this demand. This shortage results from many factors, yet is primarily due to organic production requirements for significantly more land and operating capital when compared to conventionally grown counterparts. There is a lack of information detailing the relative costs and returns of organic grain production, and, limited understanding of organic premiums. The overall goal of this study is to examine differences in price levels between organic and conventional corn, soybeans, wheat, oats, and barley between 2007 and 2015, as well as factors that may affect the organic premium. For organic grain and soybean producers, study findings reveal that the least risky organic commodities to grow include corn and soybeans, especially if sold in the cash market. However, the author suggests that growers may consider growing wheat, barley, and oats if they have a buyer willing to contract in advance to ensure a premium and reduce price risk. For purchasers of organic grains and soybeans, including major food companies as well as livestock producers, it is recommended they continue to study developments in organic grain supplies as producers continue to consider adoption of organic production methods.

Table of Contents

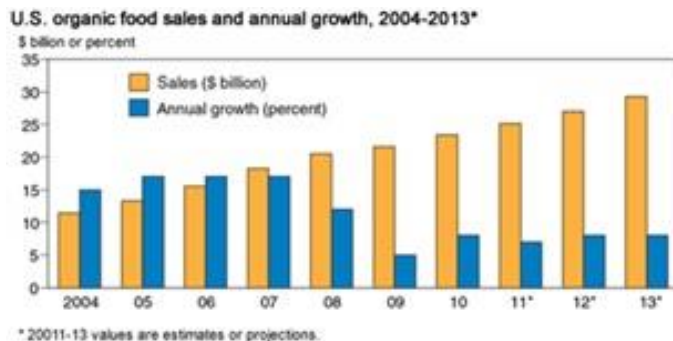
Introduction.....	1
Project Objectives.....	13
Literature Review.....	14
Examining Organic Versus Conventional Volatility.....	14
Key Factors Affecting Organic Premiums.....	19
Part I: Differences in Organic and Conventional Price Levels and Volatility.....	23
Description of Data and Methods.....	24
Discussion of Results.....	25
Part II: Understanding Organic Price Premiums.....	35
Model Development and Data.....	35
Description of Data.....	40
Results.....	47
Conclusions.....	54
References.....	56

Introduction

The agriculture and food industry has undergone many changes over the past several decades as consumers continue to demand increased transparency and sustainability from the U.S. food system. One of these changes has been most noticeable in the rise of organic food consumption.

In the United States, organic food sales have increased from \$11 billion to \$35.9 billion between 2004 and 2014 (OTA, 2015). As of 2014, these sales accounted for more than five percent of the total U.S. food sales (Organic Industry Survey, 2015). From 2013 to 2014, organic food expenditures increased by 11 percent, and demand for organic food at retail sales outlets is expected to continue to grow at a compound annual growth rate of 14 percent between 2013 and 2018 (Daniells, 2014). SPINS, a consumer insights group focused on natural and organic food trends, argues that this growth could be even more substantial. In 2014, 18 percent of consumers accounted for 50 percent of all natural/organic food category sales, which leaves 82 percent of consumers who have not yet reached their full buying potential in this category (Daniells, 2014).

Figure 1:



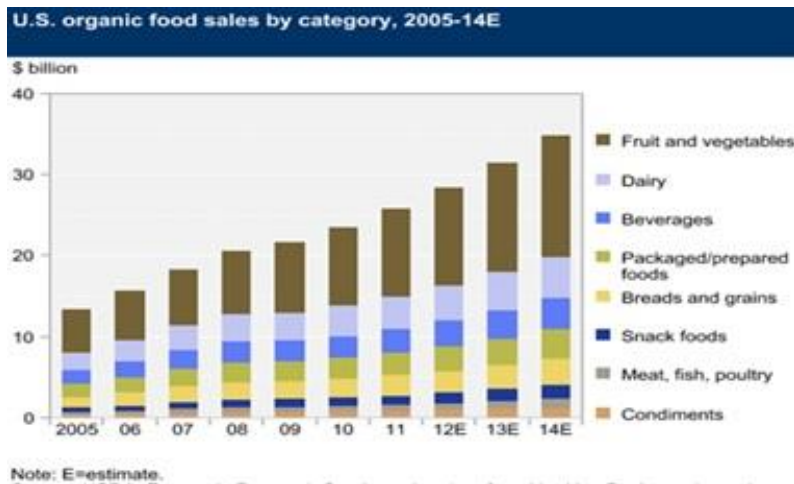
Source: USDA, Economic Research Service using data from *Nutrition Business Journal* (Public Domain)

As of 2014, organic food products could be found in nearly 20,000 natural food stores and in three out of four conventional grocery stores in the United States. Consumers have access

to organic food through three main venues: conventional grocery stores; natural food stores; and direct-to-consumer markets, such as farmer’s markets (Greene, 2014). The Organic Trade Association also reported 81 percent of Americans purchased organic at least a few times in 2012.

Since 2005, produce items have accounted for the highest percentage of organic food sales volume. This has provided opportunities for small and beginning farmers who have been able to capitalize on this niche market. However, there has also been more recent growth in dairy, beverages, and packaged food, as well as meats, breads and grains (Figure 2) (Greene, 2014).

Figure 2:



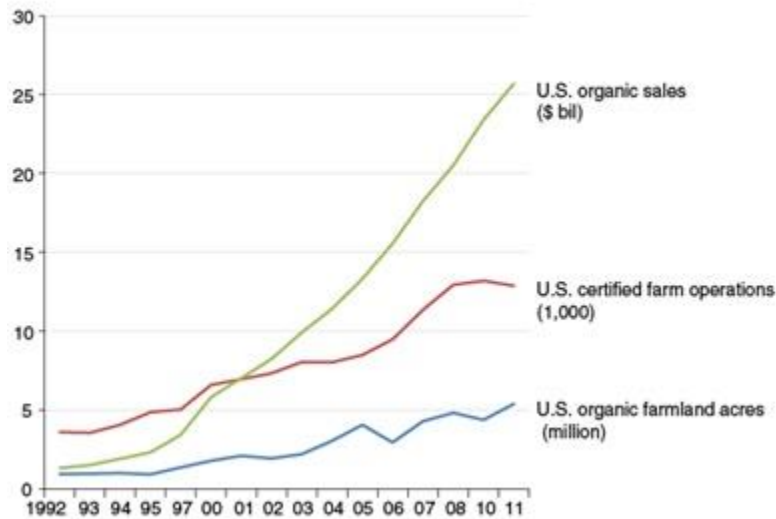
Source: USDA, Economic Research Service using data from *Nutrition Business Journal* (Public Domain)

Food processors and retailers have contributed to this growth as they expand their number and variety of organic product offerings, and have contributed to the increased demand for organic grains, soybeans, milk and meats. Within the last year, major food companies, such as Kroger, Target, McDonald’s and Wal-Mart have made commitments to sell more organic food—including grains, milk, and meat. In the case of General Mills, the food company has set goals to double their organic product sales by 2020 (General Mills, 2016).

In this context of growing demand for organic products, domestic organic food production increased by 240 percent from 2002-2011 versus three percent in non-organic food. In 2015, there were 21,781 USDA certified organic operations in the United States, representing an increase of 250 percent from 2002. In 2015, the number of certified organic operations worldwide increased to 31,160 operations in over 120 countries (USDA, 2016). As of 2011, the total certified organic acreage was just over 5 million acres, or 0.6 percent of all U.S. cropland, as seen in Figure 3. Of all U.S. farmland dedicated to commercial vegetable and fruit production, 5.7 percent and 3.4 percent of planted acreage was grown using organic production methods, respectively, compared to just 0.3% of corn acreage and 0.2% of soybean acreage in 2011 (Greene, 2011). Despite increases in organic production, there are still major shortages on the supply side of organic feed grains and soybeans.

Figure 3:

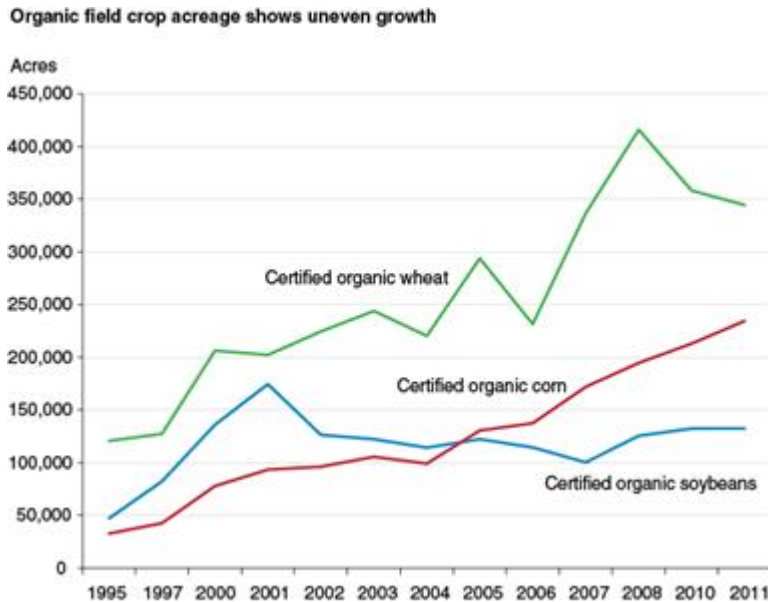
Growth in U.S. organic food sales has outpaced growth in organic farmland since the late 1990s



Source: USDA, Economic Research Service, and Natural Foods Merchandiser and Nutrition Business Journal (Public Domain)

In addition to relatively slow increases in growth of organic acreage plantings, uneven growth in the organic field crop acreage has occurred (Figure 4).

Figure 4:



Source: USDA, Economic Research Service, Organic Data Page, based on data from organic certifiers. Certifier data were not compiled for 1996, 1998, 1999, 2009, and after 2011 (Public Domain)

As more and more consumers desire organic food products, growth in demand has rapidly outpaced the growth in supply. This has led to significant supply chain problems and increases in organic food prices. Many conventional farmers also remain hesitant to explore organic production (Reaves, 2015).

Organic livestock production in the United States has expanded rapidly as a response to a growing demand for organic meats. Consequently, organic livestock are experiencing the difficulties in procuring organic feed grains to feed an increasing number of certified organic livestock. In 1992, the total number of certified organic livestock was 11,647 head versus 56,028 head in 2000 and 196,506 head in 2005. By 2011, the number of certified organic livestock had increased 40 fold to 492,353 head. While organic demand has been increasing, the supply,

especially for grains used as animal feed, lag. This has resulted in increased imports of organic grain from Canada, Eastern Europe and South Africa (Roseboro, 2015). According to Mercaris, a market data service and trading platform for organic and non-GMO agricultural commodities, as of February 2015, imports of organic corn reached 5.2 million bushels, an increase of 752 percent from 2014. Most of these imports are in response to the organic grain and soybean demand from the animal feed markets (Reaves, 2015).

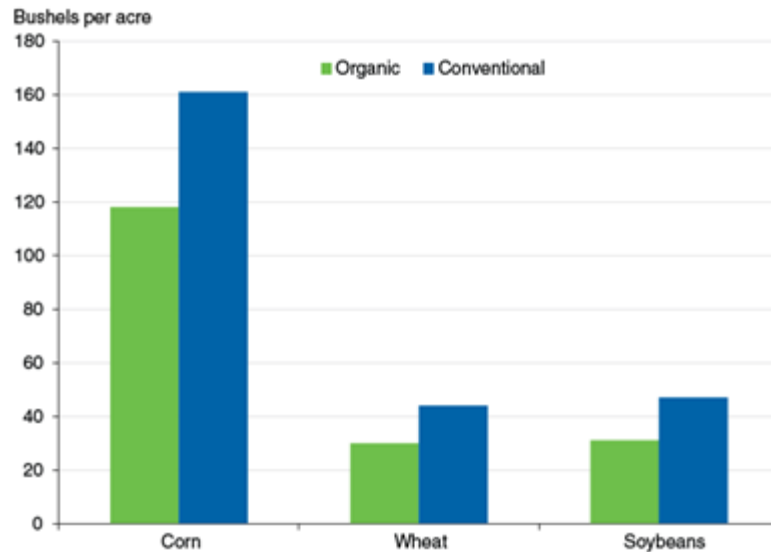
Under these market conditions, there is room for expansion in the organic grain and oilseed markets, as organic crops account for a very small share of U.S. cropland. One possible explanation for the low amount of cropland and uneven growth between grains and oilseed acreage, is the fact that it takes three years for a farm to become certified organic when transitioning from conventional production practices. According to USDA Certified Organic Standards, any land used to produce organic commodities may not have had prohibited substances applied to it for the past three years. This results in a transition period for farmers, where they must produce according to the organic standards but may not sell, label, or represent their commodity as organic or use the USDA organic seal. Thus, they cannot acquire the organic premium for their commodity and are ultimately producing at a lower profit level during the 36-month transition period (USDA, 2012). This becomes a challenge for grain and soybean farmers who have to operate at maximum efficiency using conventional methods to achieve a sustainable income. While they may receive a premium for their organically produced commodity, this premium will not be realized for three seasons.

