Abstract

PHILLIPS, JONATHAN LEE. Essays on the Impact of Crop Insurance on Chemical and Fertilizer Use; the Impact of Crop Insurance on Land Use; and the Elasticity of U.S. Import Prices with Respect to Tariffs. (Under the direction of Barry K. Goodwin.)

The first two essays of this study examine the impact of subsidized crop insurance. The first essay focuses on moral hazard via reduced chemical and fertilizer input use. This is addressed by evaluating expenditures on chemicals and fertilizer in relation to the participation rate in crop insurance. A General Method of Moments (GMM) estimation method with instruments is employed. The results indicate there is no significant increase in input use in the production of corn and soybeans driven by insurance participation. The possibility of moral hazard in wheat production cannot be rejected. The second essay focuses on market distortions caused by subsidized crop insurance. Increased planted area of insured crops was investigated using GMM modeling methods with instruments. The results find there is not a significant corn, soybean, or wheat planting response to subsidized crop insurance. Subsidies are found to impact insurance unit size choices. The third essay examines tariff reduction on agricultural imports. Specifically, this essay investigates whether reductions of import tariffs will cause changes in the price paid by importers. Using a Difference in Difference approach, no significant change is found to have occurred in the import price of selected agricultural commodities after the United States -Australian Free Trade Agreement. This result was supported with regression analysis. All agricultural products imported into the United States from two-thirds of its trading partners were then considered. Estimates found no change in import price from a change in tariff. This indicates that exporters to the United States are unable to earn significant tariff rents.

Essays on the Impact of Crop Insurance on Chemical and Fertilizer Use; the Impact of Crop Insurance on Land Use; and the Elasticity of U.S. Import Prices with Respect to Tariffs

by
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Biography

Jonathan Lee Phillips was born in rural Frederick Maryland on October 26th 1975 to Floyd Alfred Phillips, son of Floyd Alvin Phillips and Juanita Paulet Phillips, daughter of Ruth Greathouse. After graduation from Walkersville High School he attended Frederick Community College before enrolling at Frostburg State University. Under the guidance of Dr. Anthony Stair he earned his Bachelors degree in economics in 1997. Jonathan then attended Pennsylvania State University and earned a Masters degree in Agricultural Economics in 1999. In that same year he married beautiful Jennifer Ann Edwards and immediately moved to Raleigh North Carolina to begin a teaching career in the Agricultural Institute at NC State University. On October 14 2007 he and Jenni were blessed with their first daughter Catherine Elizabeth Phillips. Two years later they were again blessed with Courtney Michelle Phillips on February 3 2010. Everything in Jonathan’s life comes second to his wife and daughters. Jonathan enrolled in the Ph.D. program at North Carolina State University in 2011 while maintaining full time employment as a senior lecturer in the Agricultural Institute and undergraduate programs at North Carolina State University.

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Chapter 1. Impact of Crop Insurance on Chemical and Fertilizer Use

1.1 Introduction

Insurance companies attempt to earn profits while providing protection against financial losses to their policy holders. An insurer achieves this goal by taking on the risk of many policy holders. When exposing themselves to a large number of individual potentially risky situations, the insurer can use actuarial methods to determine premiums and thereby attempt to earn a profit. The individual policy holder, if averse to risk, experiences an increase in utility knowing they have a guaranteed protection against a great loss under adverse events. Theoretically, this allows for a relationship where all parties are better off, but unfortunately some insurance policy holders may be incentivized to behave differently than the non–insured, which may be disruptive to this theory.

Fully insured individuals are indifferent about loss. To increase their expected utility they may choose larger risks that offer higher payouts or avoid taking costly preventative measures. This change in behavior is known as moral hazard. Moral hazard can be partially mitigated if insurance companies do not offer full insurance. For example, an actuarially fair auto insurance policy may have a deductible. This will encourage the policy holder to not engage in risky behavior, as the policy holder knows he or she must pay 100% of the deductible.

Insuring only portions of a producer's total crop is similar to having a deductible and causes some moral hazard behavior to be less attractive. Subsidies have been provided for crop insurance over its entire history. The federal crop insurance program formally became part of the Farm Bill in 2008. Although all insurance coverage in the U.S. federal program is subsidized, the subsidies, as a portion of total premium, are at a lower rate at higher levels of coverage. This subsidization allowed insurance policies to be purchased below actuarially fair rates. Goodwin and Smith (2013) state that since crop insurance has positive returns for producers of most crops in most locations, then producers may alter their production practices in a way that alters risk. This study examines whether insurance participation influences producers' input choices due to moral hazard. The extensive use of fertilizer and chemical inputs is suspected to not be impacted by insurance participation by an economically significant amount. Corn and soybeans in the region of Illinois, Indiana, and Iowa as well as wheat in the region of Montana, North Dakota, and South Dakota will be examined.

Environmental protection is an ongoing issue in legislation. In recent years, many new policies designed to incentivize industries to be more "green" have been adopted. Although moral hazard is detrimental to the insurance industry, there may be positive environmental impacts from such behavior. In the case of agriculture, moral hazard is possible via a producer applying less pesticide, insecticide, or fertilizer on an insured crop relative to one that is uninsured. Conceptually, Carlson suggested over 37 years ago that insurance may reduce pesticide use. Pesticides are substitutes for crop insurance. A producer could underutilize the pesticides and file an insurance claim for damaged crops (Carlson, 1979). Conclusive findings from this study would be useful to policy makers in tackling environmental protection. The results could be used to support legislation that increases crop insurance subsidies and offers higher levels of coverage as part of an environmental protection policy. The 2014 Farm Bill created a supplemental coverage option (SCO) for producers. Conclusions of this study will be useful in planning for the impacts of future Farm Bills.

This study is organized in the following manner. Section 2 provides an overview of Farm Bill legislation. Then the history of crop insurance including government efforts to promote participation is presented. Section 3 reviews past literature that discusses moral hazard and agricultural input use. The model is described in section 4 followed by a discussion of the data in section 5. Section 6 presents the empirical results. The conclusion is discussed in Section 7. Section 8 contains tables.

