Impact of market shocks on the wheat industry: an examination of supply chain responsiveness

by

Raymond Joseph Thomas

B.S., Prairie View A&M University, 2018

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agriculture Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2020

Approved by:

Major Professor
Dr. Keith Harris

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Abstract

Supply chain responsiveness is a topic that has been discussed by researchers and practitioners in business and economics. Many agribusiness firms attempt to understand responsiveness in way that might help to respond to demand along the supply chain while experiencing uncertainty in consumer preferences and growing conditions. This study uses two classes of wheat to examine how the supply chain responded to a 'shock' in 2008. As prices changed, the use of grains in the U.S. and international markets changed as well. Firms that can respond to changes in the demand for their products are able to capitalize on market opportunities. The purpose of this research is to examine how supply chain responsiveness in the wheat industry is affected by a market shock. This study uses cycle-time as a proxy for supply chain responsiveness.

A difference-in-difference regression analysis was used to estimate the before and after effects of the 2008 wheat price increase, which is commonly associated with ethanol produced form corn and the time it took to respond to the new demand. The results indicated that a significant difference in planted acres and off-farm stocks had a negative relationship with responsiveness, while exports have and positive relationship. The time effect of Soft Red Winter Wheat, as the treatment group, did not display any significance. This would suggest that responsiveness after 2008 was not directly caused by the shock.

Key Words – Supply Chain Responsiveness, Market Shocks, Wheat

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Acknowledgements

I would like to thank Dr. Keith Harris for serving as my advisor and the members of my committee for participating in my research process. In addition, I would like to thank Dr. Zelia Wiley and the College of Agriculture Diversity programs office for recruiting me to Kansas State University

Dedication

This thesis is dedicated to my father, Roger James Thomas II. Thank you for always encouraging me to expand my mind through education. Thank you for being an example of how to walk as a man with courage, confidence, intellect, humility, and righteousness. Lastly, thank you for supporting me throughout all my experiences in life.

Chapter 1 - Introduction

The grain industry makes up one of the largest sectors of U.S. agriculture. Crops such as corn, sorghum, and wheat are used for animal feed and food for human consumption. The U.S. is one of the largest grain exporting countries in the world having exported nearly 89 million metric tons of grain between 2018 – 2019 (M. Shahbandeh 2019). Wheat, in particular, is a widely used grain. The U.S. is the third largest wheat exporter in the world, exporting an estimated $5.4 billion USD in 2018. Wheat has a variety of uses, and the demand can shift overtime. A competitive supply chain must be effective and efficient at transporting, storing, milling, and distributing grain and grain based products to consumers around the world. This requires knowledge of how each link in the chain is influenced by the market. There are a number of transactions between buyers and sellers as products move through the supply chain. Grain producers are one of the first links in the supply chain. Supply chain coordination can help to improve supply chain responsiveness and is at the core of supply chain management practice and research. Coordination requires optimizing the links in the chain that often yields sub-optimal performance, which results in an inefficient allocation of scarce resources, higher system costs, and compromised customer service. In contrast, when links in the supply chain are optimize, costs are reduced and revenue is increased through higher production and order fill rates. Hence, if the supply and demand of a product is met as the industry shifts the supply chain's profit increases. Unfortunately, how managers apply coordination mechanisms to respond changes in the market is somewhat unknown in the agri-food industries. A response to a change in the market may be observed in production, transportation, storage, milling, and distribution depending on which part of the supply chain is affected. Supply chain coordination is an effective approach to streamline operations/processes between the dependent members of the supply chain (Chopra and Meindl, 2003). An effective response in the supply chain requires optimizing the capabilities of each link in the chain. An inefficient allocation of scarce resources leads to higher costs, and reduced customer satisfaction. In order for the agriculture supply chain to be effective at meeting the demand of a changing market, firms must understand how each supply chain link is influenced by the market.

Supply Chain and Market Shocks

Efficiency and responsiveness are key concepts of supply chain performance. Efficiency measures a supply chain's capability to maximize surplus by minimizing total cost. Responsiveness measures a supply chain's capability to quickly respond to shifts in supply or demand. These changes, which will be defined and discussed as shocks later in the study, can come in many forms such as shifts in demand, supply, and extreme weather conditions that fundamentally change the patterns of production and consumption. Shocks provide either opportunities or threats to producers and agri-food firms. A supply chain that can appropriately respond to a shock will likely create a competitive advantage by responding to changes in demand or by properly communicating with and coordinating the various links in the chain. Many firms, in the agri-food industry, focus on supply chains efficiency. However, balancing responsiveness and efficiency is an important issue in supply chain design and management. Researchers have begun to explore the advantages of having a more responsive supply chain (Maier & Minnich, 2006). A firm that is capable of responding quickly to a shock has the opportunity to take advantage of changes in price and demand. Alternatively, a firm may also be able to avoid incurring additional cost or possible revenue losses. Some grain producers adjust production and management practices based on the market opportunities. Their decisions will impact other parts of the supply chain and its ability to meet consumer demand. The knowledge of how producers responded to a market shocks might provide insight into how to coordinate agri-food firms and optimize the supply chain.

1.1 Research Question and Objectives

U.S. grain is important to domestic and international buyers. Grain producers and other agribusiness firms must quickly respond to new market opportunities. There are six classes of wheat that are used in many different ways. How wheat is used determines where it is distributed. For example, there can be as many as 17 different transactions in the wheat export supply chain (See Figure 1). As demand changes, producers may change production behaviors that can affect the supply of wheat to other supply chain links. Depending on how wheat is being used, it may be subject to different standards. Knowledge of how producers respond to market shocks provides insight into how the supply chain responds to the availability of wheat for food and feed use.

This research sought to answer the following question:

How do producers of wheat respond to market changes? The overall objective is to examine the influence that a market shock has on the producers of two classes of wheat in the U.S. The specific objectives are as follows:

1. Recognize corn ethanol as a shock to the wheat industry
2. To measure how wheat producers responded to the shock
3. To examine the shock's effect on producer responsiveness

1.2 Research Contributions

This research seeks to contribute to the discussion of supply chain responsiveness in agriculture by examining the effectiveness of a measure for producer responsiveness. A shock to the agriculture industry can have implications for the demand of food and fiber. In the presence, of a market shock, a response from the supply chain could allow agribusinesses to capitalize on a change in the market environment. How producers respond to the market can help agri-food firms anticipate the availability of wheat for use in other links of the supply chain. Defining a way in which responsiveness can be quantified and measured could provide insight into how agricultural supply chains respond to the changes. This research examined the effectiveness of cycle time as a measure for responsiveness by examining cycle time for two classes of wheat in the presence of a shock.

Literature Review

In this chapter, a review of the literature on market shocks and supply chain responsiveness is presented. The methods used to measure supply chain responsiveness are also presented in this chapter. The chapter is divided into five main sections. The first section provides an overview of the definition of a shock as well as understanding how corn ethanol qualifies as a shock to the grain industry. The second section reviews the supply chain literature and its definition of responsiveness. The third section focuses on understanding the metric that was used to measure supply chain responsiveness.

2.1 Market Shocks in the Grain Industry

A shock can be defined as a large but transitory disruption of market prices caused by an unexpected event that changes the perception and level of demand with regard to a specific good or service (Chappelow, 2019). Shocks occur as the result of an event changing the behaviors of consumers and producers alike. Yim (2008) identifies two primary types of shocks: quality and market shocks. He defines a quality shock as a change in technology or product quality that impacts production. A market shock can then be defined as an event that causes fluctuations in a particular industry that is exogenous to all market participants (Yim, 2008). Agribusiness firms often experience the two types of shocks, which present internal or external threats and opportunities. Price is often regarded as an exogenous factor in agriculture production. Producers may change production behaviors in response to market prices. A shock that affects price will affect the behavior and decisions of producers. Response to a market shock may be observed in how producers adjust production and shift supply to meet the demand. Agri-food firms need to be aware of how producers respond to a market shock because a change in production activities could affect the supply of wheat.