Aside from this transition period, McBride and Greene (2015) argue that the low level of adoption of organic production among U.S. field crop producers may be the result of a lack of information about the relative costs and returns of organic and conventional production systems

on commercial farms. The main factors affecting organic profitability are labor and total costs, price premiums, reduced income during the transition period and crop yields. One meta-analysis analyzed the financials of organic production using 40 years of studies on 55 crops grown around the world. This study found that organic agriculture had between 22 to 35 percent higher profitability, but 20 to 24 percent higher benefit/cost ratios as compared to conventional. However, when the premium was taken away, organic had -27 to -23 percent lower percent profitability and -8 to -7% lower benefit/cost ratios as compared to organic suggesting that the higher costs and lower yields have a significant impact on organic production profitability (Reganold and Wachter, 2016). Research has noted that organic yields tend to be lower than conventional (Figure 5), and producers have reported that achieving yields was one of the biggest challenges in organic production (McBride and Greene, 2015). Other meta-analysis studies comparing yields between systems showed that organic average yield are 8 to 25 percent lower than conventional (Stanhill 1990; Badgley et al 2012; de Ponti, Riik, and van Ittersum, 2012; Seufert, Ramankutty, and Foley, 2012; Ponisio et al, 2015.). These difference are likely due to the fact that certified organic production may not include synthetic fertilizers as well as pesticides and herbicides, making the yield more variable. Nevertheless, yield discrepancies are not uniform across different crops. For instance, the best yielding organic crops such as rice, soybeans, corn, and grass-glover tend to yield 6 to 1 percent less than their conventional counterparts. On the other hand, lower yielding organic crops like fruits and wheat normally yield 28 and 27 percent less, respectively (de Ponti, Riik, and van Ittersum, 2012). Thus, because organic production involves additional risks, such as lower yields, organic price premiums are expected (Klonsky and Greene 2005).

Figure 5:

Organic field crops yield less than conventional crops

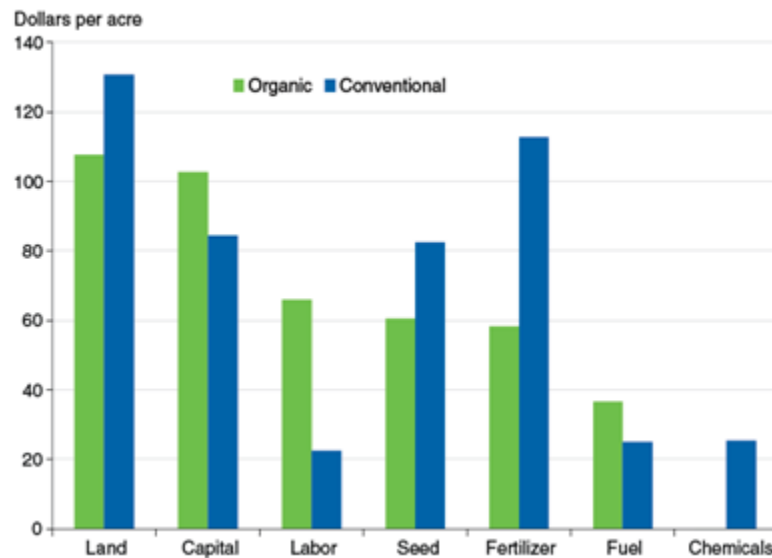


Source: USDA, Economic Research Service calculations from USDA, National Agricultural Statistics Service's 2011 Certified Organic Production Survey and Crop Production 2011 Summary. (Public Domain)

There are also differences in input costs per acre between organic and conventional production (Figure 6). Organic production is characterized by higher labor, fuel, and capital costs per acre, adding in more variability as skilled and reliable labor is hard to come by and fuel prices have varied significantly in recent years (Green, 2011). For instance, as of April 2016, organic dairy farmers have struggled keeping up with the market as they faced high feed and fuel prices (Associated Press, 2016).

Figure 6:

Costs per acre for organic and conventional corn production vary by input



Source: USDA, Economic Research Service calculations from USDA, National Agricultural Statistics Service’s 2011 Certified Organic Production Survey and Crop Production 2011 Summary. (Public Domain)

While there is obvious demand for organic commodities, farmers need to know how much demand there is and at what specifications. While this clarity on demand is needed, so is technical assistance when it comes to organic production, profitable rotations, and marketing avenues (Reaves, 2015). This has led to the development of the US Organic Grain Collaboration, which consists of various companies seeking to grow the organic grain supply and address barriers including “access to resources, knowledge, equipment, and services for transitioning to organic production; and lack of organic market information and resources that conventional farmers have” (Roseboro, 2015). Because grain and oilseed production requires more capital and land, noticeable increases in organic production that capitalize on the growing organic market have not occurred. Therefore, an opportunity exists for farmer investment in organic grain and oilseed production to meet expected increases in demand. However, the price analysis and risk

management tools used by traditional commodity producers are not widely available to organic producers.

Producers of conventional agricultural commodities have benefited from well recorded and widely available price series maintained by the United States Department of Agriculture (USDA), National Agricultural Statistical Service (NASS), and futures markets, as well as a large body of literature that had analyzed patterns in conventional prices. Such wealth of information allows farmers and firms to plan ahead and make profit-maximizing decisions and at the same time mitigate the negative effects volatility in the markets. On the other hand, consistent price reporting and studies on organic commodities are much scarcer, since most organic products are sold via a specialty broker rather than a terminal market. (Dimitri & Greene, 2000). This is reflective of the fact that buyers of organic grains and soybeans are not highly concentrated like those of their conventional counterparts and buyers often form long-term contractual relationships with producers who offer consistency and quality (Born 2005; Singerman, Lence, and Kimble-Evans, 2014). Thus, there is little insight on organic price volatility and understanding of the organic price premiums, particularly for grains and soybeans.

There have been a few steps taken by the USDA to provide more risk management tools to organic producers. In 1990, Congress passed the Organic Foods Production Act of 1990 to establish nation-wide organic standards to help in labeling accuracy and consumer confidence, all while ensuring a consistent product quality. In 2000, the USDA created the National Organic Program to carry out this legislation and the USDA Organic label was finally implemented in 2002. The 2014 Farm Act further expanded organic regulation by including several new provisions to improve enforcement of organic labeling as well as funding for the National Organic Program (ERS, 2014).

Nowadays, there are a series of USDA programs that provide support to organic agricultural producers. The USDA has made efforts to make organic certification more accessible, attainable, and affordable by implementing a *Sound and Sensible* approach which includes identifying and removing barriers to certification, streamlining the certification process, focusing enforcement, and working with farmers to address issues in a quick and efficient manner. They also launched the Organic Literacy Initiative to help USDA's employees better serve organic producers (ERS, 2014).

There have also been new and expanded efforts to connect organic farmers and businesses with resources they need to grow, including access to information on organic programs and technical and financial resources. In order to assist organic operations in defraying certification costs, the USDA developed the Organic Certification Share Program. This program involves producers receiving partial reimbursement for the organic certification costs. Market and pricing information is also available free of charge for nearly 250 organic products through USDA Market News (USDA, 2015).

In addition, over the past six years, there have been over \$220 million in funding to internal and university researchers to improve productivity and success of organic agriculture as well as steps to provide effective insurance coverage for organic crops and risk management tools for organic producers (USDA, 2015). Nevertheless, in the past, Federal crop insurance was less attractive to organic producers as compared to traditional producers. In general, regulations governing the insurability of organic and transitional practices are the same as for conventional practices. However, the program's coverage generally did not account for the higher prices that organic farmers received for their crops. Typically, producers choose a percentage of the

maximum price set by USDA's Risk Management Agency (Risk Management Agency, 2016) for their commodity, which is then used to determine the value of insurance coverage. For many commodities, the maximum price election did not reflect the price premium that growers receive for their organic production. As of 2014, a contract pricing option and a rule was added in the Federal Register that allows separate average market prices to be established for organic crops for the Noninsured Crop Disaster Assistance Program. Today, insurance is provided for any crop grown using organic farming practices when a premium rate for an organic practice is specified in the actuarial documents or there is an approved written agreement. However, many organic farmers sell their harvested crops in the “spot market,” where commodities are bought and sold in open market transactions for immediate delivery, rather than producing their crops under contract for a specified price (ERS, 2014). Lastly, changes made to provide coverage for transitional acreage has eased the transition burden, as transitioning farms will now be covered as if they were already certified farms (RMA, 2016).

Despite the progress described above, there is still a need for a better understanding of organic price levels and the associated risks. There is also a need to better inform potential organic producers. The purpose of this study is to provide new insight into the price risk exposure of organic grain and oilseed commodities as compared to their conventional counterparts. This price risk is analyzed by understanding price levels and then, price volatility over time. Secondly, this study seeks to explain organic price premiums through key variables which are expected to influence production and market conditions for corn, soybeans, wheat, barley, and oats. These explanatory variables include historical grain prices, oil prices, time, personal income, and the FAO world cereal index. There is also a case study on the effects of organic imports. This study will be beneficial for organic and conventional farmers, because it

will provide them with new information for their planting decisions. Results are also expected to better inform consumers of these organic commodities, such as livestock producers and food manufacturing firms, who seek to more fully understand the price risk exposure of their organic commodity inputs.

Project Objectives

In part I of our study, we seek to address existing gaps in the literature by examining the difference in price risk as a result of volatility in organic and conventional corn, soybeans, wheat, oats, and barley market prices. This is important to understand, as organic crop producers' profits are influenced by the mean difference between organic and conventional prices and the risk associated with volatile prices. In part II of this study, we seek to explore those factors that affect the organic price premium, including lagged premiums, oil prices, personal income, time, the FAO cereal index and in a case study, organic imports.

Literature Review

Examining Organic Versus Conventional Volatility

In existing literature on agricultural commodity prices, it is clear that price volatility has long run impacts on the incomes of producers and also creates difficulties in planning agricultural production. Since 1962, agricultural commodities have experienced increasing price volatility, and volatility is affecting modern agricultural markets (Balcombe, 2009). Volatility can be interpreted as a series' tendency to have values far from the series' mean as well as the tendency of the series to have large changes in its values from period to period (Balcombe, 2009). Historical volatility measurements have been based on price levels and have been measured with the standard deviation of prices or by estimating the coefficient of variation. The coefficient of variation expresses the standard deviation as a percentage of the sample mean. The benefit to this measurement is that it does not depend on unit of measurement (Huchet-Bourdon, 2011).

These fluctuations in commodity prices can be explained by various factors. Balcombe (2009) argues that volatility is the result of production levels that are influenced by unpredictable events, such as weather and pests, as well a result of the connectedness with other markets (e.g. energy). Because these energy markets also experience volatility and are a major input for agricultural production, they influence and translate into agricultural commodity volatility. It has also been argued by Gilbert (2006) that agricultural prices are volatile because short run supply and demand elasticities are low. Thus price changes are likely influenced as supply and demand conditions change. Moledina, Roe, and Shane (2004) point out that the classic microeconomic argument for increasing volatility is a result of mismatched supply and demand. They also point out macroeconomic policy, terms of trade shocks, exchange rates, and government interventions

as volatility influencers. The same study also examines the relationship between measures of volatility and farmer expectations. They hypothesized that producers are rational in that their expectation of future prices are a reflection of past realizations.

Other volatility factors are explained by Wescott and Hoffman (1999), who analyzed market factors and government programs that determine corn and wheat prices in the U.S. They note that prices are determined by the interaction of supply and demand functions, which historically were influenced by government agricultural policies. On the supply side, they evaluated beginning stocks, imports, and production. Beginning stocks are the carryover stocks from the previous year and large stocks typically result in lower prices. At the time of this study, imports were noted as fairly insignificant on domestic supply, but are still a supply shifter. Production is crucial in determining price and is determined by the amount of acreage harvested and yield per acre. Demand factors include food, seed, and industrial use, feed and residual, and exports. Wescott and Hoffman (1999) used these factors in their model to estimate corn and wheat prices between 1975 and 1996. They then measured mean absolute error and mean absolute percentage error for two time periods using their model and found that their models were good performers and provide an analytical framework that is useful in price-forecasting applications.

Trostle (2008) evaluated factors that contributed to the increase in food commodity prices between 2006 and 2008 as well as long term factors from 1970-2008. Long term demand factors included strong growth in demand as a result of increasing population, rapid economic growth and rising per capita meat consumption, whereas long term supply factors included slowing growth in agricultural production. Short term demand factors include declining demand for stocks of food commodities, rapid expansion of biofuels production, dollar devaluation large

foreign exchange reserves, aggressive purchases by importers, and importer policies. Short term supply factors include escalating crude oil prices, rising farm production costs, adverse weather and exporter policies.

The first objective of this paper is to examine the differences in mean and variance price levels of organic and conventional corn, soybeans, wheat, oats, and barley, and how price volatility has changed over time. The difference in mean price for organic and conventional commodities that the farmer receives represents the premium organic agricultural producers can expect from growing organic commodities. The difference in variance reflects relative price risk for organic versus conventional commodity producers. It is expected that if the organic premium is large enough, producers would be compensated for relatively higher production risk levels and thus will consider organic production. However, if there is significant price risk associated with organic crops, it may deter investment in organic production methods.

Three key existing studies that measure differences between organic and conventional commodity prices were reviewed to provide guidance for our study approach. Bertramsen and Dobbs (2009) compared prices for organic and conventional grains and soybeans in the Northern Great Plains and Upper Midwest from 1995 to 2000. The data used in their study was retrieved from the Organic Food Business News *Commodity Fax Service* and NASS. Price comparisons were based on monthly figures and were presented using line charts and ratios. Their study found that organic price premiums for soybeans were higher on a percentage basis than that of corn, wheat, and oats over those six years. Organic soybean premium was 217 percent of the conventional soybean price in 1999, but they found that organic soybeans prices fell by 27 percent versus a 22-23 percent decline in conventional prices between 1998 and 2000. Bertramsen and Dobbs (2009) found that the ratios of organic to conventional corn prices rose

continuously through 1999. Organic to conventional ratios of wheat prices increased almost every year between 1995 and 2000 as organic prices declined at a slower rate than that of conventional prices. The authors found that, on average, organic wheat prices were \$2.60/bushel and \$2.90/bushel higher than conventional in 1999 and 2000, respectively. For oats, there was a consistent price premium from 1995-1998, but a lower premium in 1999 and 2000 as organic oat prices declined proportionally more than conventional. Despite this decline in organic prices, the authors found that organic oat prices were 71 percent higher than the conventional price in 2000. Lastly, this study concluded that price variation is likely to be greater for organic farmers.