1.2 Overview of Farm Bill Legislation and Available Crop Insurance

Financial protection of the agriculture sector in comparison to other business sectors within the Unites States is needed based on the greater risk and uncertainty. Risk and uncertainty come from the random shocks caused by drought, flood, and pest damage. These uncertainties impact individual agricultural producers in two ways. First, they can create a devastating loss of an individual's crop after having paid large expenses for inputs. Perils and good fortune can also impact an entire region causing a shock in the world supply of a commodity. These supply shocks translate into volatile prices. With recent expansion of corn, soybeans, and wheat production in Brazil, weather impacts are relevant on a worldwide scale. The result is that producers can realistically see high prices when they have no crops to offer and low prices when they have a large supply to offer.

The production and price volatility problem is amplified when considering the economic requirements of agricultural operations. Agricultural production in the U.S. requires extremely large fixed costs due to land-intensive and machinery-intensive farming practices. The trend away from small family operations toward large scale operations has helped reduce this impact. The United States Department of Agriculture (USDA) reports that the average cropland farm size was 251 acres in 2012. However, this statistic can be misleading. The USDA's Economic Research Service (ERS) used the 2011 Agricultural Resource Management Survey (ARMS) and found that there were more farms with fewer than 50 acres and more farms with more than 1,000 acres in 2011 when compared to 2001. Cropland farms have been shifting toward larger operations. In 2001, 24% of cropland was held by farms greater than 2,000 acres. In 2011, this increased to 34%. This debt-to-asset ratio was 0.21 in 1986 and has steadily fallen to 0.09 in 2011 as reported by the USDA in the 2011 ARMS. With farms leveraged less against their assets, a single shift in price and production is less likely to bankrupt a farm but could still be very harmful.

To understand incentive structures in crop insurance, other farm income protections available through Farm Bill legislation need to be examined. The first Farm Bill was part of Roosevelt's New Deal. It passed Congress in 1933 and was known as the Agricultural Adjustment Act. The recurring Farm Bill as we know it today was established in 1938.

Congress required the Farm Bill to be updated every five years. This Act provided large price supports which set the tone for many Farm Bills to follow.

The 1996 Farm Bill, known as the Federal Agriculture Improvement and Reform (FAIR) Act, was a major deviation from past legislation. Some dubbed it the "freedom to farm" bill as producers were given more flexibility to make planting decisions and it eliminated annual acreage idling programs. Target prices and target price based deficiency payments were eliminated, which removed the direct link between income support payments and farm prices. The combined result was a Farm Bill that made producers rely more on market signals such as demand, supply, and price to make production decisions. To receive some benefits, producers had to comply with existing conservation plans, wetland provisions, and keep land in agricultural use (Economic Research Service, 1996).

Under the 1996 legislation, producers received Production Flexibility Contract (PFC) payments which were determined by historical base and were decoupled from production. The base was determined using acreage and yields during the 1980's. Provision for base updating occurred in 2002 and 2014. The contract rate changed every year based on available budget allotted to the Farm Bill. With the exception of fruits and vegetables, the use of historical base to determine payment means producers received payment without regard to actual plantings in that year. For example, a producer who had a historical base and yield established for wheat could react to a high demand for corn by planting corn, yet still receive a PFC payment for wheat. Non-recourse commodity loans were maintained in the 1996 Farm Bill. These were loans taken out by producers for which their crop was used as collateral. In times of low market prices, the producer could forfeit the commodity to the government instead of repaying the loan; thus, the large volume of commodities forfeited to the government became expensive to manage. To reduce these administration costs, the government allowed farmers to opt for a Loan Deficiency Payment (LDP) equal to the gap between the loan rate and market prices. Overall, the 1996 Farm Bill was a major departure from earlier legislation but continued to provide producers some income and low price protection.

The 2002 Farm Bill, also known as the Farm Security and Rural Investment Act, introduced direct payments and Counter-Cyclical Payments (CCP) while retaining non-recourse loans and LDPs. Direct payments replaced the PFC payments and were modified to include soybeans. Similar to PFCs, direct payments were not based on a producer's current production which theoretically allowed them to make production choices using market signals. Goodwin and Mishra (2006) address whether these were actually non distortionary. CCPs were designed to protect producers against low prices. A payment was made when the effective price was less than the target price for a covered commodity. Keeping with the flexibility provisions of 2002, payments did not depend on the covered crop actually being planted.

The Farm, Nutrition, and Bioenergy Act of 2007 was passed by the House of Representatives in July 2007. The Senate version of the bill, the Food Conservation and Energy Act, was reconciled with the House version but was vetoed by President George W. Bush. The veto was overridden by Congress, and the 2008 Farm Bill was passed into law

May of 2008. The legislation continued many of the commodity programs of the 2002 bill. Direct payments were reduced to 83.3 percent, down from 85 percent, and CCPs for most crops including corn were held at the same target price. Target prices for soybeans and wheat increased for the 2010-2012 time period. Average Crop Revenue Election (ACRE) was added as an alternative to CCPs. Producers who chose ACRE had to forego all CCPs and 20 percent of direct payments, and their loan rate was reduced by 30 percent. Producers who opted for ACRE were eligible for payment if the actual state revenue for the covered crop was less than the guarantee. The guarantee was 90 percent of the state average yield multiplied by the program price guarantee. With this formula, a decrease in market prices or a decrease in state yield would trigger a payment. A producer was paid the ACRE guaranteed revenue for 83.3 percent of their acres planted to cover commodities taking into account the farm's specific productivity ratio. The decrease in yield provision provided protection in years of large scale drought or flood that was not available with counter cyclical payments.

The 2012 Farm Bill, known as the Agriculture Reform Food and Jobs Act, failed to pass the House of Representatives, so the expired 2008 bill was extended via the American Taxpayer Act of 2012. The 2013 Farm Bill passed the Senate, but like the 2012 legislation it failed to pass the House of Representatives. For the 14 year period of this study, producers were impacted by the 2000, 2004, and 2008 Farm Bills.

Congress finally passed a new Farm Bill in 2014, the Agricultural Act of 2014. Title XI, section 11003 of the 2014 Farm Bill provides optional insurance that is discussed later.