An example of a grain and food industry shock driven by disruptions in price was the biofuel and ethanol development that peaked in 2008. The Food and Agriculture organization of the United Nations (FAO) reported a rise in food prices by nearly 40 percent in 2007 followed by continued increases in 2008. Nearly all agriculture commodities including rice, maize, wheat, etcetera were affected (Rosegrant, 2008). At the time, there were a variety of reason debated as to the cause of this market shock. Wiggins et al. (2010) presented several reasons as to why prices increased. They suggested that poor harvest, lower grain stock and a rise in oil prices contributed to this market phenomenon on the supply side. In regards to demand, widespread inflation rates around the world from rapid economic growth was also identified as a contributing factor (Wiggins et al., 2010). Wiggins et al. (2010) continued discussing the impact of biofuel production on prices citing research from Rosegrant (2008). The research by Rosegrant (2008) revealed, 30 percent of the spike in prices for cereal grains could be attributed to the production of biofuels from 1990 to 2000. In regard to wheat, biofuels accounted for 22 percent of the increase. This was cited in response to many claiming that biofuel production was the primary factor contributing to the price increases seen in 2008.

Wang et al. (2014) would go on to further explore the ethanol shock by identifying the relationship between oil price shocks and agricultural commodity prices. They suggest that the reason for the price increase is the substitutive effect between biofuels and oil. As the price of oil increase people would be more inclined to turn to alternative forms of energy. The bio ethanol and biodiesel extracted from corn and soybeans are often considered appropriate substitutions for crude oil (Wang et al., 2014). As a result, increases in oil prices can result in an increase in corn and soybean prices and eventually lead to a decrease in planting for other grains as acres are limited for a period of time (Chang & Su, 2010; Chen et al., 2010; Vacha et al., 2013). Wang et al. (2014) concluded their research by stating that while the response of agricultural commodity prices to oil prices was found to be not significant, the response of commodity prices to aggregate demand were revealed to be significant. The reason for this change in commodity prices has continued to be a topic of interest to researchers.

Regardless of the reason for the shock, there is no denying that as corn was used in the production of ethanol, and the prices of other grains were affected. Since commercially viable ethanol facilities require large quantities of corn, such facilities would have an effect on the U.S. and world agriculture (Elobeid et al., 2006). In the grain industry several commodities received a significant boost in price. Elobeid et al. (2006) attempt to quantify and explain the impact of prices in the grain industry and provide rationale. They found that the increase in corn-based ethanol production and prices resulted in a 20 percent increase in wheat prices accompanied by 3 percent decrease in wheat acres planted. In regards to domestic use, a significant impact was felt in the feed industry as feed use increased from 120 million bushels to 238 million during this time period likely due to the substitution effect between wheat and corn for feed use as corn production is directed to ethanol (Elobeid et al., 2006).

As prices change, farmers may be inclined to alter their production and management practices in order to take advantages of opportunities in the market. One aspect of the corn ethanol shock not discussed was the shock's effect across different classes of wheat. Data from the United States Department of Agriculture (USDA) verifies many of the observations made by previous research about how wheat was impacted during this time period but can also be used to identify how different classes of wheat were impacted. Figures 2.1 and 2.2 show how the price, and planted acres for all wheat classes changed during this time. Further examination of USDA data reveals that while all types were impacted in similar ways during this shock, Soft Red

Winter wheat (SRW) experienced the highest percent increase in planted acres during 2003 to 2013. For example, when compared to Hard Red Winter wheat (HRW), which shares a similar growing period, SRW wheat experienced twice the percentage increases in planted acreage following the price boom that occurred in the market (See Figure 4). This suggest that farmers who grew SRW wheat might have been responding differently to an opportunity present in the in the regions where this class of wheat is primarily grown. Elobeid et al. (2006) suggest that the substitution effect of corn and wheat in animal feed contributed to the increase in wheat prices. SRW wheat did experience an increase in feed use after 2008 (See Figure 5). HRW wheat, however, saw a decrease in feed use during this time (See Figure 6) The regions where SRW wheat is primarily grown coincided with regions in the U.S. where swine and poultry production are focused (See Figure 7). Wheat can be used successfully as an alternative to corn in poultry and swine feeds (Amerah & Peron, 2012). This suggest that producers that grew hard SRW wheat might have been responding to a change in demand for SRW wheat as source of livestock feed in this region. Comparing the producers that responded to the shock in 2008 could offer insight into how to measure responsiveness.

2.2 Responsiveness and Efficiency

The relationship between responsiveness and efficiency is often explored in different industries. For example, Randall et al. (2003) characterizes supply chains as efficient or responsive, which as a dichotomy first proposed by Fisher (1997). A responsive supply chain is characterized by small-scale facilities, short production lead- times, and small batch sizes that allow the responsive firm to adapt quickly to market demand, often at a higher unit cost (Skinner 1974). Conversely, an efficient supply chain is characterized by large-scale facilities, longer production lead times, and larger batch sizes that allow the efficient firm to produce at a low unit cost, often at the expense of market responsiveness. Responsive firms tend to be better suited to demand conditions with low industry growth rates, high contribution margins, high product variety, high demand uncertainty, and high technological uncertainty. Efficient firms, on the other hand, are better suited to demand conditions with high industry growth rates, low contribution margins, low product variety, low demand uncertainty, and low technological uncertainty (de Groote 1994; Fisher 1997; Silver et al. 1998). While it may be valid in some cases to assume firms are choosing between efficiency and responsiveness, there may be situations where firms are attempting to strike a balance between both. The right degree of responsiveness while also having an efficient supply chain is a difficult goal that typically involves trade-off decisions, since increased responsiveness can be perceived to come at the expense of reduced efficiency, and vice versa (Minnich & Maier, 2006). Establishing a balance between efficiency and responsiveness can provide an opportunity to add more value to their operation.

2.3 Defining and Measuring Responsiveness

The first challenge when attempting to measure supply chain responsiveness is establishing a concise definition. Responsiveness has historically had a loose definition. Performance measures that focus on the responsive supply chain have not received adequate attention from researchers in the past (Gunasekaran et al. 2004). The definition of responsiveness has since been discussed by different researchers. According to Gunasekaran et al. (2007) a responsive supply chain is defined as “a network of firms capable of creating wealth to its shareholders in a competitive environment by reacting quickly and effectively to changing market environment”.

While this definition might seem to cover the concept of responsiveness well, it creates confusion when terms such as supply chain flexibility and agility are defined in a similar way. Though these terms tend to be used interchangeably, responsive, agile, and flexibility are not completely the same (Christopher et al., 2004; Wong et al., 2005; Gunasekaran et al., 2007). In fact, Christopher (2000) recognized that agility and flexibility are both key characteristic of a responsive supply chain. He argued that a firm within a responsive chain has to be flexible in terms of volume, variety, and variability. Agility can then be defined as the ability of a firm to respond rapidly to changes in demand in terms of volume and variety. This definition was later expanded by Gunasekaran et al. (2004) and agility was defined as the capability of an organization, by proactively establishing a virtual manufacturing with an efficient product development system to (i) meet the changing market requirements, (ii) maximize customer service level, and (iii) minimize the cost of goods, with an objective of being competitive in a global market and for increased chance of long-term survival and profit potential. Understanding agility and flexibility is important to defining supply chain responsiveness as thoroughly as possible.

A different definition of responsiveness comes from Hum et al. (2018). Defined as the probability of fulfilling customer orders within a given lead-time. There are two interesting components to note about their approach to measuring responsiveness. The first is that they explore supply chains with queuing structures. Several processes such as manufacturing, assembly, inspection, and delivery need to be completed before a final product can be obtained to fulfil customer demand (Hum et al., 2018). As a result, they model what is known as a make-to-order supply chain with Jackson-type queueing systems and multiple stages. This perspective accounts for the fact each order placed is unique and the same customer may place multiple orders. In the grain industry this can be seen when elevators are asked to blend a specific mix of grains depending on the customer.

These definitions of responsiveness work in a broad perspective when developing a conceptual framework, but do not contribute to the question of how responsiveness can be measured and quantified. However, as this concept was further explored researchers began identify factors that hint at the measurability of a responsive supply chain. One example is Catalan & Kotzab (2003) who defined responsiveness of a supply chain as "the ability to respond and manage time based on the ability to read and understand actual market signals". This definition would seem to indicate that time is a key component of measuring supply chain responsiveness. It also suggests that anticipating and adapting to changes is part of what makes a supply chain responsiveness effective. This literature is expanded as other researchers continue to define responsiveness from a similar perspective.