A second study by Su et al. (2013) looked at the price differences and variation between organic and conventionally produced milk. The authors found that organic milk prices were more stable year round and increased every year as compared to conventional milk prices, which varied within the year and between years. The same study analyzed annual percentage price change from the previous year between 1990 and 2012, and concluded that organic price increased less than 10 percent each year whereas conventional milk price change was from -20 to 51 percent. The range for organic milk annual price change was between negative four percent to 10 percent, versus a range of negative 23 percent to 52 percent change for conventional milk prices. Similarly, the price changes for 2004 to 2012 were broader for conventional milk, ranging from negative 14 to 16 percent as compared to organic milk, ranging from negative 10 to 12 percent. Volatility in milk prices was also estimated with coefficients of variation (CV) using data from Gilbert and Morgan (2011). Their estimations show that the overall CV from 2004 to 2012 was 11 percent for organic milk versus 18 percent for conventional milk. Furthermore, annual CV ranged between two and six percent for organic as compared to three and 16 percent for conventional milk, suggesting that organic milk prices were more stable. Premiums for

organic milk were present most of the time, and were cited as a result of higher costs of production, increasing demand of organic milk and organic milk consumers' higher willingness to pay. Seasonality patterns, although similar between organic and conventional milk production, were also analyzed as key determinants of the organic premium in their paper.

Singerman, Lence and Kimble-Evans (2013), sought to understand the price relationships between organic and conventional corn and soybeans. Their research was a follow up to a study by Born (2005) that found that prices for organic grains and oilseeds were double that of conventional prices between 1995 and 2003, a commonly held belief in organic agriculture today. Singerman, Lence, and Kimble-Evans (2013) argue organic prices are expected to follow the conventional market because of the thinness of the organic markets as well as the low share of organic cropland. In their analysis, they looked at weekly organic and conventional corn and soybean prices in six different markets between 2003 and 2009 from the Rodale Institute. Their findings show that the average ratios for corn were above the doubling threshold, whereas soybean ratios were more closely aligned with the doubling threshold. The authors argue that consumers' preferences, additional risks and higher costs associated with organic agriculture are likely behind the premiums found. Their results suggested that prices of organic corn and soybeans are just as volatile as that of their conventional counterparts, with no significant difference between the coefficients of variation. Part I of this study will expand and update this literature by examining the mean, standard deviation, and coefficient of variation of prices of organic and conventional corn, soybeans, wheat, oats, and barley in the United States. This will also include analyzing how the volatility has varied between 2007 and 2015. Part II of this study seeks to identify major factors that influence the organic premiums.

Key Factors Affecting Organic Premiums

A review of existing research on the organic market reveals many studies focused on consumer demand and willingness to pay for organic food products. This body of literature includes purchasing behavior and consumer preferences that contributed to the growth of the organic market and higher organic price levels. Many of these studies included hedonic pricing models, where an organic claim was treated as a product attribute. For example, Lin et al (2008) used hedonic models to estimate premiums for five fresh fruits and five fresh vegetables. They used 2005 Homescan data and found varying retail premiums from 15 percent for organic carrots to 60 percent for organic potatoes.

On the farm and wholesale level, Oberholtzer, Dimitri, and Greene (2005) evaluated prices for broccoli, carrots, and mesclun mix between 2000 and 2004. They found retail premiums for organic broccoli to be around 223 percent and 202 percent for organic carrots at their highest. There have also been some studies that undertake a second-stage analysis to explain these premiums. For example, Jaenicke and Carlson (2015), evaluated a series of factors impacting the retail premiums for soup, coffee, milk, and bagged carrots. The analyzed factors include marketing costs, producer electricity cost, agricultural chemicals producer price index, U.S. population, category sales, yearly time trend, and expenditure share. They found that the organic prices were less sensitive to marketing and electricity costs than nonorganic prices. The agricultural chemical producer price index, U.S. population, category sales, yearly time trend, and expenditure share variables were found to not be significant.

Previous literature focused on explaining the growth of the organic market as a function of consumer preferences and income. Fromartz (2006) noted that organic purchases were not significantly influenced by income, as people place more value on attributes of organic foods

such as pesticide free and environmentally friendly. However, a study by Smith et al (2009) found a positive income effect for organic fresh fruits and vegetables. Therefore, it is hypothesized that while income may have an effect on consumption, there may be other variables that account for these differences in the organic food categories. These variables are likely outside of the context of consumer preferences and willingness to pay, as we see that grains, milk, and meat have been gaining interest and traction; yet, these markets are yet to be fully served by organic producers (Greene, 2013).

Park and Lohr (1996) evaluated supply and demand factors for organic fresh produce. They estimated a system of reduced form equations to evaluate supply and demand factors that influence the farm price and quantity in wholesale markets for organic broccoli, carrots, and lettuce. Supply effects included conventional farm price, seasonal effects, and weather. On the other hand, the selected demand effects were wholesaling costs, whether or not the product was a part of the NutriClean program, personal income, and wholesale price margin. They found that personal income had a positive and significant effect for quantity of broccoli and lettuce at equilibrium. The conventional farm price had a negative and significant effect for all three organic products, and the wholesale margin had positive and significant effects on organic broccoli and organic carrot equilibrium quantities. On the price side, conventional farm price had a positive and significant effect on organic broccoli prices, whereas wholesaling costs had a negative and significant effect on all three product prices.

A study by Lakner, Ihle, and Wurriehausen (2015) evaluated the producer price relationships between organic and conventional wheat in Germany. They evaluated several fundamental changes that affect this relationship, including the strong growth of the organic market, the increasing marketing of organics by supermarket chains, and the international food

price crisis. They note that the interlinkages in production and marketing of organic and conventional food sectors are not symmetric because of the institutional frameworks that protect the organic market. They utilized a novel asymmetric Markov-switching VECM to quantify changes of market dynamics and asymmetric price changes. Their results show that both prices are pushed downward if the organic premium over conventional is too high. They also found that the disequilibria during fundamental changes are twice as strong on organic prices as they are on conventional ones. Therefore, they conclude that asymmetry is important in the interactions of the prices of organic and conventional prices.

They also note that post 2006, world market prices, as measured by the FAO food price index were transmitted to the organic wheat price in Germany since it is closely related to conventional wheat prices. This suggests that world market events are more strongly transmitted to domestic organic prices since they are not as integrated worldwide as conventional wheat prices. They concluded that the growth of the organic market and its price effects will induce downward pressure on organic prices, which will increase consumption, and further intensify its interaction with conventional wheat prices.

Organic and conventional corn and soybeans are grown in similar regions, and thus confront similar production shocks, but the demand side fluctuations can be different, given the different market outlets for organic versus conventional commodities (Wurriehausen, Ihle, and Lakner, 2015; Adjemian, Saitone, and Sexton, 2016). In a recent study, Ajemian, Saitone, and Sexton (2016) noted that organic and conventional prices can fluctuate independently but organic prices will have a lower bound equal to that of the conventional commodities and can be sold in the conventional market. They noted fluctuations away from this lower bound were due to unique demand shocks and producers' inability to arbitrage due to the transition period of

organic production. They also noted producers' lack of incentive to arbitrage as long as there is a positive organic premium. In addition, the authors suggested that a consistent organic premium would be an indicator of a modern agricultural market where producers are compensated for the higher costs, lower yields, and higher risks that typically characterize organic production. However, because the organic markets are still thinly traded, this organic premium fluctuated and did not appear to reward producers for accepting higher risk production practices.

To explain the fluctuations in premiums, Ajemian, Saitone, and Sexton (2016) suggested that organic soybeans are not as easily substituted in usage as they are a major source of protein for livestock producers, therefore organic soybeans is closer to transitioning to a modern agricultural market status with a consistent premium. For corn, they note the premium may not be as consistent because corn acts a carbohydrate, and is more easily substituted with wheat or barley. Therefore, organic corn farmers are more subject to fluctuation in the prices they receive as a result of changing organic premiums based on changing supply conditions and competing products within this thin-market, where there a limited number of buyers and sellers.

Therefore, organic grain and oilseed price premiums may act as an incentive in encouraging conventional producers to switch to organic production, as they face increased costs in certain inputs and a transition period where they are operating as organic, but without earning the premiums. Previous literature on organic product premiums shows that premiums may be affected by the following: consumer preferences, organic labels, marketing costs, producer electricity costs, personal income, conventional farm prices, seasonal effects, weather, wholesale price margin, wholesale costs, and the FAO cereal index. Therefore, Part II of this paper will explain patterns and factors that affect changes in organic grain and oilseed price premiums.

Part I.

Differences in Organic and Conventional Price Levels and Volatility

In Part I, we seek to address the following two hypotheses:

1) $H_{10}: \bar{P}_o = \bar{P}_c$ $H_{1A}: \bar{P}_o \neq \bar{P}_c$

Previous literature has compared the means of organic and conventional prices in order to determine if there is a premium received for organic commodities. Therefore, we hypothesize that the mean organic price is different than the mean conventional price.

2) $H_{20}: \sigma_o = \sigma_c$ $H_{2A}: \sigma_o \neq \sigma_c$

Previous literature has also compared standard deviations of organic and conventional prices to determine if the volatility in prices is the same. Therefore, we hypothesize that the standard deviation in prices for organic commodities are different than that of conventional, and thus are more or less volatile than conventional prices.

Description of Data and Methods

Organic and conventional price data for corn, soybeans, wheat, oats, and barley used in this analysis were obtained from four main sources: Mercaris, a market data service and online trading platform for organic, non-GMO, and certified agricultural commodities; USDA Agricultural Marketing Service Custom Search; USDA National Organic Grain and Feedstuffs Biweekly Reports; and the USDA Economic Research Service Yearbook Tables. Mercaris' organic feed corn, soybean, and wheat prices are national average farm-gate prices provided by the USDA. Conventional corn and soybean prices are Chicago Board of Trade corn and soybean futures prices recorded by Mercaris. Organic wheat, oats, and barley prices were obtained from the USDA Market News National Organic Grain and Feedstuffs Biweekly Report, which report negotiated spot market prices, FOB farm. Conventional wheat, oat, and barley prices were obtained through the USDA ERS Feed Grains Yearbook Tables Database and were reported as monthly feed grade FOB prices.

Biweekly data for corn and soybeans were available from 4/14/2007 through 12/26/2015, whereas biweekly wheat data was available through 10/03/2015. Barley and oats had the least availability of monthly prices with barley data from 08/01/2008 through 08/31/2015, and oat data from 03/01/2008 through 09/30/2015. Because barley and oats were only available on a monthly frequency, biweekly prices for corn, soybeans, and wheat were averaged into monthly observations. To correct for any missing observations within the above time periods, an estimate was generated by averaging the price in the month before and a month after the missing observation. This was done for two, one, nine, eleven, and twelve observations in the corn, soybean, wheat, barley, and oat data sets, respectively. When there were consecutive months missing, in the case of wheat, those monthly observations were not included.

Descriptive statistics, including standard deviation, mean, median, minimum, and maximum values, were calculated for each of the five commodities and their organic counterparts to understand how prices of organic and conventional corn, soybeans, wheat, oats, and barley have varied from 2007 through 2015. Then, the coefficient of variation was calculated by dividing the standard deviation by the mean, as shown in Equation 1.

(1)

$$CV = \frac{\text{standard deviation}}{\text{mean}} = \frac{\sqrt{\frac{\sum_{i=1}^n (P_i - \bar{P})^2}{n}}}{\bar{P}}$$

Additionally, the corrected coefficient of variation was calculated where R^2 comes from a regression of the price on a linear trend, as seen in Equation 2.

(2)

$$CCV = CV\sqrt{(1 - R^2)}$$

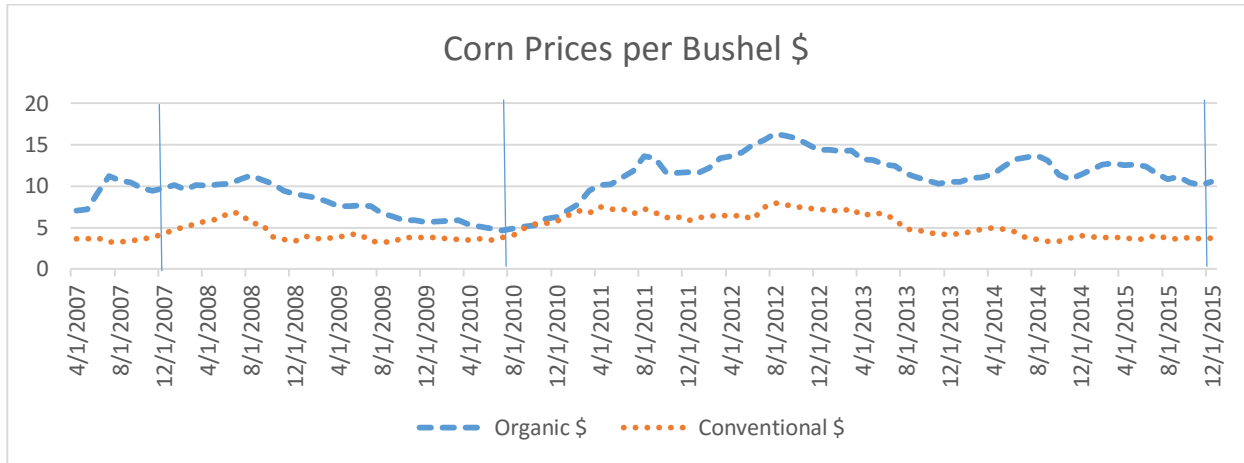
The coefficient of variation was chosen as the measure to compare price volatility since organic and conventional commodities have different price levels and thus different means. The coefficient of variation can be interpreted as the relative dispersion of prices from the mean and is more representative than comparing the standard deviation (Brown, 1998). Therefore, a higher value is interpreted as a higher volatility, in percentage terms.