Title I of the 2014 Farm Bill offers producers two types of non-insurance coverage, Price Loss Coverage (PLC) and Agricultural Risk Coverage (ARC) program. Only one program may be selected for the lifetime of the 2014 Farm Bill

The PLC program is a form of the CCP program present in the 2002 and 2008 Farm Bills. A payment is made when the price of a covered crop is below the target price. The payment is calculated using base acres and base yields. Base acres were determined from historical planting and were allowed to be updated in the 2014 Farm Bill. An Olympic average over the past five years was used to determine base. Short term production changes will not likely impact the base with this form of calculation. Base yield was determined from 90% of historical yields and was crop specific (Sec1113.d.3, 2014 Farm Bill). If a producer averaged 160 bushels/acre of corn that base yield is 144 bushels/acre. If the base acreage is 100 and the price of corn falls below the target price by $0.10, then the producer will receive a PLC payment of $0.10*144*100=$1,440. The target prices of 2014 Farm Bill PLC payments are 50-70% greater than the CCP target prices of the previous 2008 Farm Bill.

The base acre crop does not actually have to be planted to receive a payment in any given year, except for cotton. Cotton base was eliminated and made generic. A producer with corn base would have received a PLC payment if prices were low enough even if the producer planted soybeans instead of corn that year. A producer's individual yield has a negligible impact on the market price, so it will not impact the PLC payment. Therefore, once base acres are determined, gains from moral hazard do not exist. Bhaskar and Beghin (2010) and Peckman and Kropp (2012) studied possible gains from updating base acres.

PLC payment without required planting allows producers to make planting decisions based on market conditions as opposed to maximizing a specific crop subsidy. This decoupled support design is intended to avoid market distortions and trade disputes. The World Trade Organization (WTO) does not consider PLC and ARC payments to be decoupled. Goodwin and Mishra (2006) find a highly significant link between previous years payments and corn production. The exact reason behind the connection is debatable (Goodwin and Mishra 2006).

Price and individual yield can be negatively correlated during natural disasters. A drought can impact a large area of farmland, causing a significant decrease in supply leading to increases in prices. Corn prices increased 40% and soybeans increased 37% between February and 2012 during the 2012 drought. If this were to occur again, then a farm within the disaster area experiencing a total loss would not expect a PLC payment due to high market prices. Therefore, producers selecting PLC will most likely also select subsidized crop insurance to protect their yield losses.

Agricultural Risk Coverage (ARC) is designed to cover a producer's out-of-pocket loss, or "shallow loss," when farm crop revenue declines. Payments are made when revenue drops below 86% of historical revenue. Historical revenue is determined using five year rolling Olympic calculations for price and yield. These Olympic calculations eliminate the high and low observations. Average price is set the using national marketing year average price. This is a 12-month average, not a harvest price. Yield averages are calculated using actual production history.

There are two scenarios a producer considers when making the PLC/ ARC decision. First, in a year of high yield and a low market price, a producer would receive a PLC payment. No ARC payment would be made if the high yield offset the low price, thus generating normal revenue. Second, in a year of low yield with average price, a producer would not receive a PLC payment. They would receive ARC payment if the low yield combined with average price generated lower than normal revenue.

Producers can select ARC coverage at a county (ARC-C) or farm level (ARC-IC). However, coverage at the farm level is across all crops (whole farm revenue) while county level ARC is crop specific. Once this choice has been made, it is not reversible for the life of the 2014 Farm Bill. A producer whose individual marginal yield has a negligible impact on their county average would not experience gains from moral hazard if enrolled in the ARC-C program. However, the ARC county payments are based on the administrative county of the farm, not the actual location of the farm. This allows for potential adverse selection if the administrative office of a farm is located in a county that regularly performs worse during a crisis than the county where the crop is actually grown.

Tab1e 1.1 clearly shows that the preference for PLC or ARC selection is crop dependent. There is a large difference between the percentage of wheat producers who chose PLC and the percentage of corn and soybean producers that choose PLC. Many articles written before the sign-up deadlines predicted that corn and soybean producers would fare better under the ARC program, whereas wheat producers would fare better with PLC.

Table 1.1: Percentage of producers selecting PLC and ARC-C coverage.

	Barley	Canola	Corn	Peanut	Rice	Sorghum	Soybean	Wheat
PLC	57%	93%	9%	99%	96%	54%	4%	34%
ARC-C	42%	7%	91%	1%	4%	46%	96%	66%

Source: USDA-Farm Service Agency

In addition to the financial protection received from farm bills, producers have the option to purchase crop insurance. The crop insurance program was legislated into existence in 1938 with the Crop Insurance Act. The Act provided protection from multiple risks. The program experienced low participation and a high loss in the 1980's to early 1990's, but now insures about 90% of crop acreage. Insurance is purchased through private companies which are reimbursed by the U.S. government for their administrative costs and policy losses. Low participation was often blamed on ad-hoc disaster relief payment programs. When a disaster would occur, farmers would lobby for federal disaster relief. As this became common practice, producers did not see the need to buy insurance because they would receive payments through federal disaster relief. The 1980 Federal Crop Insurance Act tried to encourage farmers to get away from the "premium free" ad-hoc disaster payments. The crop insurance program included more crops and more regions. The bill also provided a 30% subsidy on insurance premiums up to 65% coverage. The changes were unsuccessful in enticing most farmers to participate. Weather caused major agricultural disasters in 1988 and 1989, and each disaster was followed by ad-hoc relief. The relief bill in 1992 provided disaster payments for individual losses in 1990, 1991, and 1992. Flooding in 1993 resulted in more crop losses and more ad-hoc disaster relief. With each additional ad-hoc payment, farmers were shown that there was no need to pay for insurance. This path was not sustainable for the crop insurance program.

In 1994 Congress passed the Federal Crop Insurance Reform Act which dramatically restructured crop insurance. The Act mandated that farmers purchase insurance in order to be eligible to receive other benefits such as price support programs. Catastrophic (CAT) coverage became available. CAT covered losses over 50%, was completely subsidized, and only required a $50 per crop administrative fee. Higher levels of coverage received an increase in subsidies. The Act successfully doubled participation in crop insurance by 1998.

The Risk Management Agency (RMA) of the USDA was created in 1996. The RMA manages the Federal Crop Insurance Corporation (FCIC) which is the government owned corporation that provides crop insurance. The Agricultural Risk Protection Act (ARPA) passed in May of 2000 dramatically increased subsidies. ARPA also allowed the RMA to create partnerships and hold contracts with private agencies for research and development of new insurance offerings. The role of the private sector greatly expanded. They were encouraged to propose new insurance products, receive reimbursement for development costs, and after three years retain ownership of the insurance product. With ownership of the insurance product, the private company could then charge a fee to other companies that use that product. This provided private industry an economic incentive to invest in the development of crop insurance products. As a result, producers had access to different types of insurance products.