The definitions of supply chain responsive discussed by previous research can offer insight into how responsiveness could potentially be measured. Grain producers and agribusiness firms may attempt to respond to the demand in the market by reducing the amount of time for certain operations within the supply chain. Examples of metrics for measuring supply chain responsiveness focus on using time as the primary unit of analysis. One such example is order lead time, which is defined as the time it takes to fulfil a customer's order (Verweijen, n.d.). This measurement may be relevant to links in the supply chain that focus on getting added value goods to customers. The downside to using this measurement of responsiveness in agriculture is it would require proprietary information on orders between buyers and sellers. Another measure that could offer insight into responsiveness in agriculture is cycle time. Cycle time refers to average time it takes to supply a product and is considered to be a key element to directly assess the functionality of a supply chain (Nichols et. al, 1996). In agriculture this could translate to the time it takes a producer to grow a particular commodity. Since prices change constantly in the agriculture industry, a producer may look to change their behaviors in order to accelerate the production time and take advantage of increased prices. At the production level of the supply chain, where time also has implications for the quality and yield, cycle time could also offer insight into quality of the grain produced. Understanding how grain producers adjust production practices to influence the length of time for production can offer insight into supply chain responsiveness at this link. Time also has implications for quality of product available for other operations in the supply chain.

Linear Regression and Difference-in-Difference Analysis

Based on the literature a suitable metric for measuring supply chain responsiveness has implications for how producers and agribusiness firms respond to market indicators. This requires that a relationship can be established between the indicators and the response variable. One analysis method used to identify relationships between various factors and a response variable is linear regression. Regression analysis is one of the most widely used method for analyzing data with multiple factors (Montgomery et. al, 2013). The aim of linear regression is to construct mathematical models that describe or explain the relationships that between variables (Seber & Lee, 2003). Identifying the relationship between cycle time as a response variable and market indicator can allow for conclusions to be draw about how grain producers are responding to the industry.

Shocks have the potential to leave a lasting impact on an industry. Observing how producers respond to changes before and after a shock could help to further understand supply chain responsiveness as it is applied to the agriculture industry. This would require that differences in the measurement used between groups for responsiveness are correlated with the presence of a market shock. One method of analysis that is used to measure correlation is Difference-in-Difference (DID) modeling. DID is a quasi- experimental model that uses longitudinal (cross-sectional) data from a treatment and a control group in order to estimate the effect of an observable difference between the two groups. In essence, it estimates the difference in average outcome in the treatment group before and after treatment minus the difference in average outcome in the control group before and after treatment: it is literally a "difference of differences" (Dittler, 1957). In order to effectively estimate the casual effect, four assumptions must be met. These assumptions are exchangeability, positivity, and the Stable Unit Treatment Value Assumption, and the Parallel Trend Assumption. Of these assumptions the Parallel Trend Assumption is often seen as the most critical (Dixon, 2018). It requires that, in the event there is no noticeable effect, the difference between the “treated” and “control” groups are constant. This can be observed through visual inspection using data collected. DID is typically used to measure the association between changes in policy and correlate those changes with subsequent outcomes through pre/post assessment (Dixon, 2018). One way to apply DID modeling to supply chain responsiveness could be to see if a change in cycle time is correlated with the presence of market shock. This would establish the effectiveness of cycle time as a measure for responsiveness and offer insight how producers respond to changes. With this consideration the research question can be further specified to: Is the relationship between cycle time and market shocks correlated to supply chain responsiveness?

Chapter 2 - Data Collection and Methods

This chapter describes methods used to address the objectives of the research. First, a brief overview of the data collection for the variables in this analysis. Second, a brief discussion on the variables used in this research is presented. The last section gives a description of the models being used in this study discusses the descriptive statistics for variables used in the model.

Data Collection

State level secondary data were used for this study. Quantitative and qualitative data was collected from the United States Department of Agriculture National Agriculture Statistics Service (NASS) and the Economic Research Service (ERS). Qualitative data for CT came from the NASS Weekly Crop Weather Reports. This data referenced crop progression from 2003-2013 with the years 2003 – 2007 observed before the shock, and 2009 – 2013 observed after the shock in 2008. Quantitative independent variable data were collected from NASS Quick Stats (reference). The data collected for the independent variables were cross-sectional data and time series. They covered 18 states over 10 years (n = 180). Only SRW and HRW wheat producing states were included. Wheat growing states that did not have crop progression reports for either of the wheat classes used in the study were excluded.

Description of Variables

Product Cycle Time (CT) – Dependent

Cycle time is a metric used to determine the responsiveness of grain producers in each state. This is an indicator of how quickly supply chains perform in order to meet the market demands. In order to determine if this is an effective measure of responsiveness, this research will use cycle time in reference the availability of wheat that is used to respond to a shock.

Cycle time (CT) is hypothesized to be dependent on supply and demand factors, including the crops' planting, harvesting and completion stages. According to seasonal state crop reports, completion is determined by the number of days in the production cycle. The reports use the highest percent level of crop maturation reached to establish the crops' completion date. For example, in 2010 Kansas (which grows hard red winter wheat) reported that 96% of its wheat crop was planted by the week of November 29, 2009. It was later reported that 100% of the crop had been harvested by the week of August 25, 2010. This means the cycle time to make wheat available took 238 days

Wheat Price

Price is commonly referred to as the invisible hand that drives the market (Adam Smith, 1759). According to the Law of Supply, as prices increase in the marketplace producers will increase production in order to take advantage of the opportunity to increase revenue. However, prices do not remain constant and are subject to changes. When prices are higher, farmers would try capitalize on prices with any product in storage before they change again. Essentially, producers attempt to be more responsive by attempting to reduce the time it takes to deliver product to customers. This could occur by producers planting more in a year to have more product available for the next season. Therefore, the expected sign for this variable is negative (-) as higher prices would encourage producers to make decisions that would decrease the time it takes to deliver product to customers. A negative coefficient suggests an inverse relationship with cycle time.

Planted Acres

Planted acres is a supply indicator of how much wheat is being produced in a given year in order to meet demand. When approached from a responsiveness perspective, as prices change producers would likely try to increase production ceteris paribus. However, as production increases we hypothesize that there would be a proportional increase in the amount of time it takes to complete production. With this in mind, the expected sign for this variable is positive (+) as an increase in the amount of wheat crop planted would require more time to produce and thus increase the cycle time for the product. A positive coefficient suggests a direct relationship with in cycle time. This variable is measured in thousands of acres.

Off-farm Ending Stock

Off-farm stock refers to the amount of harvested product held in storage at grain elevators or in any other commercial facility off the farm. This is an indicator of supply that shows how much product is available and ready to use in order to meet changing demand resulting from unforeseen market shifts, i.e. shock. Considering that this variable is an indicator of the supply that may be used for anticipation of market shift or risk management, this would mean that producers may not have to increase production in order to meet demand. We estimate the coefficient for this variable is negative (-). The rationale behind this is that if ending stocks are below average for the year the marketplace is less capable of responding to an increase in demand before harvest, and higher prices for the current crop will have a negative impact on the time it takes to produce. A negative coefficient suggests an inverse relationship time This variable is measured in millions of bushels.

Exports

Exports refers to the value of wheat exports. This is designed to be an indication for demand in the industry. The U.S. is a major exporter of wheat to the world market. The hypothesis is that an increase in the demand in the world market would increase prices and thus affect how much product wheat producing states would grow in the U.S. as a principal exporter. If there is an increase in demand for wheat in the world that increased prices, we would expect producers to attempt to increase production. The expected sign on this is positive (+) as attempting to increase production could lead to producers taking longer to get the product to customers. This variable is measured in millions of dollars. A positive coefficient suggests a direct relationship with cycle time

Modeling

Linear Regression

A linear regression model is used to examine the relationship between cycle time as a measure for supply chain responsiveness and the other variables in this study. The outcome variable Y represents cycle time as the dependent variable in the regression. This is used to determine the nature of the relationship that exists between the dependent and independent variables. Equation 1 demonstrates how the linear regression is specified:

Equation 1

$$\boldsymbol{Y = \beta_0 + \beta_1(PRICE) + \beta_2(PLANTED\ ACRES) + \beta_3(STOCKS) + \beta_4(EXPORTS) + \varepsilon}$$

The coefficient α_0 is a constant term. The variables ***PRICE***, ***PLANTED ACRES***, ***STOCKS***, and ***EXPORTS*** represent the market price of wheat, amount of planted acres, amount of off-farm stock, and the value of exports. These variables serve as indicators for supply and demand for producers of HRW and SRW wheat. The symbol ε represents the error term for the regression.