Discussion of Results

The price level differences are easily seen when historical prices are plotted graphically, as illustrated in Figures 7-11 below. Organic price levels were substantially higher than conventional price levels in most years for all grains. For the entire time period, organic corn and soybeans had an average premium ratio of 2.09 and 1.85, respectively, as compared to

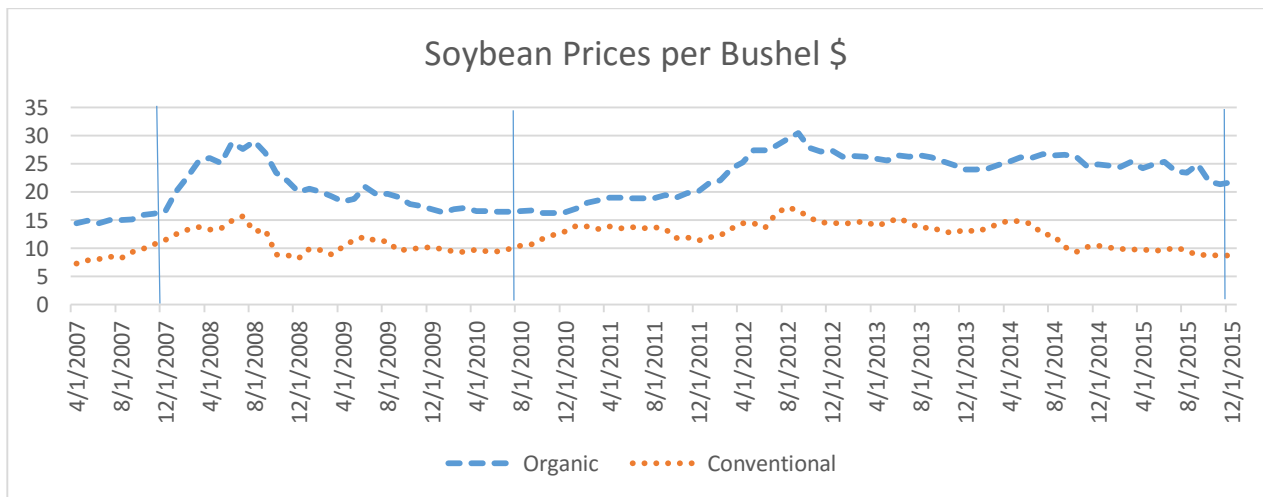
conventional. Organic wheat, barley, and oats had an average premium ratio of 1.54, 1.55, and 1.63 respectively, as compared to their conventional counterparts.

Figure 7. U.S. Organic and Conventional Corn Prices (\$/bushel) 2007-2015



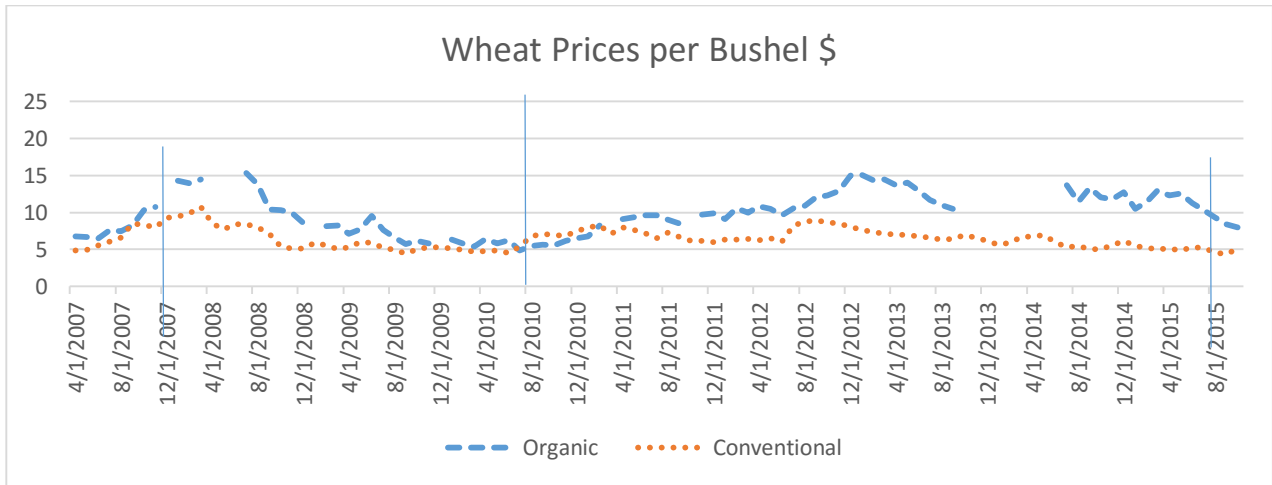
Source: Mercaris & USDA

Figure 8. U.S. Organic and Conventional Soybean Prices (\$/bushel) 2007-2015



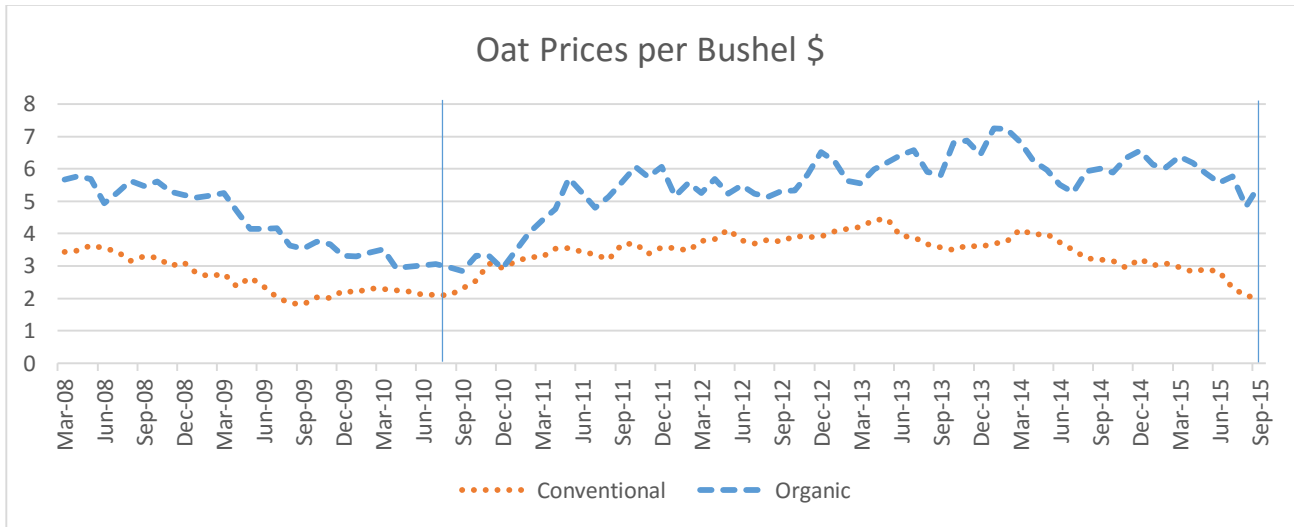
Source: Mecaris & USDA

Figure 9. U.S. Organic and Conventional Wheat Prices (\$/bushel) 2007-2015



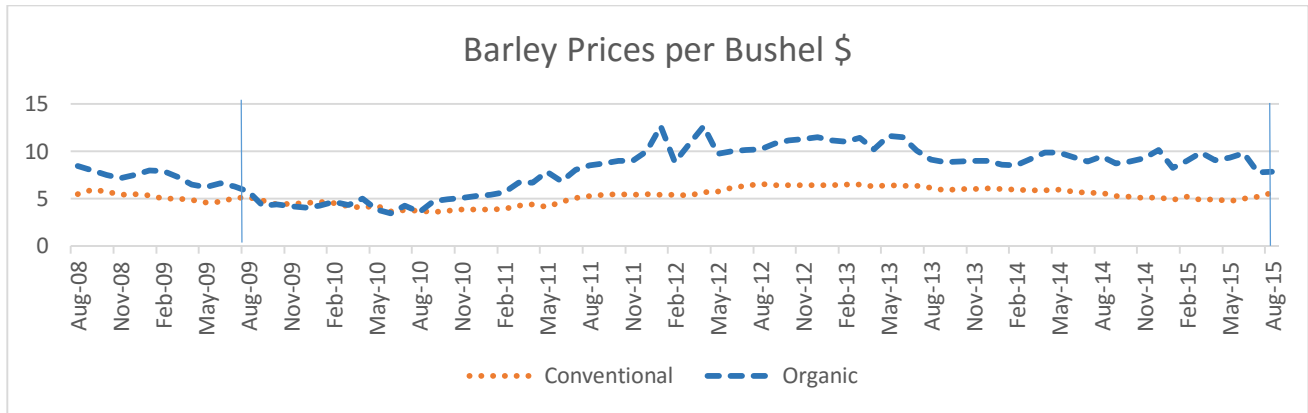
Source: Mercaris & USDA

Figure 10. U.S. Organic and Conventional Corn Prices (\$/bushel) 2008-2015



Source: Mercaris & USDA

Figure 11. U.S. Organic and Conventional Barley Prices (\$/bushel) 2008-2015



Source: Mercaris & USDA

The calculated mean, standard deviation, median, range, coefficient of variation and corrected coefficient of variation for organic and conventional corn, soybeans, wheat, barley and oats are shown in Table 1. Between 2007 and 2015, the average price of organic corn was \$10.42 with a range of prices between \$4.70 and \$16.33 a bushel. These prices are significantly higher relative to conventional corn, which averaged \$4.96 a bushel and had a minimum price of \$3.25 and maximum price of \$8.01 a bushel. Soybean price levels were similar in proportion to that of corn. Average organic soybean price is \$21.97 per bushel with a range between \$14.40 and \$30.38 a bushel as compared to the average conventional soybean price of \$11.86 a bushel and minimum price of \$7.31 and maximum price of \$17.23 a bushel.

Organic and conventional prices for wheat, oats, and barley were closer in proportion. Organic wheat prices averaged at \$9.93 with a range of \$4.83 and \$21.53 a bushel versus conventional wheat prices at an average of \$6.47 with a range between \$4.35 and \$10.74 a bushel. Organic barley had a mean price of \$8.12 a bushel and a range of prices between \$3.47 and \$12.66, whereas conventional barley had a mean price of \$5.26 a bushel and minimum price close to that of organic barley at \$3.61 but a maximum price only at \$6.54. Lastly, organic oats

had a mean price of \$5.18 with a range of prices between \$2.84 and \$7.25 a bushel.

Conventional oats, on the other hand, had a lower mean at \$3.18 a bushel and a smaller range of prices with a minimum price of \$1.82 and maximum price of \$4.45 a bushel.

During the periods of analysis, organic corn, soybean, and oat prices appear to be less volatile than their conventional counterparts with the corrected coefficients of variation at 24, 16 and 18 percent versus 29, 19 and 20 percent, respectively. Similar to the Ajemian, Saitone, and Sexton (2016) study, we found that organic corn premiums were more subject to price fluctuations than organic soybean premiums. However, for wheat and barley, the organic prices appear to be substantially more volatile than the conventional prices at 30 and 26 percent versus 21 and 13 percent, respectively. On average, organic prices were approximately double the conventional prices for corn and soybeans and 53, 54, and 62 percent higher for wheat, oats, and barley, respectively.

Table 1: Descriptive statistics of U.S. organic and conventional feed commodity farm gate prices (\$/bushel) 2007-2015

		N	Mean	Standard Deviation	Median	Min	Max	Coefficient of Variation*	Corrected Coefficient of Variation*
Corn	Organic	105	10.410	2.899	10.705	4.700	16.330	0.278	0.239
	Conventional	105	4.961	1.430	4.305	3.240	8.010	0.288	0.287
Soybeans	Organic	105	21.967	4.308	21.995	14.400	30.380	0.196	0.163
	Conventional	105	11.855	2.327	11.923	7.305	17.230	0.196	0.192
Wheat	Organic	103	9.925	3.088	9.885	4.830	21.530	0.311	0.295
	Conventional	103	6.465	1.371	6.335	4.350	10.740	0.212	0.208
Barley	Organic	85	8.118	2.349	8.695	3.470	12.660	0.289	0.259
	Conventional	85	5.256	0.826	5.340	3.610	6.540	0.157	0.128
Oats	Organic	91	5.176	1.139	5.470	2.840	7.250	0.220	0.181
	Conventional	91	3.181	0.675	3.280	1.820	4.450	0.212	0.200

Note: The coefficient of variation was calculated by dividing the standard deviation by the mean, and the corrected coefficient of variation was calculated by multiplying the coefficient of variation by the square root of one minus the R^2 of a regression of the prices against a time trend.

However, these organic price premiums appear to have diminished and even disappeared during 2008-2010 period. This collapse in organic price premiums coincided with the economic recession that took place between December 2007 and July 2009, according to the National Bureau of Economic Research (2010). The impact of the recession on organic price premiums tended to linger for approximately one year, according to the insight provided by USDA, ERS (Greene, 2015). Due to these factors, the sample was divided into several different subsamples: pre-recession between 4/2007 and 11/2007, recession from 12/2007 through 7/2010, and post-recession 8/2010 through 12/2015. These time subsamples were used to analyze differences in mean and variance of organic and conventional price levels for corn, soybeans, and wheat. For oats and barley, two subsamples were used: 3/2008 through 7/2010 and 8/2010 through 8/2015 due to data availability limitations. The subsamples are indicated in Figures 7-11 with blue lines.