The three most common insurance policy types offered to producers are yield protection, revenue protection, and area protection. Yield protection is designed to protect a producer from yield shortfalls. An established price is determined using the futures market by averaging the futures contract price from the Board of Trade over a given time period. The time period known as the "discovery period" varies by state and commodity. For example, the discovery period for corn is January 15th to February 14th for North Carolina farms and February 1st to February 28th for Iowa farms. A set number of bushels are determined using the farm's actual production history and level of insurance selected. For example, if a farm produces 100bu/ acre and selects 60% insurance, then anything less than 60bu/acre triggers an indemnity payment. The payment is the difference between 60bu/acre and the actual yield multiplied by the established price determined at the beginning of the year. Yield protection provides no direct price protection. If the producer has a yield loss and the harvest price is below the established price, then they will receive some price benefit from having a high established price. This price advantage would only be on the bushels below the trigger and would not apply if the trigger was not reached.

Revenue protection is similar to yield protection but protects against both price movements and yield loss. Revenue protection plans calculate expected revenue as expected yield multiplied by expected price. This is compared to actual revenue which is calculated as actual yield multiplied by harvest price. Harvest price is determined using the same discovery period average method as expected price. An example of revenue protection would be if a farm has an average yield production history of 100bu/ acre with expected price of $5/bu and selected 60% insurance. Revenue less than $300/acre is protected and triggers an indemnity payment. This could be from a price below $3/bu, a yield below 60bu/acre, or a combination of both low price and yield. Harvest price exclusion is a less expensive policy option, but disallows revenue updating if the harvest price is more favorable. A plausible scenario would be a high price of $6/bu and low yield of 50bu/acre. This would generate no indemnity payment from revenue protection insurance, but would have generated a yield protection payment for those who select the harvest price exclusion. Almost no producers select the harvest price exclusion, so the previous scenario revenue guarantee would have been recalculated at $360, generating a $60 indemnity payment.

Area protection provides yield and revenue coverage based on the experiences of an entire area, generally a county. When the estimated area yield or revenue falls below the insurance level chosen by the producer, an indemnity is paid without regard to the individual farm’s performance. Table 1.2 presents the percentage of total insurance liability of corn, wheat, and soybeans for the different plans from 2001-2014 in Illinois, Indiana, Iowa, Montana, North Dakota, and South Dakota. Note that these are the crops, time period, and regions used in this study. Producers have overwhelmingly chosen to purchase revenue protection insurance which provides protection against both yield and price volatility.

Table 1.2: Average percentage of insurance plan type 2001-2014.

	Revenue	Yield	Area
Corn	77%	7%	16%
Soybeans	74%	11%	15%
Wheat	82.5%	17%	0.5%

Source: Risk management agency

If an insurance company chooses to sell insurance in a state, then they are required to offer their product to all plots. They must offer the same base rate to everybody in the same county. This mandate does not allow for penalizing producers who make claims more frequently due to poor management practices or soil quality. To help with the problem of adverse selection, a producer who purchases insurance on a crop must do so on all of their eligible plots of that crop in that county.

Title XI of the 2014 Farm Bill provides optional insurance. The supplemental coverage option (SCO) covers a portion of losses not covered by the same crop's insurance policy up to 86%. SCO is bought as an endorsement to other crop insurance policies. Payments will depend upon coverage level selected and are determined at the area level even if the underlying policy is individual farm protection. SCO premium is subsidized at 65% by the federal government. Crop insurance options already available will continue to be subsidized. Producers who opt for PLC coverage will probably purchase subsidized federal crop insurance and subsidized SCO. The overall effect of Title XI is to raise the available level of crop insurance to 86%.

1.3 Past Literature

Using a stochastic dynamic programming approach to solve the producer's optimization problem, Bhaskar and Beghin (2010) find producers make fertilizer decisions taking into account the possibility of future base updates. Base acre and yield updates will be allowed under both ARC and PLC programs of the 2014 Farm Bill. Producers cannot retroactively apply inputs to increase averages. However, if we assume producers maximize the present value of lifetime expected utility and producers anticipate being allowed to update their base in the future, they could change current chemical and fertilizer use. This implies potential environmental damage from the PLC programs if producers increase fertilizer to achieve a higher base.

Peckman and Kropp (2012) tested this theory using 1991-2008 chemical expenditure data from USDA and National Agricultural Statistics Services (NASS) as a proxy for chemical use. Quantities of nitrogen, phosphate, and potash were also analyzed. Their analysis focused on the original policy in 1996 and the 2002 revision. Empirical results suggest that updating in 2002 influenced input use. An increase in decoupled direct payments of $1 caused increased fertilizer expenditure by $0.15. Other government payments increased expenditure by $0.04. The mean marginal effect of decoupled payments on inputs was insignificant from 1991-2008. The introduction of decoupled payments in 1996 and base updating in 2002 created two structural breaks. When the structural breaks are considered, changes in fertilizer and other chemical use are found significantly positive from the introduction of decoupled payments and base updating (Peckman and Kropp, 2012).

The social welfare loss from an increase in base yields due to increased chemical use goes beyond environmental impacts. Artificially raising the base causes a wealth transfer to farms from a government budget generated from disproportionate taxes. Although Bhaskar and Beghin (2010) and Peckman and Kropp (2012) both found positive correlation, both also found the effect to be very small. If the impact of insurance from Title XI decreases input use enough to offset these small effects, then the 2014 Farm Bill could have an overall effect of incentivizing producers to make less environmentally harmful input decisions.

Horowitz and Lichtenberg (1993) used 1987 data to study input levels of corn producers. Using a Probit model with considerations for the producer's wealth, they found those who purchased insurance applied 19% more nitrogen, spent 21% more on pesticides, and increased insecticide treatments by 63%. Results suggest that providing a typical producer with an insurance contract will cause an increase in nitrogen applications by 18.4lbs/acre. Results from this study could indicate adverse selection and not lack of moral hazard. Producers who live in areas of low rainfall are at high risk of drought, so they are more likely to purchase insurance. The correlation between high levels of nitrogen application and insurance could be a result of the correlation to areas of low rainfall, and not to each other.