DID Regression

States that grow HRW and SRW are used to observe if the changes in cycle time are correlated with the presence of a market shock. These two types of wheat share a similar growing period which can allow for specific conclusions to be drawn as to if the differences in cycle time observed are correlated with the presence of a market shock. This research examined the correlation between the 2008 grain market shock and cycle time as an indicator for responsiveness. SRW wheat experienced a larger percent increase in planted acres following 2008 than HRW wheat. The hypothesis is if producers grew SRW wheat were responding to shifts in industry demand in that region, then the differences in cycle time as a metric for responsiveness should be correlated with the presence of the shock. If producers of SRW wheat experienced a significant change in cycle time as a result of the shock, then conclusions can be made about how producers respond to the market using cycle time as an indicator.

To examine the correlation between the 2008 grain price increase and the difference in cycle time for HRW and SRW wheat, a linear regression analysis is used and specified as a difference-in-difference model (Tsiboe et. al, 2015). The outcome variable Y_{it}^{j} represents the cycle time for production in the *ith* state in period *t* measured in days, the subscript *j* is the group designation: experimental (j = 1) and control and control group (*j* = 0). The number of days for cycle time is used to compare how quickly producers in each state had wheat available. This will be used to determine whether or not there is any correlation between difference in the cycle times for states growing SRW wheat and the price increase in 2008. Equation 2 represents supply chain responsiveness and supply and demand factors attributed to influencing cycle time.

Equation 2

$$\boldsymbol{Y_{it}^{j} = \alpha_0 + \alpha_1 YEAR_t + \alpha_2 TREATMENT^j + \beta_0(WHEAT\ CLASS) + \delta_1(PRICE) + \delta_2(PLANTED\ ACRES) + \delta_3(STOCKS) + \delta_4(EXPORTS) + \varepsilon_{it}^{j}}$$

The coefficient α_0 is a constant term. The coefficient α_1 is the time effect common to the control and the experiment group. $\boldsymbol{YEAR}$ will be given a value of one (t = 1) in the post shock group and zero in the time period before the shock (t = 0). The time effect is designed to capture the outcome changes over time as a result of unobservable factors present in both groups. The coefficient α_2 is the experimental group specific effect. Showing the average difference between the experiment and control group. The variable $\boldsymbol{TREATMENT}$ is a dummy variable with the value of one for the treatment group and zero for the control group. The vector β_0 is the effect of the treatment group after controlling for the time and permanent differences between the treatment and control groups. The vector ***WHEAT CLASS*** is binary variables for the two wheat types, hard red winter and soft red winter with the latter being used as the experimental group. This data was captured on the state level with the *ith* state only growing one of the two types of wheat according to the data. The vectors ***PRICE***, ***PLANTED ACRES***, ***STOCKS***, & ***EXPORTS*** contain variables for the market price of wheat, amount of planted acres, amount of off-farm stock, and the value of exports in a given year. These vectors serve as indicators for supply and demand in the market

Chapter 3 - Analysis and Discussion

In this chapter, the data is analyzed in order to address the objectives of the study are presented and discussed. The section is organized into three main sections. The first presents a summary statistic that quantitatively describes the variables used in the study. The second presents the summary statistics before and after the grain industry shock. The third section presents a before and after the shock analysis acquired from a difference-in-indifference model.

Descriptive Statistics

Table 4.1 presents the descriptive statistics for the dependent and independent variables use in this research across all states for the entire time period between 2003 and 2013. There were 18 states that reported the planting and harvesting dates for the two classes of wheat in the study. Of these states 11 reported for HRW wheat and seven for SRW wheat during the time between 2003 and 2013. The states in this analysis represent the primary producers of these classes of wheat across the U.S.

Table 1 Descriptive Statistics 2003 – 2013 (n =180)

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Cycle Time (CT) - *days*	264	19.44	217	308
Price - *$ dollars*	4.93	1.69	2.85	8.1
Planted Acres - *millions*	2.115	2.437	0.220	10.5
Off-farm Stocks – *millions/bushels*	47.1	50.7	4.91	30.4
Exports – *millions/$ dollars*	293.43	285.349	4.917	1588.81
Number of States	18	-	-	-
Hard Red Winter	11	-	-	-
Soft Red Winter	7	-	-	-

The mean value for States, Hard Red Winter (HRW), and Soft Red Winter (SRW) are absolute numbers denoting how many states grew either type of wheat. The average production cycle time across all states and wheat types over this time period was 264 days with a standard deviation of 19.44 days. The average price was recorded at $4.93 per bushel with a standard deviation of $1.69. The variables used as indicators of supply were planted acres and off-farm stocks. Average planted acres across all states and wheat types was 2.1 million acres with a standard deviation 2.4 million acres. The average number of bushels of off-farm stocks was calculated at 47.5 million bushels with a standard deviation. The value of exports is used as an indicator for demand and shows an average of $293.43 million with a standard deviation of $285.34 million.

Tables 2 and 3 report the descriptive statistics before and after the 2008 market shock. The independent variables experienced a significant change for both hard and soft red winter wheat overtime. Other variables such as price, suggest the change is positive and similar for both types of wheat. In contrast, planted acres for hard red winter wheat experienced a negative change between the two time periods, while soft red winter experienced a small positive change. The dependent variable (CT) experienced a negative change for both types of wheat, with the change for SRW wheat being slightly larger than the change for HRW wheat. The analysis examines whether or not the difference in cycle time between the two wheat classes is correlated with the presences of the market shock. This will reveal whether or not cycle time is a suitable metric for measuring responsiveness from a supply chain perspective.

Table 2 Descriptive Statistics by Wheat Type (2003 – 2007)				
Hard Red Winter	**Mean**	**Std. Dev.**	**Min**	**Max**
Cycle Time (CT) - *days*	270	17.40239	231	294
Price - *$/bu dollars*	3.54	0.44	3.06	4.70
Planted Acres - *million*	3.08	2.86	0.450	10.5
Off-farm Stocks – *millions/bushels*	57.5	49.8	10.1	246
Exports – *$ million*	298.75	227.39	51.38	1,194.095
Soft Red Winter	**Mean**	**Std. Dev.**	**Min**	**Max**
Cycle Time (CT) - *days*	258	13.8	231	287
Price - *$ dollars*	3.2	0.26	2.85	4.4
Planted Acres - *millions*	0.645	0.212	0.220	1.05
Off-farm Stocks – *millions/bushels*	17.7	7.6		29.5
Exports – *millions/$ dollars*	83.85	40.72	19.65	196.55

Table 3 Descriptive Statistics by Wheat Type (2009 – 2013)				
Hard Red Winter	**Mean**	**Std. Dev.**	**Min**	**Max**
Cycle Time (CT) - *days*	268.8	19.64	231	308
Price - *$ dollars*	6.58	1.03	4.41	8.1
Planted Acres - *millions*	2.963	2.66	0.500	9.7
Off-farm Stocks – *millions/bushels*	67.9	67.4	11.8	304
Exports – *millions/$ dollars*	498.25	364.66	113.17	1,588.81
Soft Red Winter	**Mean**	**Std. Dev.**	**Min**	**Max**
Cycle Time (CT) - *days*	253.8	21.76	217	294
Price - *$ dollars*	6.18	1.06	4.04	8.04
Planted Acres - *millions*	0.740	0.213	0.330	1.28
Off-farm Stocks – *millions/bushels*	27.1	12.0	5.48	59.6
Exports – *millions/$ dollars*	172.77	74.72	40.21	326.68

Linear Regression Results

Table 4 summarizes the results of the linear regression analysis. The results provide insight into the relationship between cycle time as a response (dependent) variable and the indicators for supply and demand in the market as independent variables.