To test equality of means, the Welch F-test was used. When the homogeneity of variances assumption is not held, the Welch F-test is recommended to compare the means of different populations (Welch, 1951). For this test, the null hypothesis is that organic and conventional prices have equal variances. When the probability is significant at 0.05 or less, then we reject the null hypothesis and accept the alternative that the means are significantly different. The Brown-Forsythe Test was used as the primary test of equality in variance. This test of homogeneity does not assume that all populations are normally distributed and tests whether two or more populations with different means, in this case organic and conventional prices, have equal standard deviations (Brown and Forsythe, 1974). The null hypothesis is that organic and conventional prices have equal variances. Thus, if the p-value is significant at 0.05 or less, we reject the null hypothesis and the alternative hypothesis is true, where the organic and conventional prices have different variances. The Brown-Forsythe and Welch tests were chosen

as they are recommended to be used together and are extensions of previous statistical tests (Tabachnick and Fidell, 2007).

As highlighted in Table 2 below, we reject the null hypothesis for all commodities in all subsamples. This means that the conventional mean prices are significantly different than the organic mean prices. Pre-recession, organic corn had the largest difference in mean, with an average premium of 162 percent as compared to the conventional price. Organic soybeans and wheat had the lowest premium pre-recession at 73 and 22 percent higher than the mean conventional soybean and wheat price. During the recession, corn only commanded an 86 percent premium whereas soybeans had an 87 percent premium. Wheat, oats, and barley had organic premiums of 54, 22 and 67 percent, respectively, during the recession. Post-recession, organic corn had a higher premium than during the recession at 115 percent. Organic soybean premium remained similar to during the recession at 86 percent and wheat premium increased to 61 percent post-recession. One reason the organic soybean premium did not collapse may be because there are no clear substitutes for organic soybeans as a source of protein in livestock feed. Lastly, organic barley premium increased dramatically to 66 percent post-recession and oats dropped slightly to 61 percent.

Table 2. Test for Equality of Mean between Conventional and Organic

Commodity	Date	Conventional Mean	Organic Mean	Percentage Difference	Welch F-Test Statistic	P-value
Corn	4/2007-11/2007	3.569	9.381	1.628	110.791	0.000***
	12/2007-7/2010	4.291	8.006	0.865	81.346	0.000***
	8/2010-12/2015	5.463	11.721	1.145	296.073	0.000***
Soybeans	4/2007-11/2007	8.740	15.119	0.729	189.548	0.000***
	12/2007-7/2010	11.011	20.574	0.868	150.499	0.000***
	8/2010-12/2015	12.655	23.497	0.856	425.946	0.000***
Wheat	4/2007-11/2007	6.600	8.037	0.217	3.379	0.090*
	12/2007-7/2010	6.285	9.666	0.537	16.183	0.002***
	8/2010-10/2015	6.541	10.557	0.613	132.394	0.000***
Barley	8/2008-7/2010	4.801	5.836	0.215	8.590	0.009***
	8/2010-8/2015	5.436	9.016	0.658	173.048	0.000***
Oats	3/2008-7/2010	2.634	4.390	0.666	66.859	0.000***
	8/2010-9/2015	3.438	5.545	0.612	206.534	0.000***

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

As highlighted in Table 3 below, we fail to reject the null hypothesis for soybeans and wheat in the first subsample, as the Brown-Forsythe test returns p-values of 0.1827 and 0.9449, respectively. However, in comparing the significance of the Brown-Forsythe test with the calculated coefficient of variation for this first subsample, there are conflicting results as the CV for conventional and organic soybeans and wheat are largely different at 13 versus 4 percent and 25 versus 21 percent, respectively. Based on these results, caution should be exerted when comparing price volatility for soybeans and wheat during the pre-recession period. For all other commodities and time subsamples, the Brown-Forsythe test indicates that the prices of all organic commodities and their conventional counterpart had significantly different variances at the one ad five percent levels.

Using the reported standard deviations and means calculated for each commodity and their counterparts from the tests of variance, the CV was calculated for each subsample to compare how the price variation of organic and conventional commodities changed over time.

Before the recession, conventional corn was significantly less volatile than organic corn, with a CV of 6 versus 16 percent. During the recession, all organic crop prices were more volatile, and a collapse in organic premiums was evident. This is evidenced by the slightly lower CV of conventional corn, soybeans, and oats at 24, 18, and 22 percent, respectively, relative to organic corn, soybeans, and oats CV values of 26, 20 and 23 percent, respectively, during 2007-2010. Conventional wheat and barley had CV of 29 and 12 percent, respectively, while organic wheat and barley demonstrated much greater CV of 45 and 28 percent, respectively. During the post-recession period, organic corn and soybeans were significantly less volatile with coefficients of variation at 22 and 16 percent, respectively, whereas organic wheat, barley, and oats remain more volatile than their conventional counterparts, but at a much smaller difference than experienced during the recession, with CV of 23, 22 and 18 percent respectively.

Table 3. Tests for Equality of Variance between Conventional and Organic

Commodity	Date	Conventional Standard Deviation	Organic Standard Deviation	Percentage Difference	Brown-Forsythe Test Statistic	Probability	Conventional Coefficient of Variation	Organic Coefficient of Variation
Corn	4/2007-11/2007	0.224	1.546	5.901	7.978	0.014**	0.062	0.164
	12/2007-7/2010	1.031	2.089	1.026	25.702	0.000***	0.240	0.260
	8/2010-12/2015	1.443	2.552	0.768	5.748	0.018**	0.264	0.217
Soybeans	4/2007-11/2007	1.410	0.645	-0.542	1.966	0.182	0.130	0.042
	12/2007-7/2010	1.959	3.950	1.016	7.843	0.006***	0.177	0.198
	8/2010-12/2015	2.141	3.654	0.706	9.49	0.002***	0.169	0.155
Wheat	4/2007-11/2007	1.473	1.649	0.119	0.005	0.944	0.245	0.205
	12/2007-7/2010	1.812	4.396	1.426	9.93	0.002***	0.288	0.454
	8/2010-10/2015	1.088	2.402	1.207	24.971	0.000***	0.166	0.227
Barley	8/2008-7/2010	0.596	1.624	1.724	40.444	0.000***	0.124	0.278
	8/2010-8/2015	0.839	1.953	1.327	16.379	0.000***	0.154	0.216
Oats	3/2008-7/2010	0.577	1.002	0.736	13.776	0.001***	0.219	0.228
	8/2010-9/2015	0.557	1.011	0.815	7.643	0.007***	0.162	0.182

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

In conclusion, we have documented that there are significant differences in means and variances for all the commodities in a majority of all subsamples. Specifically, we see a narrowing of mean prices between organic and conventional commodities during the recession subsample. Therefore, it appears that organic prices are sensitive to US macroeconomic conditions. Furthermore, we conclude that organic corn and soybeans are actually less volatile post-recession, which may explain why more producers have entered into corn and soybean production over oats, barley and wheat.

Part II.

Understanding Organic Price Premiums

Based on the findings in Part I, further analysis was conducted to better understand and explain factors that may influence organic commodity price premiums. This section begins with a discussion of the key variables followed by the descriptive statistics of those variables, a description of the model and relevant tests, and finally, its estimation and a discussion of empirical results.

Model Development and Data

In reviewing the literature, previous studies on the organic premiums suggest, and in some cases found, that premiums are affected by the following: consumer preferences, organic labels, marketing costs, producer electricity costs, personal income, wholesale margin conventional farm prices, seasonal effects, weather, time, conventional prices, and the FAO cereal index. Therefore, Part II of this paper will utilize these variables as well as expand upon them to seek to explain patterns and factors that affect changes in organic grain and oilseed price premiums.

Our dependent variable, the organic premium, is the dollar difference between organic and conventional price. While consumer preferences have been a valuable factor in explaining organic premiums, this study seeks to explain the premium that raw commodity producers receive when selling their crops as inputs rather than retail goods. Therefore, the consumer preferences variables and marketing costs are unobserved and not included in our model.

Organic labels are often included as a dummy variable in previous models. However, since our study focuses on grain and oilseed commodities, sold to livestock producers or food

processors, the label does not directly apply, but rather the organic certification. The value of certified organic is captured in this study due to the nature of our organic price data, which is for USDA organic certified corn, soybeans, wheat, oats, and barley only.

Also due to the nature of the organic certification and the previously discussed transition period from conventional to organic, we include lagged premiums. The premium of organic prices over conventional were lagged 1, 2, and 3 years respectively and included as independent variables to measure the relationship between previous year's prices and production decisions by farmers. This was important to consider as organic production takes 3 years to transition and new organic acreage will enter into the market each year as they become certified. Furthermore, the lagged premiums stand in somewhat similar the wholesale margin variable included in other studies. It is hypothesized that the lagged premiums will have a negative effect on the current premium, as more producers enter the market to capture the premium, more supply is available, thus decreasing organic prices and organic premiums, respectively.

Previous studies included producer electricity costs. This was due to the fact that those studies evaluated organic premiums for fruit and vegetables, which can be grown in greenhouses. However, because our study is looking at grains and soybeans, which require much more land and fuel, we include monthly oil prices as a reflection of producer cost. As described in the introduction, organic production is shown to have higher fuel input costs, which is affected by the price of oil. Thus it is hypothesized that an increase in the price of oil will have a positive effect on the premium. However, this effect may be minimized by the effect of higher oil prices on conventional producers, because conventional producers use petroleum-based chemical fertilizers and pesticides. Thus increased oil prices will result in increased conventional crop prices, thus reducing the organic premium. Lastly, oil prices and ethanol production are related

for corn, as the need for corn to produce much larger quantities of ethanol has inflated conventional corn prices (Luchansky and Monks, 2009). When oil prices are higher, more corn will go to ethanol production, resulting in higher conventional corn prices, again narrowing the gap between organic and conventional prices. Oil prices used in the model are historical monthly crude oil spot prices reported by the U.S. Energy Information Administration. Monthly oil prices were also lagged six months to account for the grain production time. Therefore, oil prices are expected to have either a positive or negative effect on organic premiums, depending on if organic input costs, or conventional costs and demand for ethanol are demonstrated to have a greater effect.

Other studies included personal income and found mixed results with either income having no significant effect on organic premiums, or a positive effect, suggesting that as income increases, so does the willingness to pay a premium for organic foods. Further, as analyzed in Part I, the recession appears to have had an effect on organic prices, and thus our model includes personal income as an independent variable to examine if economic conditions have an effect on organic premiums for corn, soybeans, wheat, oats, and barley. Monthly personal income data was obtained from the Bureau of Economic Insights and is measured in billions of dollars and months are seasonally adjusted at annual rates. This was important to include in order to test whether there is a relationship between income and higher organic prices, since organic goods historically are more expensive than conventional. Personal income values were lagged one month to allow for changes in income to be reflected the following month within the markets.

While seasonality and weather were proposed variables in previous studies, we found in preliminary analysis seasonality demonstrated little significance in influencing organic premiums. This is likely due to the fact that both organic and conventional crops face similar

production and harvest cycles and would be impacted by weather the same, as they are usually grown in the same regions. A time trend, however, is included via a dummy variable to help interpret how the premium has changed over time. Furthermore, including the time trend variable will help explain results in Part I.

Because this part of the study seeks to explain the organic premium, and not just price levels, we do not include conventional price as another study did, because of the issue of endogeneity. Endogeneity is the result of a correlation between an independent variable and the error term (Sorensen, 2012). This becomes an issue because we choose to use an OLS regression and a major assumption of this technique is that the independent variables are uncorrelated with the error terms (Aaron, 2005). Therefore, it is expected that because our dependent variable, the organic premium, and conventional price are jointly determined, there would be an endogeneity issue, resulting in correlation with the error term if we were to use conventional price as an explanatory variable. Instead, we use the world cereal index, as recorded by the Food and Agriculture Organization (FAO), as an instrument for the conventional price. This cereal index is a proxy of price developments of international grain markets, which would influence the conventional grain price, given its interconnectedness with the global markets, a characteristic that organic grains do not have at this time. The FAO cereals price index was included as a monthly variable and is reported as a percentage with the base years of 2002-2004 equal to 100. We expect that a one percent increase in the FAO world cereal price index will result in a decrease in organic premium, as the conventional grain price will increase, narrowing the gap between organic and conventional, since organic prices do not appear to be directly influenced by global markets because of limited trade of organic grains and soybeans, as compared to conventional.

The resulting model used to estimate the organic premium is illustrated in Equation 3 below and was estimated using an OLS method.

$$(3)$$

$$P_{o_t} - P_{c_t} = \alpha_0 + \alpha_1(P_{o_{t-12}} - P_{c_{t-12}}) + \alpha_2(P_{o_{t-24}} - P_{c_{t-24}}) + \alpha_3(P_{o_{t-36}} - P_{c_{t-36}}) + a_4(\text{Time})$$

$$+ \alpha_5(\text{Price of Oil}_{t-6}) + a_6(\text{Personal Income}_{t-1}) + \alpha_7(\text{FAO Cereal Index})$$

Lastly, as mentioned in the introduction, there have been increasing numbers of organic imports because of the slow growth in domestic supply of organic grains. Since 2011, the Foreign Agricultural Service has reported organic imports for soybeans and wheat and since 2013, has reported organic imports for corn. Due to the data limitations, we decided to estimate our model again, but as a case study for soybeans and wheat between January 2011 and December 2015 and corn between July 2013 and December 2015. Organic imports were included as a monthly variable and as a proportion of total imports, both organic and conventional, for each commodity. We expect that as organic imports increase in volume, the U.S. organic premium will decrease.

Description of Data

Descriptive statistics were calculated for the premiums of each of the five commodities as well as independent variables, personal income and oil (Table 4).