Quiggin, Karagiannis, and Stanton (1993) used 1988 data to model inputs and outputs of insured and uninsured farms. The model indicated that insured farmers tend to use fewer variable inputs relative to fixed inputs and fewer inputs per acre to produce a given output than do uninsured farmers. Insured farmers are also shown to have lower yields. Lower yields could be from adverse selection; however, reduced inputs are an indicator of moral hazard.

Smith and Goodwin (1996) explain that increased application of chemicals raises the variance of yields. Mathematically this alone could be used to show an incentive for insured producers to increase their chemical use. Additional inputs after a historical yield has been determined will increase the expected yield which then lowers the chance of yields below the predetermined guarantee. Therefore, increase in chemical use due to insurance is counter intuitive. Using 1992 data, Smith and Goodwin (1996) find insured Kansas dryland wheat farms use less chemical inputs than those that are uninsured. Chemicals were an aggregate of fertilizer, herbicide, and pesticide expenditures. They also fail to reject at the 1% level the hypothesis that farms which use more chemical inputs are less likely to purchase insurance. This indicated moral hazard. These results imply positive environmental impacts from increased participation in the crop insurance program.

Babcock and Hennessy’s (1996) results support insurance being a substitute for nitrogen fertilizer. Their results hold at all the reasonable levels of risk aversion they tested. An insurance coverage of 70% does not induce a large reduction in the optimal fertilization rate. At 90% coverage, fertilizer usage is reduced by 18.7%. They conclude that producer responses to insurance are not linear. With the 2014 Farm Bill allowing producers to purchase 11% greater coverage of area level protection, positive environmental impacts via lower input use may be quite large over previous reductions. Hennessy (1998) modeled nitrogen use for insured producers a few years later. The model allowed for producers to be risk neutral, constant absolute risk averse, or decreasing absolute risk averse. Results show producers that had decreasing absolute risk aversion (DARA) preferences would decrease nitrogen use a small amount with insurance.

Seo and Leatham (2005) modeled optimal nitrogen rates for Texas cotton and sorghum using 1980-2001 data. Results show that with insurance, both high-risk averse and low-risk averse producers will increase nitrogen rates for cotton and decrease rates for sorghum. The model does not use historical nitrogen and insurance data to reach a conclusion. The results are totally dependent on model specification and calibration. Nitrogen is treated as a variance increasing input. This could explain some of the differences between this model and empirical modeling by others.

In the same study that Peckman and Kropp (2012) found increased inputs during base readjustment, they also investigated insurance relationships. They found the effect of insurance on inputs to be negative. They conclude that this is unexpected when considering that this suggests risk averse farmers tend to use less fertilizer. They do not consider the possibility of moral hazard.

A recent experimental study by Gunnsteinsson (2014) concluded moral hazard exists in the Philippines crop insurance market. Producers were asked to choose one of their plots to be put in a lottery to receive free insurance. Risk averse selection was estimated by comparing damages on a producer's first choice with their other plots while considering the plot's natural characteristics. By separating adverse risk from moral hazard, these moral hazard results are more compelling.

Moral hazard was considered with seed choice, earlier planting, and fewer protective chemicals in this rice production study. Insured plots were found 10-15% less likely to be planted with pest, insect or disease resistant seeds. Earlier planting was done to take advantage of higher harvest prices but was done with the risk of pest and insect damage occurring. If unsuccessful, the producer was able to shift the risk to the insurer; if successful, the producer would be able to keep the benefits. Moral hazard was concluded to exist. Further, statistically significant lower expenditure on chemicals was not found. This is potentially because they only make up 1% of total expenses (Gunnsteinsson, 2014).

Weber, Key, and O'Donoghue (2015) used farm level data that allowed them to know the initial level of input use and compare changes in input use with changes in insurance participation. Focusing on individual farms allowed soil quality, management skills, and other time invariant factors to be controlled tightly. They concluded that expanded coverage had very little impact on fertilizer and chemical input use.

Past literature offers conflicting results. Each study is focused on a different crop or uses a different technique to come to conclusions. Seo and Leatham's (1996) study uses identical economic methods across two crops and reaches results with different signs for chemical use. Walters, Shumway, Chouinard, and Wandschneider (2012) state reductions in risk associated with crop insurance are unlikely to be symmetric across crops. Since crops differ in their agronomic and environmental characteristics, changes in risk will inevitably affect production decisions. Producers use crop insurance to partially manage production risk, so one should not assume all crop input decisions will behave the same once a grower is when insured. Smith and Goodwin (1996) specifically state their "results could be sensitive to differences in production practices for alternative crops" (p. 437).

There have been many past studies linking fertilizer use to insurance. None of these studies have been of an empirical nature for corn and soybeans with historical data spanning over 10 years since large insurance subsidies began. The present study focuses on corn and soybean production in the U.S. Corn Belt and wheat production in Montana, and the Dakotas. Unlike previous studies, data include several years of subsidized insurance coverage at the county level. I also consider joint determination of insurance and input use.

1.4 Model

Goodwin and Mishra's (2006) study evaluated whether Agricultural Market Transition Act (AMTA) payments are linked to production decisions. They characterize producers as maximizing their expected utility of wealth, stating "In each period, wealth is given by initial wealth, plus profits derived from production, direct government payments and non farm activities" (p. 74). Current period wealth was written as: $P_{it}Q_{it}\left(A_{it}, X_{it}, A_{it-1,} e_t\right) - wX + C\left(A_{it-1,}\right) + G_t + PS(P_{it}) + W_{t-1}$, where P_{it} is the price of crop i at time t, Q_{it} $(\cdot)$ is output, A_{it} is planted acreage, X_{it} is a vector of variable inputs, e_t is exogenous shock, w is the price of those inputs, C is fixed costs, G_t is decoupled government payments, and PS are government payments effected by price such as market loss assistance, and W_{t-t} is wealth the previous period. To maximize the expected utility, they stated the producer will select acreage and other inputs yielding the reduced from equation $A_{it} = f(\, A_{it-1}, P_t, w_t, G_t, PS_t, W_{t-1})$ (Goodwin and Mishra, 2006, p. 75).