Table 4 Linear Regression Results

CT (days)	Coef.	Std. Err.	p-value	Sign. Level
Price	-2.222	0.845	0.009	*
Planted Acres	-3.78e-06	9.28e-07	0.000	***
Stocks	-1.20e-08	4.65e-08	0.010	*
Exports	.0523878	.0073065	0.000	***
Constant	273.292	4.155284	0.000	
Significance level	*** = 1%	** = 5%	* = 10%	

The result from the linear show that price has a negative relationship with cycle time. This would indicate that as prices increase or decrease cycle time will move in the opposite direction. This suggest that if prices increase producers adjust production practices in a way that decreases cycle time. The p-value indicates that this relationship is significant at the 10% level. The variables for supply indicators, planted acres and off- farm stocks are both shown to have a negative relationship cycle time. This implies that an increase in planted acres or off-farm stocks held would result in a decrease in cycle time and vice versa. While this is the hypothesis made for off-farm stocks, this contradicts the hypothesis about the relationship between planted acres and cycle time. The relationship planted acres and off-farm stocks have with cycle time are both shown to be significant at the 1% and 10% levels respectively. It should be noted however that, given the small value of the coefficients for these variables, the impact is not large enough to be considered truly significant. Lastly, exports are shown to have a positive relationship with cycle time. This would indicate that as export values increase cycle time increases as well. This could potentially be the result of to increase production to meet the demands of the world market. The relationship between exports and cycle time is shown to be significant at the 1% level. If cycle time is shown to be a suitable metric for wheat producer responsiveness, then the relationship between these independent variables and cycle time can be further explored. Table 5 provides a summary of the independent variables' relationship to cycle time.

Table 5 Summary of Variables Impact on Cycle Time		
Variable	**Sign**	**Impact on Cycle Time**
Price - *$ dollars*	+	Increase
Planted Acres - *millions*	-	Decrease
Off-farm Stocks – *millions/bushels*	-	Decrease
Exports – *millions/$ dollars*	+	Increase

DID Regression Results

Table 6 summarizes the results of the difference-in-difference regression analysis. The analysis was conducted using HRW wheat (control group) as the base to compare the differences in the variables with SRW wheat (treatment group). The results show whether or not there is a significant difference in the averages for the two classes of wheat during the period 2003 -2013.

Table 6 Regression Results

CT (days)	**Coef.**	**Std. Err.**	**p-value**	**Sign. Level**
Price	0.221	1.513363	0.884	
Planted Acres	-5.23e-06	8.48e-07	0.000	***
Stocks	-8.49e-08	4.19e-08	0.044	
Exports	.0408157	.0067868	0.000	***
SRW	-18.85676	3.486016	0.000	***
Time Period	-9.323869	5.232264	0.077	
Time effect, treatment group	2.15092	4.623102	0.642	
Constant	277.5808	5.813266	0.000	

Significance level	*** = 1%	** = 5%	* = 10%

Supply & Demand Variables

Based on the foregoing results, price is shown to have a positive difference between the two classes of wheat. The coefficient (0.221) suggest that SRW wheat experienced slightly higher in prices than HRW wheat. However, the p-value indicates that this difference in price is not significant. The supply indicators, planted acres and stocks, both show a negative difference between the two classes of wheat. The coefficients for planted acers (-5.23e-6) and stocks (-8.49e-8) indicate that SRW wheat had less acres planted and storage of off-farm stocks during this time. With regards to planted acres, it should be noted that though the amount of planted acres might be smaller than the acres planted for HRW, SRW wheat still saw a greater difference in terms of the percent change in planted acres. The difference in planted acres is shown to be significant at the 1% level however the coefficient suggests that this difference is small. The demand indicator for exports is shown to have a positive difference between the two classes of wheat. The coefficient (.0408) indicates that the value of exports for SRW wheat were higher. This is supported by the fact that SRW did experience higher prices. In addition, the states that producer SRW wheat are closer to major ports which would make it easier to participate in export exchanges. The p-value indicated the difference is significant at the 1% level.

Time and Treatment Variables

Soft Red Winter (SRW) wheat was chosen as the treatment group due to the greater percentage increase in planted acres and feed use observed after the 2008 price boom. The analysis shows that there is a negative difference in cycle time between the two classes of wheat. This implies that producers of SRW wheat have shorter production cycles than producers of HRW wheat. The coefficient (18.85) indicates that this difference in production time can be close to 3 weeks. This would primarily be due to differences in the climate where the two classes of wheat are grown. The difference in cycle time for SRW wheat is shown to be significant at the 1%. The analysis also shows that the differences in the cycle time over the during this period is negative. The coefficient suggest that overtime SRW wheat experienced a greater decrease in cycle time than HRW which is verified by the descriptive statistics. This differences between the two classes of wheat is not shown to be statistically significant.

SRW Regions

While the difference in cycle time between the two classes of wheat is shown to be significant, the relationship between time and SRW wheat as the treatment group is not shown to be statistically significant. This would indicate that there is no significant correlation between the decrease in cycle time for SRW wheat and the presences of this particular market shock. This lack of correlation could suggest that even in the presence of a market shock it is not possible a producer can significantly alter production activities in order to shorten the cycle of production. This would imply that shorter production cycle seen in SRW wheat is a result of biological and regional factors that producers are unable to directly influence. These factors could possibly include differences in soil, rainfall, and overall climate conditions in each region. In order to further explore the responsiveness of SRW wheat producers Table 6 reports the results for the difference-in-difference result for the states producing SRW. Note the one state (Oregon) was omitted because it was not in the same longitudinal region as the primary states producing this class of wheat. In addition, Illinois was selected as the state to use as a base to compare the averages of the other states.

Table 7 SRW Wheat States

CT (days)	Coef.	Std. Err.	p-value	Sign. Level
Price	1.336266	2.248535	0.555	
Planted Acres	-8.43e-06	.0000124	0.501	
Stocks	-1.53e-08	2.46e-07	0.951	
Exports	.1621478	.0443483	0.001	***
Arkansas	-13.15764	7.157855	0.072	
Indiana	7.503352	5.677528	0.193	
Michigan	20.34402	4.764343	0.000	***
Missouri	-3.93531	5.355838	0.466	
North Carolina	3.65772	7.666192	0.635	
Time Period	-21.33463	6.325835	0.001	***
Time effect, States	-10.52445	7.231524	0.152	
Constant	242.072	12.39237	0.000	***
Significance level	*** = 1%	** = 5%	* = 10%	

The results show that the only market indicator to experience any significant differences in the across states that producer SRW wheat was exports. This difference is shown to be significant at the 1% level. The only state to show a significant difference in cycle time was Michigan. The coefficient suggest that Michigan's cycle time was roughly 20 days longer on average and this difference is shown to be significant at the 1% level. The time effect is shown to be significant at the 1% however the time effect on states is not shown to have any level of significance. This further suggest that states growing SRW wheat were not responding in a particularly different way to the shock when through cycle time.

Chapter 4 - Conclusion

The purpose of this research was to examine how producers in the wheat industry respond to changes in the market place from a supply chain perspective. The question this research sought to answer was: How do producers of wheat respond to market changes? The objectives outlined in order to answer this question were: 1) to identify a market shock that occurred in the industry; 2) To apply a method of measurement for responsiveness from a supply chain perspective; and 3) to examine the effect that the shock had on the responsiveness of the industry. The rationale behind of using cycle time as a responsiveness metric was to examine whether the shock resulted in any significant differences in production or management practices that would indicate whether producers were taking advantage of an opportunity in the market. This further specified the research question to: Is the relationship between cycle time and market shocks correlated to supply chain responsiveness? Knowledge of this provides insight in to the effectiveness of cycle time as measure for determining the responsiveness of wheat producers. The actions of the producers can affect operations throughout the entire supply chain. Information about how producers respond to changes can help firms coordinate activities. Agri-food firms that use wheat in production need to be aware of how the supply of wheat may be impacted by market shocks and shifts in demand. Anticipating these shift can help agri-food firm adapt their supply chain assets to continue to meet customer needs.