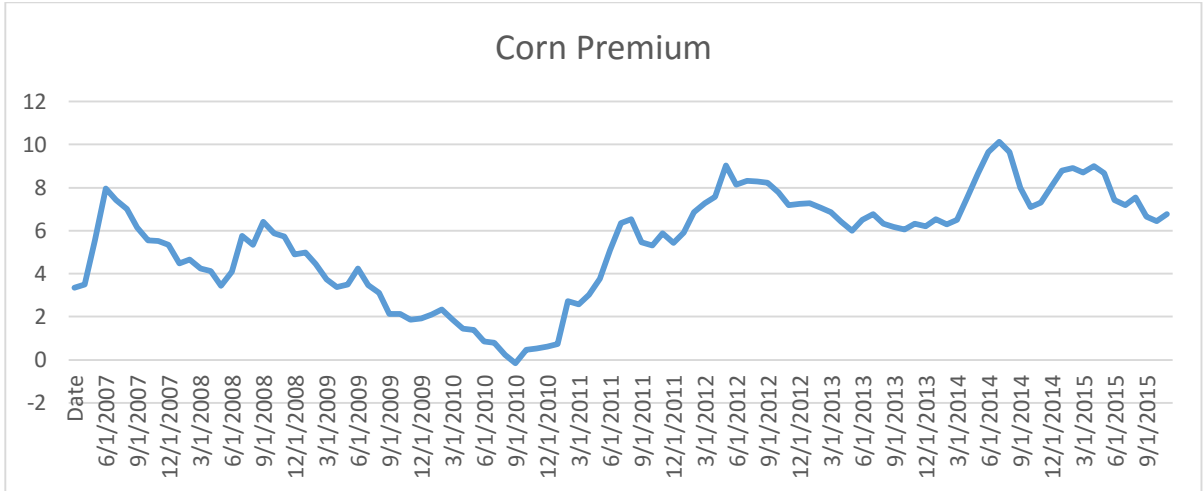
Table 4. Descriptive Statistics of Dependent and Independent Variables

	Mean	Standard Deviation	Median	Min	Max	Coefficient of Variation	Corrected Coefficient of Variation
Corn Premium	5.448	2.481	5.996	-0.155	10.140	0.455	0.381
Soybean Premium	10.112	3.481	10.700	3.043	16.900	0.344	0.285
Wheat Premium	3.513	2.764	3.477	-1.500	13.815	0.787	0.703
Barley Premium	2.861	1.727	2.995	-0.530	7.220	0.603	0.499
Oat Premium	1.995	0.824	1.980	-0.020	3.550	0.413	0.354
Oil Price	83.118	21.341	86.186	37.186	133.880	0.257	0.255
Personal Income (Billions)	13418.420	1137.449	13345.90	11925.50	15648.00	0.085	0.0264
FAO Cereal Index	201.089	36.445	195.040	141.021	267.690	0.181	0.181

On average, corn premiums were \$5.44 a bushel as compared to \$10.11 a bushel for soybeans, \$3.51 a bushel for wheat, \$2.86 a bushel for barley, and \$1.99 a bushel for oats. These premiums had a wide range and were even negative, with conventional commending a higher price than organic for corn, wheat, and oats, for at least one month, most likely during the recession. Organic premiums for the five commodities are highly variable at 38 percent for corn, 28 percent for soybeans, 70 percent for wheat, 50 percent for barley, and 35 percent for oats. Two of the key independent variables used to explain this variation include oil price, which has a CV of 26 percent and personal income, with a CV of 3 percent.

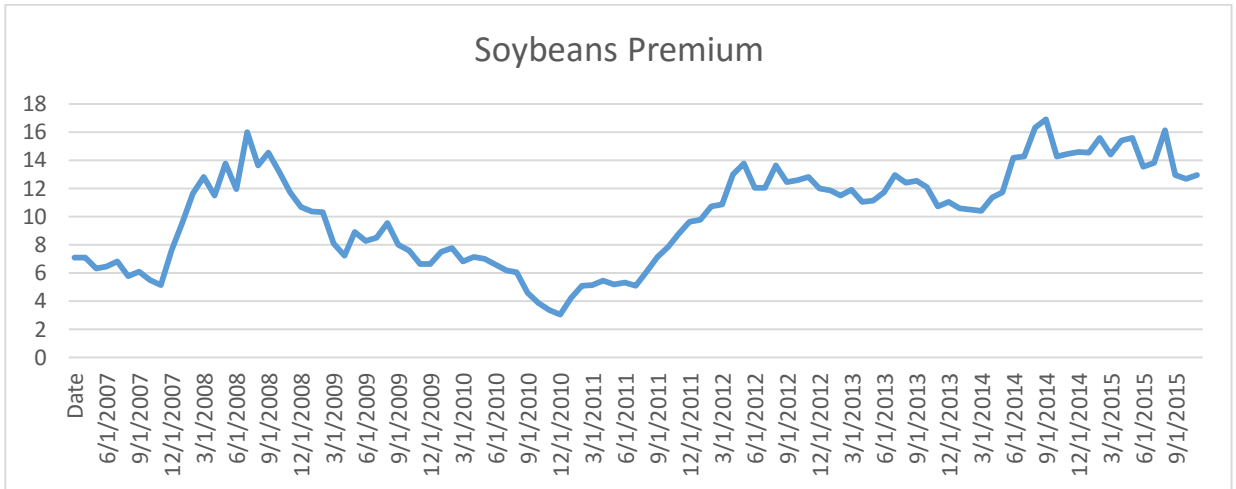
In looking at graphs of our variables, as seen in Figures 12-19 below, it appears that the data is not stationary. A stationary time series would consist of a constant mean and variance, over time, and this is important to have, because stationaries series are more easily interpreted and provide more meaningful insight (Nau, 2016).