Goodwin and Mishra's (2006) model of wealth and reduced form equation will be loosely followed in this study. Only the variable inputs of interest, insurance and fertilizer and chemicals will be modeled. County level data will be used, so meaningful wealth data were not available. Acreage itself represents an important component of wealth in the agricultural sector. The producer's welfare problem will be characterized as maximizing expected utility of wealth.

(1.1) $V_t = \sum_0^T U\{P_{it}Q_{it}(A_{it}(A_{it-1}, pasture_{t-1}), w_{it}, I_{it}(I\_prate_{it-1}, lvstk_t,)\ e_t) - w_{it}(Oil_t)\}$

where P_{it} is price of crop i at time t, Q_{it} $(\cdot)$ is output, which is assumed to be a function of planted acreage, A_{it}, fertilizer and chemical expenses, w_{it}, insurance participation, I_{it}, and an exogenous shock, e_t, w_{it} is fertilizer and chemical expenses which are influenced by oil prices, Oil_t. A_{it} is influenced by lagged acres planted, A_{it-1}, and pasture land, $pasture_{t-1}$. I_{it} is influenced by net farmer paid premium percentage rate, I_prate_{it-1}, and livestock sales, $lvstk_t$.

County level chemical and fertilizer input expenses will be modeled instead of application quantity. The price of fertilizer and chemical inputs are positively correlated with their effectiveness and concentration. This causes total expenditures to be a better aggregate indicator of pesticide use than a measure of application (Horowitz and Lichtenberg, 1993). Chemical and fertilizer data are not available by crop. Most producers only know their total annual expenditure and do not keep records of how much of their total expenditures are attributed to each crop they grew. For this reason it is not possible to separate these input expenses by crop even if individual farm data is accessible. Use of aggregated data is common in past studies. This is acceptable due to the homogeneity of the crops grown in the regions of this study. One consideration to address this issue is to use percentage of crops grown in a county and weight each county accordingly. An increase in corn prices will incentivize producers to have a continuous corn crop, increase fertilizer application to achieve greater yields and will increase insurance liabilities. As a result, assigning a crop mix weight to each county will not be a statistically sound. Expenses are not converted to per acre. Instead, planted acreage of crop i at time t in county z, A_{itz}, is used as an explanatory variable.

The main parameter of interest is insurance participation, I_{itz}. This may reveal possible moral hazard behavior if there is a significant relationship with fertilizer and chemical expenses. The ratio of insured acres to planted acres is commonly used as a measure of insurance participation. This methodology does not account for the fact that a producer may change their level of coverage by changing level of price or yield coverage. For example, consider an area with two producers where one insures their 100 acre field at 60% coverage and the other does not purchase insurance on their 100 acre field. The ratio of insured acres to planted acres is calculated to be 50%. Now suppose the insured producer selects 75% coverage. Insurance participation would continue to be calculated at 50%. A more accurate level of insurance participation used by Goodwin, Vandeveer, and Deal (2004) calculates the ratio of actual insurance liability in a county to the total possible insurance liability of that county, $I_{itz} = ALib_{itz}/PossLib_{itz}$. Total possible liability considers all of crop i that could have been insured in that county based on 85% of plantings, expected harvest prices, and historical county yields. Percentage of plantings, 85%, was based the maximum insurance available for purchase during the time period of this study.

Iowa State University Extension finds producers can often increase profits by increasing nitrogen applications in response to higher crop prices. The additional fertilizer will increase yields allowing the producer to earn greater revenue, and potentially greater profit (Sawyer 2015). Producer fertilizer decisions must be made before actual harvest prices, P_{it}, are known. Therefore, a producer's decisions are influenced by expected harvest price, EP_{it}. If a high price is expected, then producers should be incentivized to apply additional fertilizer. Fuel is a major input in the production of fertilizer and thus oil prices, Oil_t, should be an explanatory variable of chemical and fertilizer expenditures.

(1.2) $lnw_{tz} = \beta_1 lnA_{itz} + \beta_2 lnI_{itz} + \beta_3 lnEP_{it} + \beta_4 lnOil_t + \varepsilon_{itz}$

where: w_{tz} is fertilizer and chemical inputs at time t in county z, A_{itz} is planted acreage of crop i at time t in county z, I_{itz} is insurance participation of crop i at time t in county z, EP_{it} is expected price of crop i at time t, Oil_t is price of oil at time t, ε_{itz} is the error term.

Smith and Goodwin (1996) indicate instrumenting for land use and insurance will be necessary in this model. They point to the fact that many producers have already applied a large portion of their chemicals and fertilizer before they purchase insurance. This is due to producers waiting until the deadline to purchase insurance so that they will have maximum information. This joint determination may cause a simultaneity problem when ordinary least squares (OLS) models are implemented (Smith and Goodwin, 1996). The common OLS regression of $y = \beta x + \varepsilon$ assumes regressors are uncorrelated with the errors, $E[x'\epsilon] = 0$. If the error term is correlated with an explanatory variable, then the variable would not be exogenous and the estimator would be biased and inconsistent. Hansen and Singleton (1982) show instruments can be used to construct a function that insures parameters estimates are consistent. Instruments must be uncorrelated with the error term and be explanatory of the endogenous variable of concern. A Hausman test is used for each commodity to examine if insurance participation and planted acres are exogenous. Table 1.3 reports the chi-square statistics for each commodity reject the hypothesis of exogeneity. Results confirm the a priori expectation that both acres planted and insurance participation are simultaneously determined with fertilizer and chemical expenditures. General Method of Moments (GMM) with instrumentation will be used for estimations.

As stated by Wooldridge (2001), the validity of the instruments must be tested in the sense they are uncorrelated with the error term. To test for orthogonality conditions, a theorem from Hansen (1982) commonly known as the Hansen J test will be used, $J = J(\hat{\delta}(\hat{s})^{-1}, \hat{s}^{-1})$. Under conditions of regularity and if moment conditions are valid, then as n→∞, $J \overset{d}{\rightarrow} x^2(K-L)$ (Hayashi, 2000). With the J behaving like a chi-square random variable, I will test the null hypothesis that $E[x'\epsilon] = 0$. If the model is mis-specified or some of the moment conditions do not hold, then J will be large. If the hypothesis is failed to be rejected, p>0.05, then instruments are considered to satisfy orthogonality conditions.