The descriptive statistics from the analysis showed that for both HRW and SRW wheat the variables were used to demonstrate the changes in the market over time. Both classes of wheat experienced changes in the dependent variables before and after the shocks occurred. The results from the linear regression showed price and exports have a positive relationship with cycle time as a response variable while planted acres and off-farm stocks both showed negative relationships. In order for these relationships to be further examined, the effectiveness of cycle time as a response variable needed to be evaluated. Based on the results from the DID and regression the difference in planted acres in exports were both significant between the two classes of wheat. SRW overall was shown to have a shorter cycle time than HRW wheat. However, the effect of the time on SRW revealed that this difference was not significantly correlated with the presence of the 2008 grain price boom as a market shock. As stated in the analysis, the differences in cycle time could be attributed the biological and environmental factors relevant to the growing process. This also suggest the changes in cycle time experienced over this period of time are a result of improvements in production technologies and practices. Though no correlation was observed between the different cycle times for HRW and SRW wheat, it is important to note that this does not necessarily mean that producers in the supply chain are not responding to the market. Rather this might suggest that in the agriculture industry producers cannot adjust production practices in a way that would significantly decrease cycle time. Thus, cycle time may not be the most suitable metric for measuring responsiveness from a supply chain perspective in agriculture.

Future Research

This research shows that there are factors to consider when attempting to measure responsiveness in the agriculture and agri-food industry from a supply chain perspective. Future studies could build on this research in different ways. One approach is to change the cross-sectional level that the data represents. The data used for this research was secondary data collected at the state level. However, district or county level data could be captured for all of the variables used in the analysis, it could potentially reveal more specific regional implications into the nature of supply chain responsiveness for producers. A different cross-sectional level could also reduce the time period used to evaluate the effects of the shock by providing more observations to analyze. Shortening the periods of observation could reveal more about the specific changes that took place as a result of the shock. Changing or adding additional classes of wheat or other types of cereal grains to the study could reveal more changes across the grain industry.

Further explorations into other supply and demand indicators could prove useful in future research on wheat supply chain responsiveness. Future studies could expand on this research by including other variables that can serve indicators of supply and demand in the market. For example, if food use and feed use for each class wheat was captured on the state level it could provide even deeper insight in to how producers in the supply chain are responding to market opportunities. Furthermore, since the cycle time was shown to not be correlated with the presence of this market shock, another metric for supply chain responsiveness could be used to measure the effect of a market shock on producers in the supply chain. If a better measure for supply chain responsiveness can be identified, this method of analysis could be used to explore the impacts of other of shocks in the agriculture and agri-food industries. Recent global shocks have impacted supply chain operations over a short period of time. The COVID19 pandemic has affected the demand for products across different industries including agriculture. Examining how the agriculture supply is able to respond to a shock of this magnitude could help to develop management practices that would address health and safety issues and improve supply chain operations in the future.

References

Amerah, A., & Peron, A. (2012). Wheat as an alternative to corn. *Asian Feed Technical*.

Aung, M. M., & Chang, Y. S. (2014). Traceability in a food supply chain: Safety and quality perspectives. *Food Control*, *39*(1), 172–184. https://doi.org/10.1016/j.foodcont.2013.11.007

Bennet, G. (2009). *Food identity preservation and traceability: Safer grains*. Boca Raton, Florida, US: CRC Press.

Catalan, M., & Kotzab, H. (2003). Assessing the responsiveness in the Danish mobile phone supply chain. International Journal of Physical Distribution & Logistics Management, 33(8), 668-685. doi:10.1108/09600030310502867

Chenhall Robert H. and Langfield-Smith Kim (2007). *Multiple Perspectives of Performance Measures.* European Management Journal, 25, pp. 266–282.

Chen, S., Kuo, H., & Chen, C. (2010). Modeling the relationship between the oil price and global food prices. *Applied Energy, 87*(8), 2517-2525. doi:10.1016/j.apenergy.2010.02.020

Christopher, M. (2000). The Agile Supply Chain: Competing in Volatile Markets. Industrial Marketing Management, Vol 29, No. 1 http://www.sclgme.org/shopcart/documents/agile_supply_chain.pdf

Christopher, M., Lowson, R., & Peck, H. (2004). Creating agile supply chains in the fashion industry. International Journal of Retail & Distribution Management, 32(8), 367-376. doi:10.1108/09590550410546188

Dabbene, F., Gay, P., & Tortia, C. (2014). Traceability issues in food supply chain management: A review. *Biosystems Engineering*, *120*, 65–80.

https://doi.org/10.1016/j.biosystemseng.2013.09.006

Dittler, E. (1957). Case of recurrent contralateral spontaneous pneumothorax with a twenty-eight-year follow-up. New York State Journal of Medicine, 57(5), 949-950.

Dixon, B. S. (2018). Difference in difference method. *Journal of the American Medical Association*, *312*(21), 2401–2402. https://doi.org/10.1001/jama.2014

Elobeid, A. E., Hayes, D. J., Babcock, B. A., & Hart, C. E. (2006). *The Long-Run Impact of Corn-Based Ethanol on the Grain , Oilseed , and Livestock Sectors : A Preliminary Assessment The Long-Run Impact of Corn-Based Ethanol on the Grain , Oilseed ,*

Fisher Marshall L. (1997). *What is the right supply chain for your product?* Harvard business review, pp. 105-116

Griffin, T. W., Economics, A., Harris, K., & Economics, A. (2019). *Distributed Ledger Technology Applied to Farm Data : Tracking Yield Monitor Data Changes With Blockchain*. 1–7.

Groote, X. D. (1994). Flexibility and marketing/manufacturing coordination. Fontainebleau, France: INSEAD.

Gunasekaran Angappa, Lai Kee-hung and Cheng T.C. Edwin (2007). *Responsive supply chain: A competitive strategy in a networked economy*. The international journal of management science, 36, pp. 549-564.

Gunasekaran A., Patel C. and McGaughey Rondal E. (2004). *A framework for supply chain performance measurement*. International journal of production economics, 87, pp. 333–347.

Hum, S. H., Parlar, M., & Zhou, Y. (2018). Measurement and optimization of responsiveness in supply chain networks with queueing structures. *European Journal of Operational Research*, *264*(1), 106–118. https://doi.org/10.1016/j.ejor.2017.05.009

Hussain, M., & Dawson, C. (2013). Economic Impact of Food Safety Outbreaks on Food Businesses. *Foods*, *2*(4), 585–589. https://doi.org/10.3390/foods2040585

Minnich, Dennis & Maier, Frank. (2007). Responsiveness and Efficiency of Pull-Based and Push-Based Planning Systems in the High-Tech Electronics Industry.

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2013). Introduction to linear regression analysis. Oxford: Wiley-Blackwell.

Nichols, E. L., Jr., Retzlaff-Roberts, D., & Frolick, M. N. 1996. *Reducing order fulfillment cycle time in an international supply chain*. Cycle Time

Skinner (1974)Skinner, W., 1974. The focused factory. Harvard Business Review, 113–121.

Randall, T. R., Morgan, R. M., & Morton, A. R. (2003). Efficient versus Responsive Supply Chain Choice: An Empirical Examination of Influential Factors. *Journal of Product Innovation Management*, *20*(6), 430-443. doi:10.1111/1540-5885.00041

Rosegrant, M. (2008). *Biofuels and grain prices: Impacts and policy responses*. http://www.ifpri.org/publication/biofuels-and-grain-prices

Seber, G. A., & Lee, A. J. (2003). *Linear regression analysis*. New York: Wiley.

Silver, E.A., Pyke, D.F., Peterson, R., 1998. Inventory Management and Production Planning and Scheduling, third ed. New York

Thakur, M., & Hurburgh, C. R. (2009). Framework for implementing traceability system in the bulk grain supply chain. *Journal of Food Engineering*, *95*(4), 617–626. https://doi.org/10.1016/j.jfoodeng.2009.06.028

Tsiboe, F., Dixon, B. L., Nalley, L. L., Popp, J. S., & Luckstead, J. (2016). Estimating the impact of farmer field schools in sub-Saharan Africa: The case of cocoa. *Agricultural Economics, 47*(3), 329-339. doi:10.1111/agec.12233

Verweijen, H. (n.d.). *Manage performance measurement in responsive supply chains* .

Wang, Y., Wu, C., & Yang, L. (2014). Oil price shocks and agricultural commodity prices. *Energy Economics*, *44*, 22–35. https://doi.org/10.1016/j.eneco.2014.03.016

Wheat Production Map. (n.d.). Retrieved July 16, 2020, from https://www.wheatworld.org/wheat-101/wheat-production-map/

Wiggins, S., Keats, S., & Compton, J. (2010). What caused the food price spike of 2007 / 08? Lessons for world cereals markets. *Food Prices Project Report, UK-Aid*, *44*(0), 1–15.