Figure 12: U.S. Organic Corn Premium (\$/bushel) 2007-2015



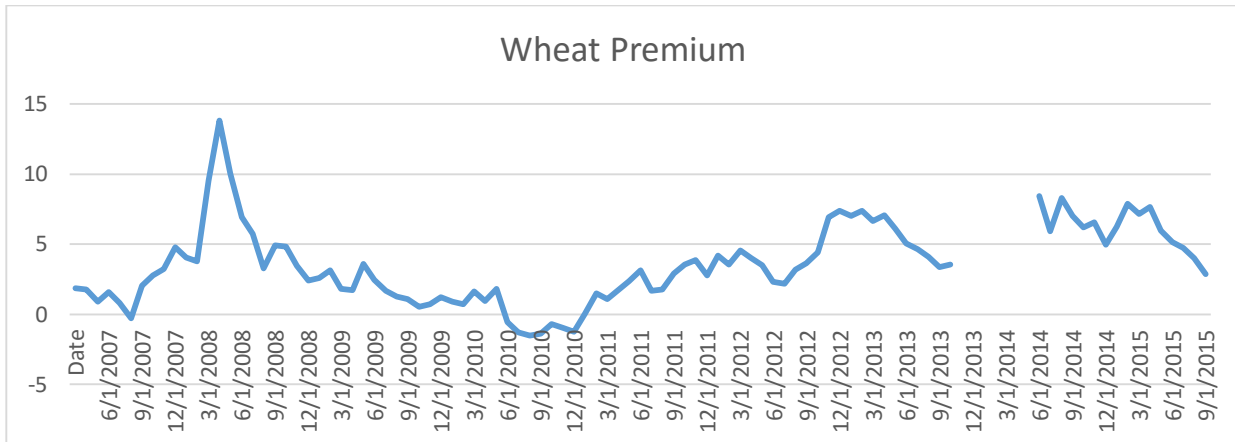
Source: Mercaris & USDA

Figure 13: U.S. Organic Soybean Premium (\$/bushel) 2007-2015



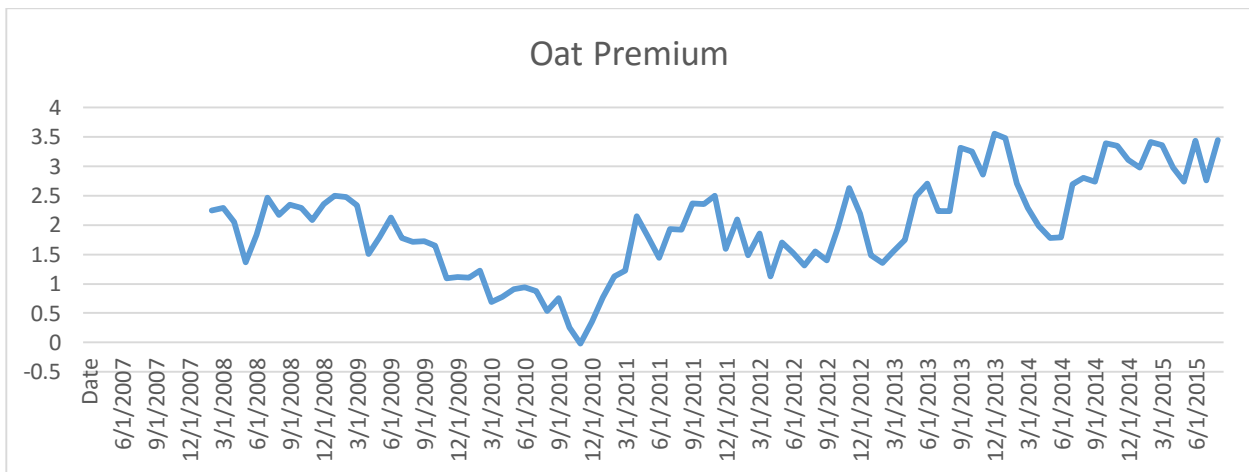
Source: Mercaris & USDA

Figure 14: U.S. Organic Wheat Premium (\$/bushel) 2007-2015



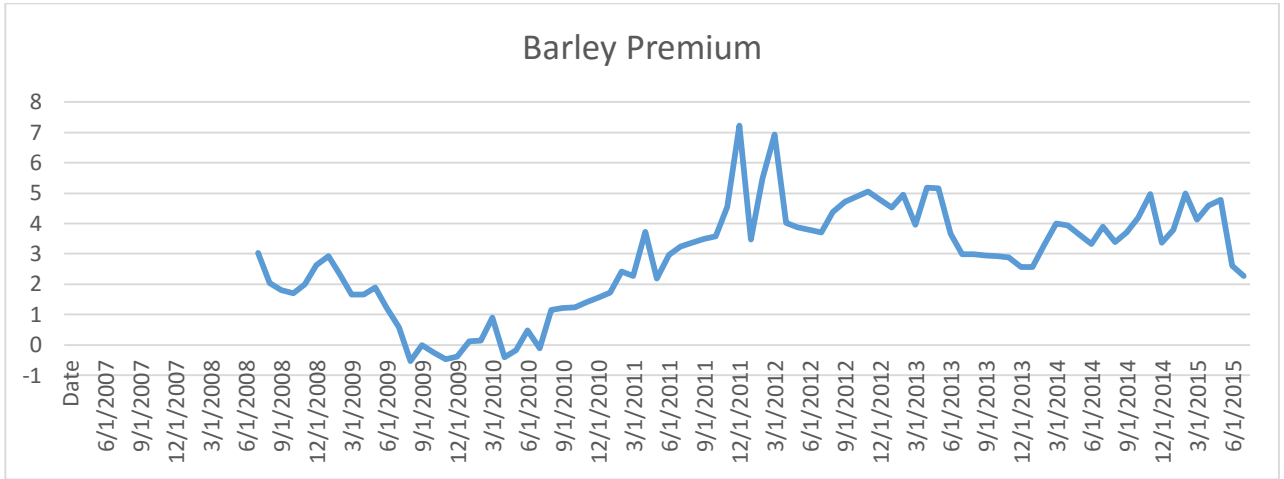
Source: Mercaris & USDA

Figure 15: U.S. Organic Oat Premium (\$/bushel) 2008-2015



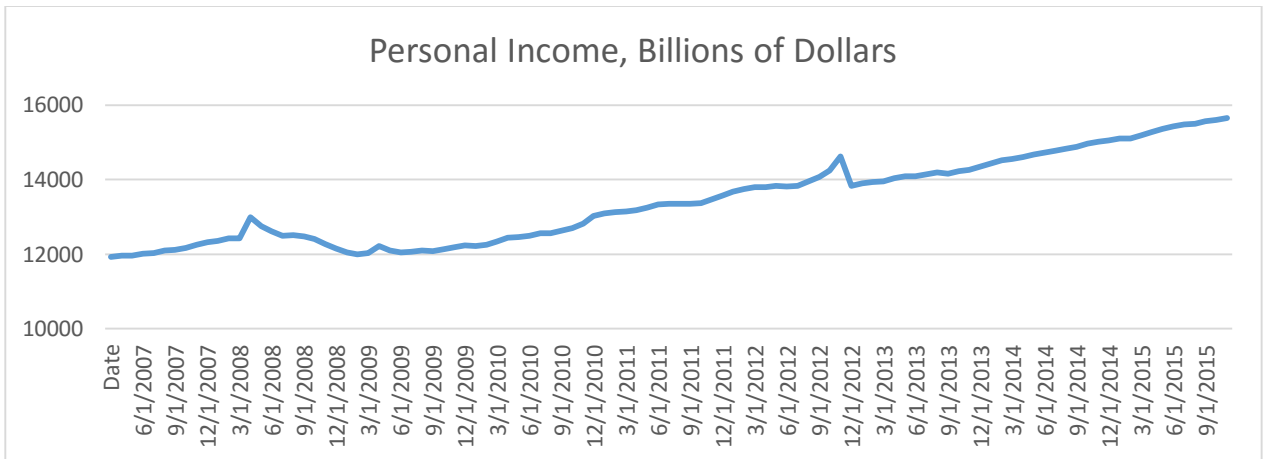
Source: Mercaris & USDA

Figure 16: U.S. Organic Barley Premium (\$/bushel) 2008-2015



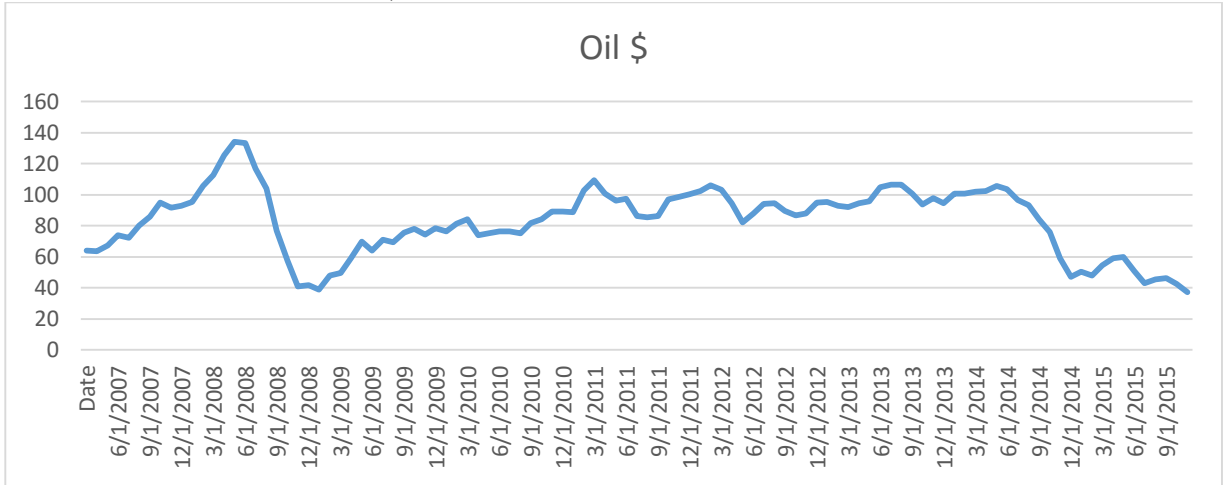
Source: Mercaris & USDA

Figure 17: U.S. Personal Income in Billions of Dollars 2007-2015



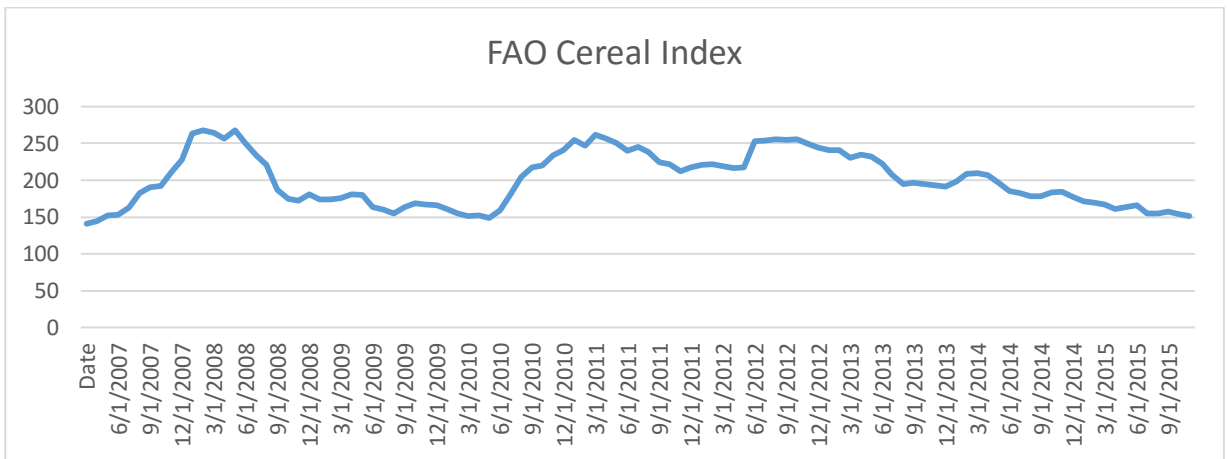
Source: Mercaris & USDA

Figure 18: Monthly Crude Oil Spot Prices as Reported by the U.S. Energy Information Administration, 2007-2015.



Source: Mercaris & USDA

Figure 19: FAO World Cereal Index with 2002-2004=100



Source: Mercaris & USDA

In order to determine if our data is in fact nonstationary, unit root tests were applied after running the initial OLS model to identify the stationarity of the data. The null hypothesis for the Dickey Fuller unit root test is that the statistic for the series does not follow the t-distribution. However, this test is only valid if the series is an AR(1) process and if the series is correlated at higher order lags, the Augmented Dickey-Fuller (ADF) test should be used, which was done for this study (Said and Dickey, 1984). In the ADF test, the null hypothesis that the series has a unit root and this null hypothesis is rejected if the p-value is less than 0.05. However, if the p-value is greater than 0.05, then we fail to reject the null hypothesis and the series does indeed have a unit root and is not stationary. The Phillips-Perron unit root test was also used to test the stationarity. The Phillips-Perron (PP) test modifies the ADF test statistics by correcting any serial correlation and heteroscedasticity in the errors (Phillips and Perron, 1988). To transform the data into a stationary series, the first differences of the data are taken and ADF and PP tests applied again to test whether the null hypothesis can be rejected. The ADF and PP test statistics for the levels and first differences of all variables used in the model are reported in Table 5. The results from the ADF and PP tests indicate that the null hypothesis cannot be rejected for all variables in levels, but may be rejected when variables are reported using first differences. Therefore, first differences were used in the model to ensure stationary data and robust results.

Table 5: Results of Stationarity Tests using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests both in levels and first differences

	ADF Unit Root Test Results		ADF Unit Root Test Results for First Difference		PP Unit Root Test Results		PP Unit Root Test Results for First Difference	
	t-statistic	p-value	t-statistic	p-value	t-statistic	p-value	t-statistic	p-value
Corn Premium	-1.957	0.305	-7.609	0.000	-1.693	0.431	-7.525	0.000
Soybean Premium	-1.519	0.520	-11.698	0.000	-1.807	0.376	-11.584	0.000
Wheat Premium	-2.697	0.078	-7.658	0.000	-2.767	0.067	-8.935	0.000
Barley Premium	-1.328	0.612	-9.839	0.000	-2.238	0.195	-13.401	0.000
Oat Premium	-2.218	0.201	-10.775	0.000	-2.102	0.244	-11.175	0.000
Personal Income	0.449	0.984	-11.559	0.000	0.698	0.992	-11.599	0.000
Oil	-2.542	0.108	-6.089	0.000	-2.137	0.231	-6.089	0.000
FAO Cereal Index	-2.332	0.164	-6.491	0.000	-2.359	0.156	-6.673	0.000

Results

The results of our model with the coefficient listed first and the p-value below in parentheses are presented in Table 6.

Table 6: Results from OLS Regression Using Levels

Variable	Corn Premium	Soybean Premium	Wheat Premium	Barley Premium	Oat Premium
Constant	-33.870 (.000)	-31.966 (.002)	-17.465 (.266)	-2.195 (.827)	-10.723 (.056)
Premium Lagged 1 Year	0.061 (.532)	-0.221** (.042)	0.116 (.549)	-0.101 (.540)	-0.194 (.131)
Premium Lagged 2 Years	-0.387*** (.000)	-0.353*** (.000)	0.155 (.412)	-0.106 (.508)	0.229* (.069)
Premium Lagged 3 Years	0.107 (.256)	-0.222*** (.006)	-0.028 (.763)	0.077 (.635)	-0.229 (.033)
Time	0.158 (.702)	-0.369 (.479)	1.347* (.056)	0.322 (.510)	-0.380** (.036)
Oil Price	0.076*** (.000)	0.033* (.056)	0.076*** (.001)	-0.006 (.672)	0.014** (.015)
Personal Income	0.002*** (.001)	0.004*** (.000)	0.000 (.884)	0.000 (.969)	0.001*** (.004)
FAO Cereal Index	-0.004 (0.563)	-0.046*** (.000)	0.014 (0.335)	0.021* (0.057)	-0.0115** (.012)
R ²	0.863	0.863	0.718	0.166	0.674

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

The OLS model is most useful for explaining corn, soybean, and wheat premiums, with R² of 0.86, 0.86, and 0.72, respectively. The model does not work as well for oats and barley, as it only explains 67 percent of the oat premium variability and 17 percent of the barley premium variability. As illustrated by the coefficients of the lagged premiums, previous years' prices have a negative effect on current premiums for corn and soybeans. This may be explained by more producers being incentivized to get into production based on previous prices, resulting in more organic supply in the market, thus driving the premium down. Wheat and barley organic

premiums are unaffected by previous year's prices and organic oat premiums are positively affected by prices two years ago and negatively affected by prices three years ago. Significant time trends are present for wheat, with an increase in premiums by \$1.34/bushel a year and a yearly decrease in organic oat premiums by \$0.380 per bushel.

With regards to the oil price variable, premiums responded as expected—as the price of oil used as a production input goes up by \$1.00 a barrel, the organic premium increases for corn, soybeans, wheat, and oats by \$0.076, \$0.033, \$0.076 and \$0.014 per bushel, respectively.

Personal income is significant for corn, soybeans, and oats, which is consistent with previous studies as outlined in the literature review. However, the impact is very minimal, in that for every one billion dollar increase in national personal income, organic corn, soybeans, and oat premiums increase by \$0.002, 0.004, and 0.001 per bushel, respectively. Wheat and barley organic premiums do not appear to be significantly affected by personal income. An explanation for this finding may be due to earlier findings that revealed organic demand is influenced more heavily by consumer preferences than income levels.

The FAO World Cereal Index has an expected effect on soybean and oat premiums, decreasing the organic premium by \$0.046 and 0.012 per bushel, respectively for every one percent increase in the world cereal index as compared to the base year of 2002. This is consistent with what we expected, as the conventional price is likely to increase when the world cereal index increases, narrowing the gap between organic and conventional prices, thus decreasing the organic premium.

Based on the unit root test results, the model was recalculated using the first differences of the premium, lagged premiums, oil prices, and personal income variables. The results are detailed below in Table 7.

Table 7: Results Using First Differences

Variable	Corn Premium	Soybean Premium	Wheat Premium	Barley Premium	Oat Premium
Constant	0.642 (.066)	0.740 (.167)	1.313 (.04)	0.511 (.617)	0.244 (.508)
Premium Lagged 1 Year	0.046 (.721)	0.011 (.932)	0.047 (.753)	-0.177 (.413)	-0.295* (.064)
Premium Lagged 2 Years	0.035 (.776)	-0.089 (0.409)	0.099 (.353)	0.152 (.343)	-0.288* (.084)
Premium Lagged 3 Years	0.126 (.228)	0.213** (.039)	0.006 (.943)	-0.123 (.444)	0.031 (.866)
Time	-0.089 (.938)	-0.103 (.190)	-0.221** (.034)	-0.075 (.596)	-0.030 (.564)
Oil Price	-0.011 (.938)	0.008 (.712)	-0.064** (.023)	0.011 (.698)	-0.011 (.359)
Personal Income	0.000 (.769)	0.000 (.798)	0.001 (.466)	0.001 (.442)	0.000 (.763)
FAO Cereal Index	-0.028*** (.0035)	-0.053*** (.000)	-0.035** (.024)	0.015 (.476)	-0.003 (.746)
R ²	0.161	0.226	0.312	0.104	0.152

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

When the variables are transformed into first differences and made stationary, we see that our R-squared for the model decreases, explaining 16, 23, 31, 10 and 15 percent of the variation in premiums for organic corn, soybeans, wheat, barley, and oats, respectively. In this model, the previous year's premium is negative and significant in influencing the expected premium for organic oats. If the previous year's premium increases by one dollar, the current premium is expected to decrease by 30 cents per bushel. Similarly, if the premium from two years ago increases by one dollar, the current organic oat premium is expected to decrease by 29 center per bushel.

Dissimilar to the model estimated using the variables in levels, the oil price lagged six months, is only significant for wheat, in which a one-dollar increase in the price of oil results in a

decrease in the organic wheat premium by six cents. Personal income is not significant for any of the commodity premiums. The only significant time trend is for wheat, in which the organic wheat premium appears to decreasing yearly by 22 cents per bushel.

Because of the low R-squared values and low number of significant variables, it is hypothesized that the premium may be better explained by factors that are outside the scope of this study. These factors include production of the organic crops and demand from livestock producers, however, due to data limitations, these were not able to be included in this study.

Other factors that may explain the organic premium include import and exports. In 2011, the USDA Foreign Agricultural Service began collecting data on organic imports in their GATS database. While the number of observations is limited, we decided to run a case study using available import data for organic and conventional corn, soybeans, wheat, barley, and oats and export data for conventional corn, soybeans, wheat, barley, and oats, as the export volume of these organic commodities is negligible. Below are the results from this case study, which included 30 observations for corn, 60 for soybeans, and 44 for wheat. The organic imports are included as a proportion of all imports, both conventional and organic, as measured in metric tons.

Table 8: Regression Results in Levels Including Organic Imports

Variable	Corn Premium	Soybean Premium	Wheat Premium
Constant	101.573 (.000)	-41.222 (.002)	-4.245 (.817)
Premium Lagged 1 Year	-0.306 (.133)	-0.234** (.035)	-0.371 (.141)
Premium Lagged 2 Years	0.433** (.014)	-0.364*** (0.000)	-0.035 (.881)
Premium Lagged 3 Years	0.652*** (.000)	-0.216** (.019)	0.097 (.344)
Time	0.983*** (.009)	0.227 (.683)	2.610*** (.003)
Oil Price	-0.016 (.343)	0.044** (.019)	0.054*** (.010)
Personal Income	-0.001 (.344)	0.004*** (.000)	-0.001 (.395)
FAO Cereal Index	-0.038*** (.006)	-0.021 (.113)	0.011 (.536)
Organic Imports	1.808 (.276)	6.274* (.069)	132.743 (0.007)
R ²	0.877	0.852	0.685

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

When organic imports are included in the model using variables in levels, we see that the premium lagged one, two, and three years is significant and has a negative effect on organic soybean premium, as we expected. Different than the model estimated without organic imports, we see that the time trend is actually positive for wheat and corn. Oil price has a positive and significant effect on soybeans and wheat, where for every one-dollar increase in the price for a barrel of oil results in an increase of approximately four cents and five cents per bushel for organic soybeans and wheat, respectively. Income has a positive and significant influence on soybeans, where for every one-billion-dollar increase in national personal income, the premium for organic soybeans increases by \$0.004. The FAO cereal index variable is also as we expected

for corn with for every one percent increase in the index, the organic corn premium drops by \$0.038. Lastly we see that the proportion of organic imports does not have a significant effect that makes economic sense.