Coble, Knight, Pope, and Williams (1993) found the demand for crop insurance has negative price elasticity and suggested that producers are responsive to subsidy and premium changes. The premium rate after subsidies is a factor that influences insurance participation. However, the farmer paid premium rate would cause endogeneity problems if used to model insurance participation. One component that determines premium rate is coverage level. Higher coverage levels will increase the premium rate in a similar manner as lower deductibles on automobile insurance. Simultaneously, higher coverage levels increase insurance participation rates as discussed prior. Therefore, paid premium rate will have a positive correlation with insurance participation. Within the available data set, an alternative parameter is the net farmer paid premium rate lagged one year. This rate is predetermined when selecting the current year's level of insurance participation. Insurance participation of crop i in year t in county z will be instrumented with lagged net farmer paid premium percentage rate, $I\_prate_{it-1z} = (premium_{it-1z} - subsidy_{it-1z})/libility_{it-1z}$. Insurance rates and subsidies are explanatory variables of insurance. They are exogenous to land use allocation or fertilizer application decisions. Therefore, they meet the requirements discussed by Wooldridge (2001).

Jones and Larson (1965) found insured farmers were less diversified. Livestock sales may provide diversification, and thus lower the relative financial impact of crop failure on a farm. Modeling of corn, soybeans and wheat insurance participation finds the percentage of cash receipts from livestock sales to be significant making it a reasonable explanatory of the endogenous variable of concern, insurance participation. This study will use percentage of farm cash receipts from livestock as an instrument of insurance participation. A greater percentage of livestock should decrease insurance participation following Wu (1999) and Hennessy (1998). It is important to note that if expected returns from insurance are positive, then risk aversion is not required as a precondition for insurance purchase. However, insurance will provide less utility to those who are less risk averse, and therefore risk aversion may influence decisions. Table 1.4 shows statistically significant first stage results for both instruments of insurance participation.

Pasture land defined by the USDA as land convertible to crop land with little improvement is used to represent any expansion of operations due to insurance. This land could be used by the producer to increase the acres of a crop planted without decreasing planting of another crop. The lag of county level pasture land is found to be statistically significant in the first stage results shown in Table 1.5. Additionally, pasture and is found significant in modeling acres planted in Chapter 2 making it a reasonable explanatory of the endogenous variable of concern, acres planted. The lag of county level pasture land will be used as an instrument for acres of a commodity that is planted.

1.5 Data

The commodities of interest are corn and soybean production in Illinois, Indiana, and Iowa. Also of interest is wheat production in Montana, North Dakota, and South Dakota. Corn, soybeans, and wheat were selected for this study because of their importance and prominence in U.S. agriculture. These grains are used as inputs for many food products and are used as feed for a large portion of U.S. livestock. Together they make up over 70% of all crop insurance liability in the period of this study. Corn is 40% of all crop insurance liability while soybeans are second at 23%, and wheat makes up the third largest component of liability at 8% (RMA).

The states were selected as they represent a large portion of production of the respective crops. Figures 1.1, 1.2, and 1.3 show the harvested acres in the United States.

Illinois, Indiana, and Iowa are the top three soybean states the U.S. Illinois and Iowa are the top two corn producing states while Indiana is the fourth largest producer. These states are part of the region known as the Corn Belt. This region in the Midwestern United States has a favorable combination of soil and climate for large scale crop production. Many economic studies, including those referenced in this study, investigate this region. By using data from Illinois, Indiana, and Iowa, results of this study can be more easily compared to findings from other studies. North Dakota produces the most wheat in the United States. Montana is the third largest producer and South Dakota the fourth. By focusing on corn and soybean production in Illinois, Indiana, and Iowa and wheat production in Montana, North Dakota, and South Dakota, this study will be concentrating on the largest production areas of the crops that make up largest liabilities in crop insurance.