Wong, C. Y., Arlbjørn, J. S., & Johansen, J. (2005). Supply chain management practices in toy supply chains. Supply Chain Management: An International Journal, 10(5), 367-378. doi:10.1108/13598540510624197

Yim, H. R. (2008). *Quality shock vs . market shock : Lessons from recently established rapidly growing U . S . startups*. *23*, 141–164. https://doi.org/10.1016/j.jbusvent.2007.03.001

Appendix A - Figures

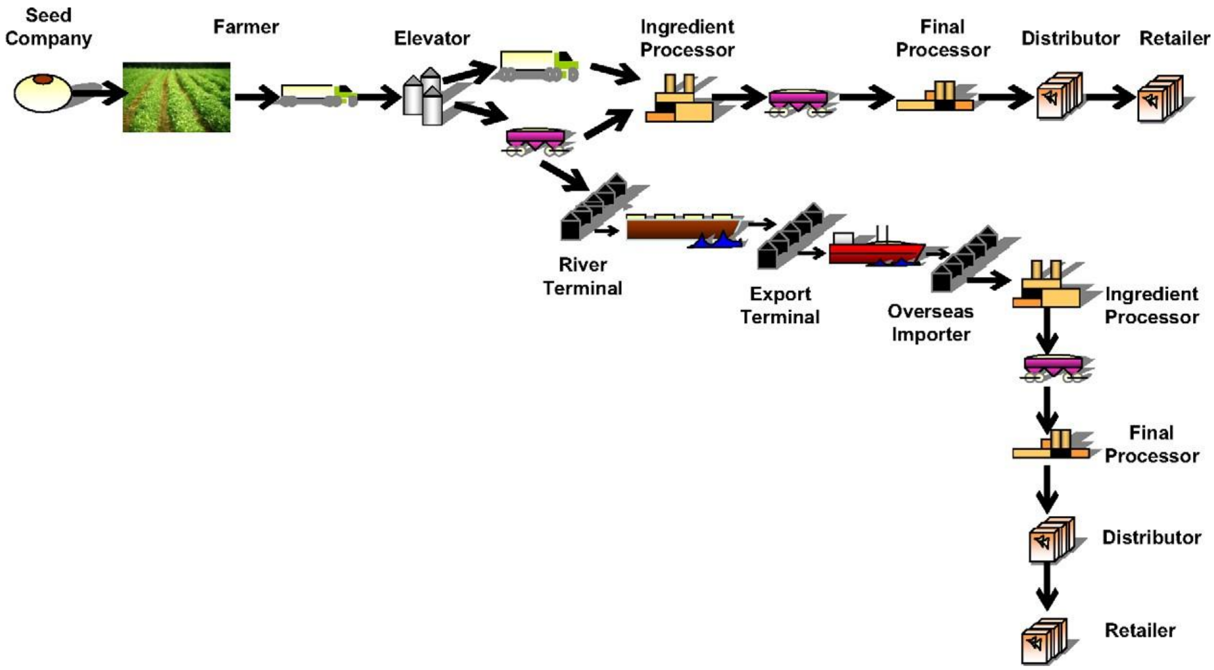

Figure 1 The bulk grain supply chain in United States Source: (Thakur & Hurburgh, 2009)

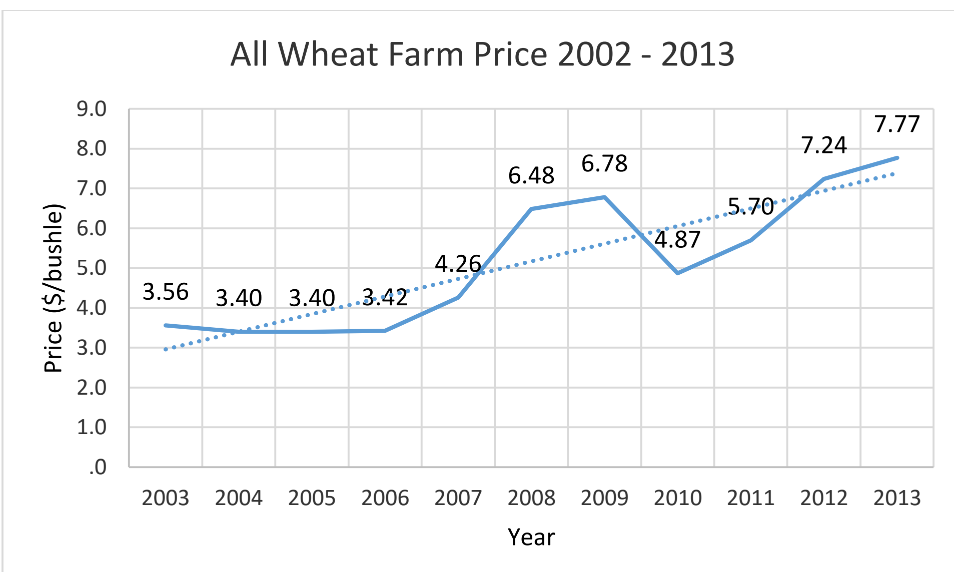

Figure 2 Wheat Farm Price 2003 – 2013 (Source: USDA Economic Research Service Wheat Data)

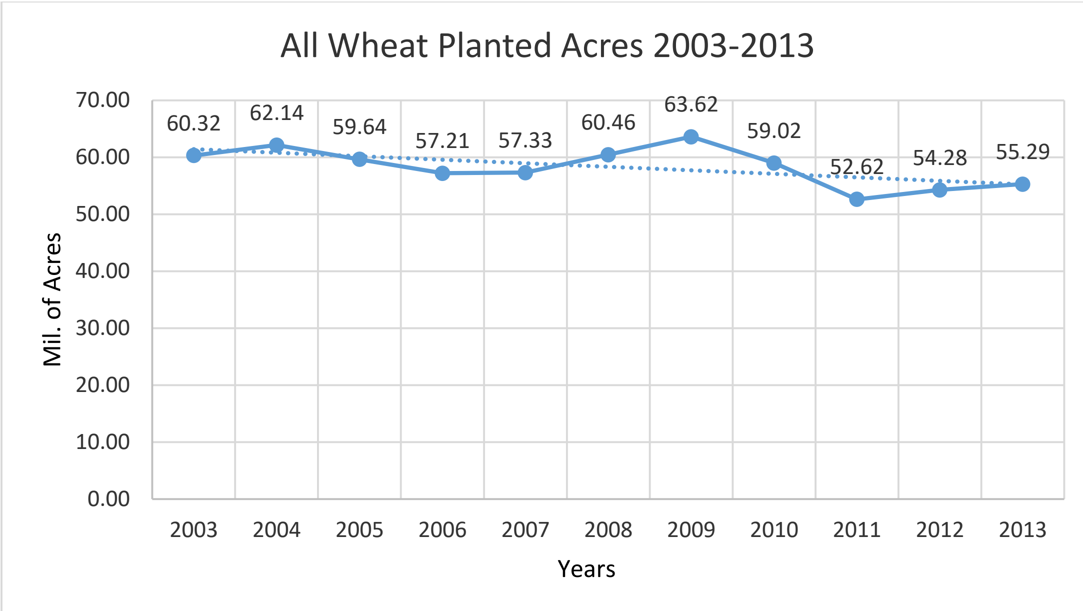

Figure 3 Wheat Planted Acres 2003 – 2013 (Source: USDA Economic Research Service Wheat Data)