To be consistent with the first set of results, we also estimate the model including organic imports, but with all variables first-differenced. These results are illustrated in Table 9 below.

Table 9: OLS Regression Results with Organic Imports Using First Differences

Variable	Corn Premium	Soybean Premium	Wheat Premium
Constant	-0.536 (.69)	1.174 (.081)	2.304 (.008)
Premium Lagged 1 Year	-0.183 (.493)	0.016 (.913)	-0.134 (.449)
Premium Lagged 2 Years	0.088 (.670)	-0.033 (0.827)	0.249 (.181)
Premium Lagged 3 Years	0.381** (.037)	0.249** (.021)	0.069 (.471)
Time	0.013 (.936)	-0.163* (.084)	-0.358*** (.007)
Oil Price	-0.005 (.829)	0.007 (.777)	-0.065** (.034)
Personal Income	0.004 (.437)	0.000 (.729)	0.000 (.737)
FAO Cereal Index	-0.058** (.015)	-0.053*** (.002)	-0.025 (.173)
Organic Imports	1.134 (.392)	6.124** (.014)	16.227 (0.561)
R ²	0.416	0.331	0.389

Note: Significance levels of 10, 5, and 1 percent are noted by *, **, and ***, respectively.

When we include organic imports in the model and use first differences to make the data stationary, we see that the three year lagged premium has the opposite effect than what we expected, with positive and significant coefficients for organic corn and soybean premiums. We see that time has a negative effect for soybean and wheat, in that each year, the organic premium

is expected to decrease by \$0.163 and 0.358, respectively. The significant variable for wheat makes economic sense in that for every dollar increase in oil price, the premium will decrease by \$0.065, perhaps due to the higher cost of fertilizers and pesticides. The FAO Cereal Index has the effect we would expect as it is negative, suggesting that as world corn and soybean prices increase, so does conventional domestic corn and soybean prices, narrowing the gap between organic and conventional prices, and thus decreasing the organic premium by \$0.058 and 0.053 respectively. Similar to the model including imports in levels, we see that organic imports do not have a significant value that makes economic sense.

Conclusions

In part I of this study, we illustrated that there are indeed differences in volatility between organic and conventional corn, soybeans, wheat, barley, and oats. For years 2007-2015, organic corn, soybeans, and oat market prices were less volatile, whereas organic wheat and barley market prices were more volatile than their conventional counterparts. Organic prices collapsed during the recession and remained low one year following the recession. The volatility of organic and conventional prices was significantly different pre-, during, and post-recession for all commodities except soybeans and wheat pre-recession.

In part II of this study, we explored key factors that influence the premium received by organic corn, soybeans, wheat, barley, and oats using an OLS model with those variables both in levels and first differences. Using levels of the variables, we found that lagged premiums were significant for corn, soybeans, and oats, but at varying lags and levels. Oil price was positively significant for all commodities except barley premiums and personal income was only significant for corn, soybeans, and oats. There is a significant time trend for wheat and oats. Unit roots were found for all of the non-dummy variables, so the model was re-estimated using first differences. When the model was run with the stationary data, significant variables included lagged premiums, oil price, and the FAO Cereal Index.

Data frequency and availability limited this study and a case study was conducted using organic imports as an additional variable. However, it was found to be insignificant. This study could be further improved on as more organic agriculture data becomes available. Specifically, comprehensive organic crop production data as well as organic livestock monthly and annual numbers would be of value in expanding the depth of this study. More months of organic import

data would also provide more insights into how premiums change for organic corn, soybeans, wheat, barley, and oats.

For organic grain and soybean producers, this paper demonstrates that of the five commodities, the least risky organic commodities to grow include corn and soybeans, especially if they plan to sell in the spot market. However, it is suggested that growers may want to consider growing wheat, barley, and oats if they have a buyer willing to contract in advance, in order to ensure a premium and reduce price risk. For purchasers of organic grains and soybeans, including major food companies as well as livestock producers, it is recommended to continue to follow these organic markets, especially as they become modernized and no longer “thin.”

Lastly, policy makers and the USDA can help organic producers by collecting more accurate and frequent data on organics, especially with regards to planted and harvested acreage, yields, stocks, imports, exports, and use. This will provide the opportunity for premiums to be better explained by key supply and demand factors as compared to conventional commodities.

References

- Adjemian, M. K., Saitone, T. L., & Sexton, R. J. (2016). A framework to analyze the performance of thinly traded agricultural commodity markets. *American Journal of Agricultural Economics*, 98(2), 581.
- Associated Press. (2016). Organic milk low as demand up and farmers struggle." *Terra*. Retrieved from http://en.terra.com/news/news/organic_milk_low_as_demand_up_and_farmers_struggle/act459966.
- Badgley, C., Moghtader, J., Quinterom, E., Zakem, E., Chappell, M. J., Avilés-Vázquez, K., Samulon, A., and Perfecto, I. (2007). Organic agriculture and the global food supply. *Renew. Agr. Food Syst.* 22, 86–108.
- Balcombe, K. (2010). The nature and determinants of volatility in agricultural prices: An empirical study from 1962-2008. *Commodity Market Review*, , 2.
- Bertramsen, S.K., & Dobbs, T.L.(2001). "Comparison of Prices for 'Organic' and 'Conventional' Grains and Soybeans in the Northern Great Plains and Upper Midwest: 1995 to 2000. Econ Pamphlet 2001-1. South Dakota State University.
- Bertramsen, S. K., & Dobbs, T.L. "An Update on Prices of Organic Crops in Comparison to Conventional Crops." *Economics Commentator*. February 22, 2002. South Dakota State University
- Brown, M. B., & Forsythe, A. B. (1974). Robust tests for the equality of variances. *Journal of the American Statistical Association*,69(346), 364-367.
- Born, H. (2005). *Marketing Organic Grains*. National Sustainable Agriculture Information Service.
- Daniells, S. (2014). US organic food market to grow 14% from 2012-2018. *Food Navigator*. Retrieved from <http://www.foodnavigator-usa.com/Markets/US-organic-food-market-to-grow-14-from-2013-18>
- de Ponti, T., Rijk, B. & van Ittersum, M. K. (2012). The crop yield gap between organic and conventional agriculture. *Agr. Syst.* 108, 1–9.
- Dimitri, C., and Greene, C. (2000). Recent growth patterns in the US organic foods market. US Department of Agriculture, Economic Research Service, Agricultural Information Bulletin 777
- ERS. (2014). Support for the organic sector expands in the 2014 farm act. *Amber Waves*. Retrieved from <http://www.ers.usda.gov/amber-waves/2014-july/support-for-the-organic-sector-expands-in-the-2014-farm-act.aspx#.VfYjWBFVikr>

- Fromartz, S. (2006). *Organic, Inc.: Natural Foods and How They Grow*. New York: Harcourt Trade Publishers.
- General Mills. (2016). General Mills to double organic acreage sourcing to meet growing demand for natural and organic foods. Retrieved from <http://www.generalmills.com/en/News/NewsReleases/Library/2016/March/organicacreage3-9/c336c600-8b39-461d-90d0-b69f5c3bb99a>
- Gilbert, C. L. & Morgan, W. (2011). Food Price Volatility. Methods to analyse agricultural commodity price volatility. I. Piot-Lepetit and R. M'Barek. New York, Springer: 45-61.
- Gilbert C.L. (2006). Trends and volatility in agricultural commodity prices. In A. Sarris and D. Hallam eds, *Agricultural Commodity Markets and trade*, Cheltenham, Edward Elgar.
- Greene, C. (2013). Consumer Demand Drives Growth in the Organic Food Sector. Retrieved June 13, 2015 from <http://www.ers.usda.gov/data-products/chart-gallery/detail.aspx?chartId=35003>.
- Greene, C. (2014). Organic Market Overview. Retrieved from <http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-market-overview.aspx>
- Huchet-Bourdon, M. (2011). Agricultural Commodity Price Volatility: An Overview. *OECD Food, Agriculture and Fisheries Papers*, No. 52, OECD Publishing. Retrieved from <http://dx.doi.org/10.1787/5kg0t00nrthc-en>
- Jaenicke, E. C., & Carlson, A. C. (2015). Estimating and investigating organic premiums for retail-level food products: ESTIMATING AND INVESTIGATING ORGANIC PREMIUMS. *Agribusiness*, 31(4), 453-471. doi:10.1002/agr.21413
- Klonsky, K. & Greene, C. (2005). Widespread adoption of organic agriculture in the US: are market-driven policies enough?" Selected Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24–27
- Lakner, S., Ihle, R., & Würriehausen, N. (2015). Price relationships between qualitatively differentiated agricultural products: Organic and conventional wheat in Germany. *Agricultural Economics*, 46(2), 195-209. doi:10.1111/agec.12151
- Lin, B.-H., Smith, T., & Huang, C.L. (2008). Organic premiums of US fresh produce. *Renewable Agriculture and Food Systems* 23(2008):208–16.
- McBride, W. & C. Greene (2015). Despite Profit Potential, Organic Field Crop Acreage Remains Low. From <http://www.ers.usda.gov/amber-waves/2015-november/despite-profit-potential,-organic-field-crop-acreage-remains-low.aspx#.Vm14N0orLIW>

- Moledina, A.A.; Roe, T.L.; & Shane, M. (2004). Measuring commodity price volatility and the welfare consequences of eliminating volatility. *Retrieved from* <http://purl.umn.edu/19963>
- National Bureau of Economic Research. (2010). US business cycle expansions and contractions. <http://www.nber.org/cycles.html>
- Nau, R. (2016). Statistical forecasting: notes on regression and time series analysis. Duke University. Retrieved from <http://people.duke.edu/~rnau/411diff.htm>
- Oberholtzer, L.; Dimitri, C; and Greene, C. (2005). Price premiums hold on as U.S. organic produce market expands. USDA ERS.
- Organic Trade Association. (2015). Organic Industry Survey. From <https://www.ota.com/resources/organic-industry-survey>
- Organic Trade Association [OTA].(2015). State of the Industry Fact Sheet. From http://ota.com/sites/default/files/indexed_files/StateOfOrganicIndustry_0.pdf
- Park, T. A., & Lohr, L. (1996). Supply and demand factors for organic produce. *American Journal of Agricultural Economics*, 78(3), 647-655. doi:10.2307/1243282
- Ponisio, L. C., M'Gonigle, L. K., Mace, K. C., Palomino, J., Valpine, P., and Kremen, C. (2012). Diversification practices reduce organic to conventional yield gap. *Proc. R. Soc. B* 282, 20141396.
- Reaves, E. (2015). US food companies collaborate to increase supply of organic grain. From <http://www.sustainablefoodlab.org/all-news-articles/293-newsletter-winter-2015>.
- Reganold, J.P. and Wachter, J.M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*. Doi:10.1038/nplants.2015.221
- Risk Management Association (2016). Organic crops. From <http://www.rma.usda.gov/news/currentissues/organics/>
- Roseboro, K. (2015). Organic food companies collaborating to increase organic supply. From <http://www.non-gmoreport.com/articles/april-2015/organic-food-companies-collaborating-to-increase-organic-grain-supply.php>
- Seufert, V., Ramankutty, N. & Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. *Nature* 485, 229–232.
- Singerman, A., Hart, C.E., & Lence, S.H. (2011). Price analysis, risk assessment, and insurance for organic crops. Retrieved from http://www.card.iastate.edu/policy_briefs/display.aspx?id=1163.

- Singerman, A., Lence, S.H., & KimbleEvans, A. (2014). How related are the prices of organic and conventional soybean? *Agribusiness* 30 (3): 309–30.
- Smith, T. A., Huang, C. L., & Lin, B. (2009). Does price or income affect organic choice? analysis of U.S. fresh produce users. *Journal of Agricultural and Applied Economics*, 41(3), 731.
- Stanhill, G. (1990). The comparative productivity of organic agriculture. *Agr. Ecosyst. Environ.* 30, 1–26.
- Su et al. (2013. August). Stability in Organic Milk Farm Prices: A Comparative Study. Retrieved from <http://ageconsearch.umn.edu/bitstream/150735/2/Stability%20in%20Organic%20Milk%20Farm%20Prices%20A%20Comparative%20Stud%20AAEA%203180.pdf>
- USDA. (2012) Becoming a Certified Operation. Retrieved from <https://www.ams.usda.gov/services/organic-certification/faq-becoming-certified>
- USDA Organic Agriculture. (2015). Retrieved from <http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=usda-results-organic-agriculture.html>
- USDA. (2016). USDA reports record growth in U.S. organic producers. http://www.usda.gov/wps/portal/usda/usdahome?contentid=2016/04/0084.xml&navid=N EWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&edeployment_action=retrievecontent
- Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335. doi:10.2307/2336182
- Said, S.E and Dickey, D. A. (1984). Testing for unit roots in autoregressive-moving average models of unknown order. *Biometrika*. 71(3), 599-607.
- Tabachnick, B.G., & Fidell, L.S.(2007). *Using Multivariate Statistics* (5th ed.). Needham Heights, MA: Allyn & Bacon.
- Welch, B. L. (1951). On the comparison of several mean values: An alternative approach. *Biometrika*, 38(3/4), 330-336. doi:10.1093/biomet/38.3-4.330