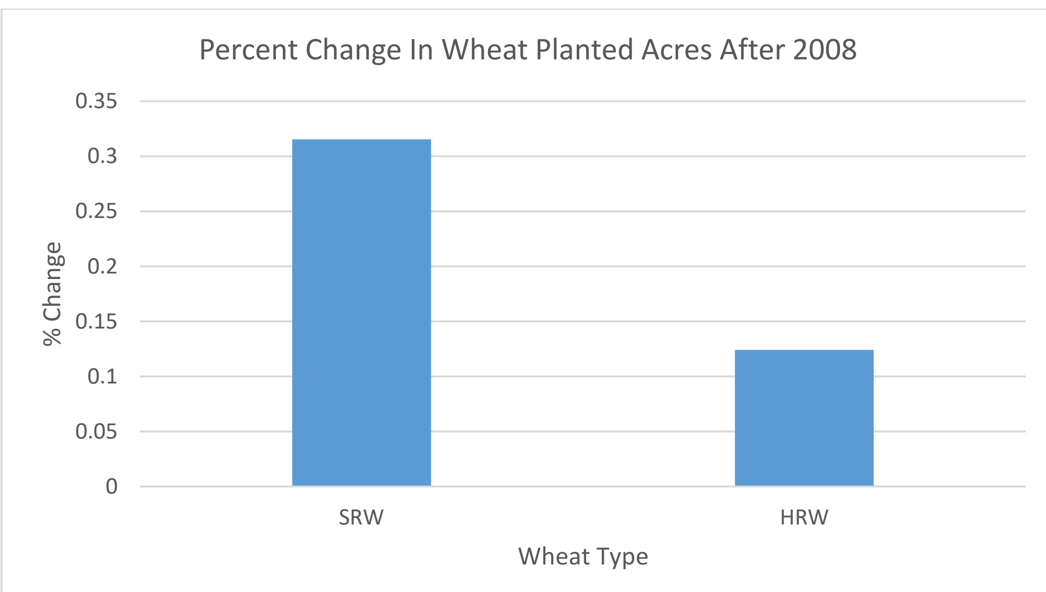

Figure 4 Source: USDA Economic Research Service Wheat Data

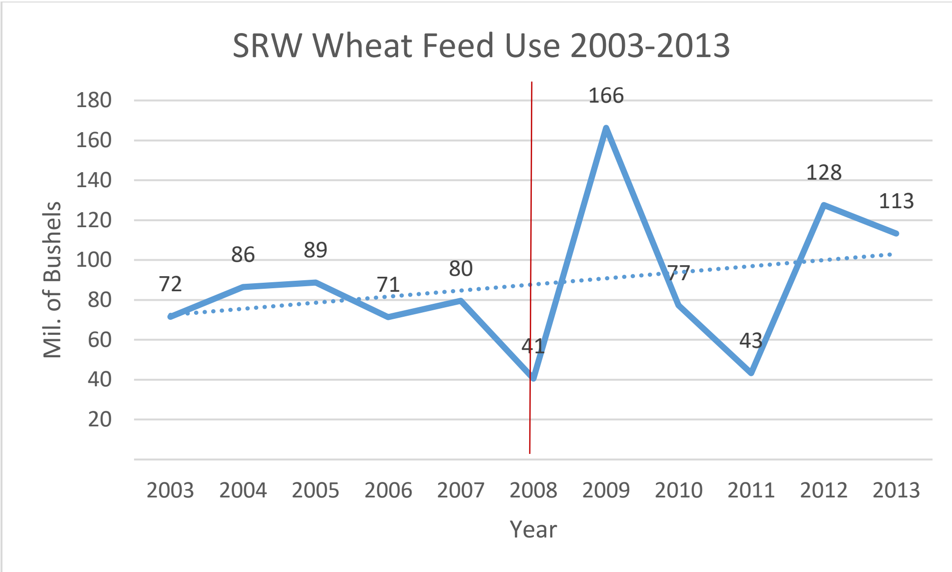

Figure 5 Soft Red Winter Wheat U.S. Feed Use (Source: USDA Economic Research Service Wheat Data)

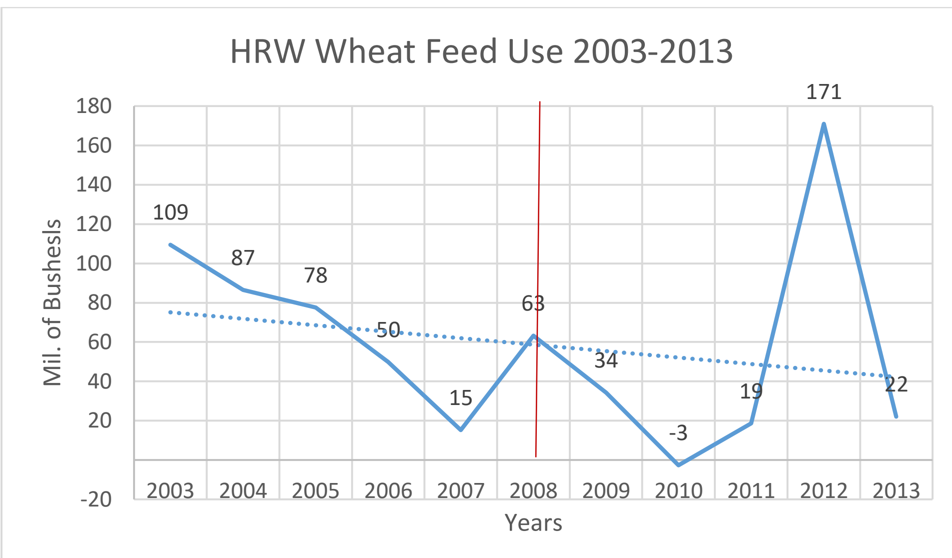

Figure 6 Hard Red Winter Wheat U.S. Feed Use (Source: USDA Economic Research Service Wheat Data)

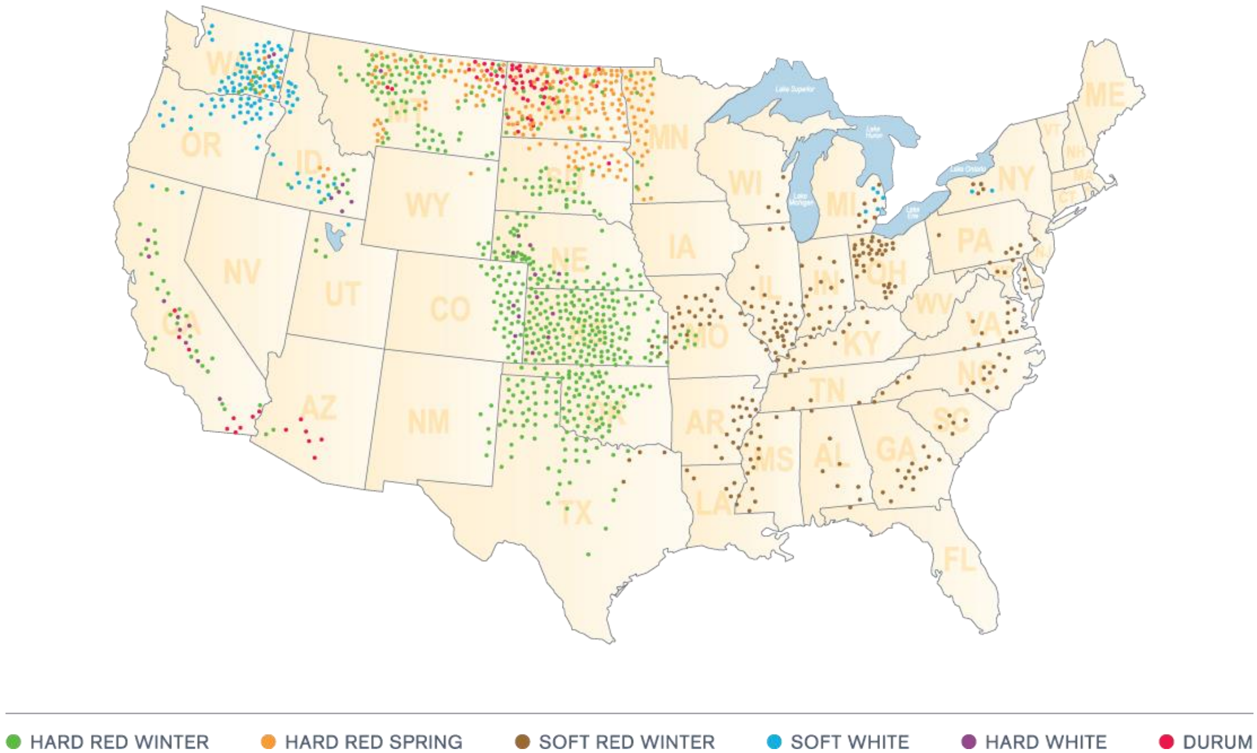

Figure 7 U.S Wheat Production Map (Source: National Association of Wheat Growers)