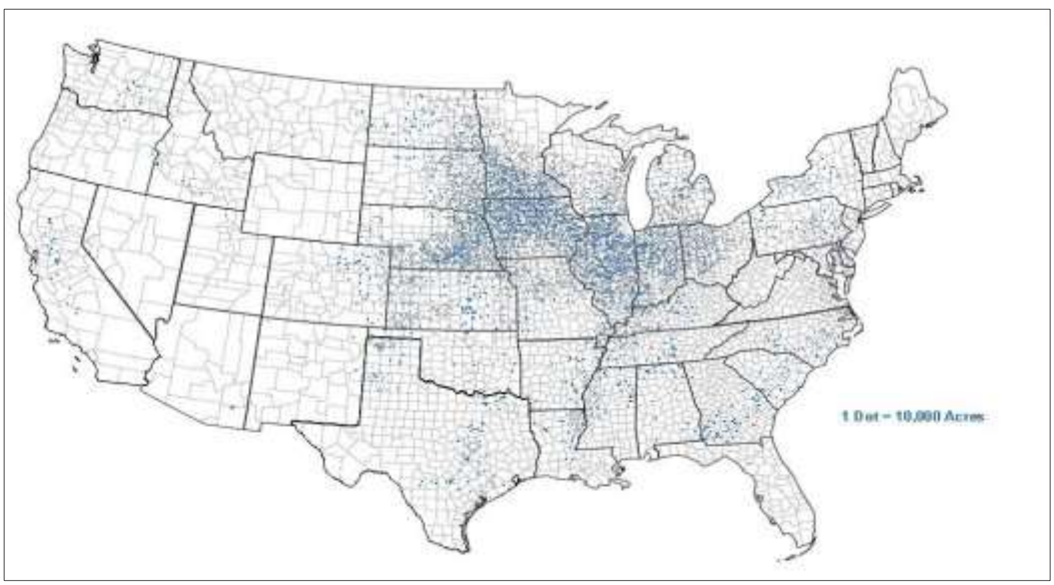

Figure 1.1: Corn harvested acres. Source: USDA, NASS. Census of Agriculture

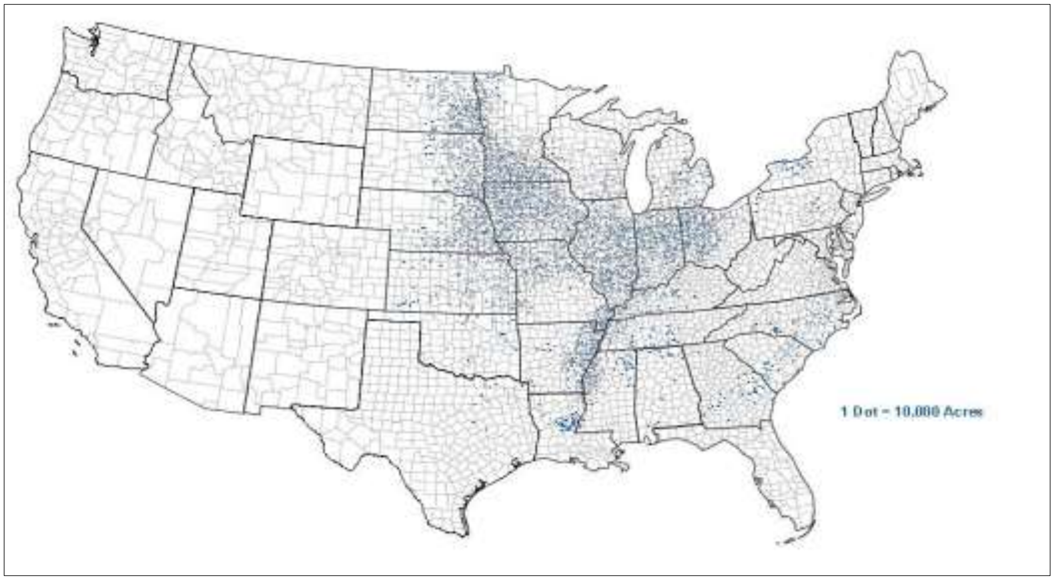

Figure 1.2: Soybeans harvested acres. Source: USDA, NASS. Census of Agriculture

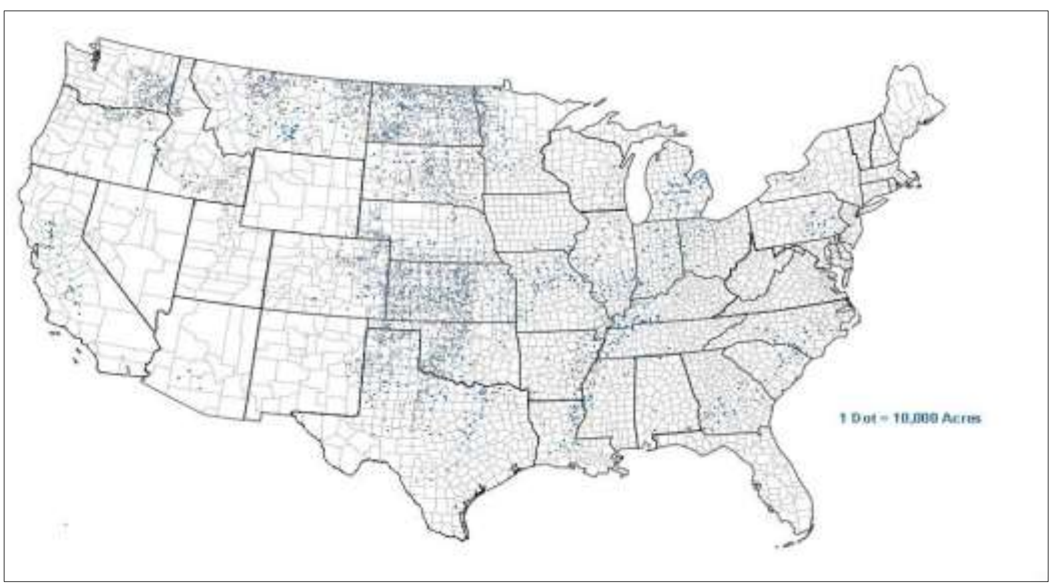

Figure 1.3: Wheat harvested acres. Source: USDA, NASS. Census of Agriculture

As discussed in section 1.2, in 2000 legislation expanded the role of the private sector within the Risk Management Agency. This caused programs before 2000 to be very different. Model estimations for this study will be calculated using data between years 2000 and 2014.

County level data were available from the National Agricultural Statistical Service (NASS) of the USDA. NASS conducts many surveys every year and prepares reports covering nearly all components of U.S. agriculture. They conduct the Census of Agriculture every five years which is the most complete and consistent set of information for every county in the US. Unfortunately, the completeness and consistency is offset by only two samples every ten years.

NASS conducts a County Estimates Survey (CES) of agriculture annually. They target all farms and ranches not already in another NASS survey that year. Most states mail the survey and some use follow-up phone calls to increase participation. Survey participation is not 100%. NASS used different sampling techniques for surveys prior to 2002 to sample farms. There was little nonresponse follow-up. The sampling procedure "precluded the use of standard small area estimation techniques based on known selection probabilities" (Bellow, 2007, p. 2). Additionally, "since 2002, multivariate probability proportional to size sampling has been used to select farms" (Bellow. 2007, p. 2). These data are merged with data from the other NASS surveys to form a combined data set. These data are then used to calculate county level estimates. These estimates must be consistent with state estimates which are conducted under more rigid controls. It is important to recognize the data used in this study are estimated from a sample of a population and contain some sampling errors.

Modeling using only data of census years was considered. This would limit the data set to the years of 2002, 2007, 2012. With only three observations results from a difference model may not be very meaningful.

Most producers have an accurate accounting of their expenses on chemicals and fertilizer. However, they do not separate these expenses by crop. A county level aggregate of expenses over all crops is the best data available for this study. The NASS Agricultural Chemical Use Program collects statistics about chemical and pesticide use on farms. Surveys are conducted on a rotating basis for a few crops each year. These data are too incomplete for this study. Aggregated chemical and fertilizer expenses were available annually at the county level from the Bureau of Economic Analysis (BEA). BEA released the data using the Regional Economics Information System (REIS).

Futures contracts traded on commodity exchanges allow producers and consumers of agricultural products to enter into contracts promising trade of commodities on a certain date at a certain location for a set price. A producer that uses the commodity market to hedge typically sells contracts promising delivery at a location such as Chicago after the harvest date. Near the time of harvest, the producer then buys an offsetting contract so that no commodity is actually delivered. Not accounting for basis and transactions fees, the producer should theoretically gain $1 on the future contract transaction for every dollar lost in value of their crop and vice versa. There are many complexities and opportunities for loss and gain, but the general principle is the producer can have a predictable income.

The market price for a futures contract is considered by many to be the market's best guess of harvest price with the available information. If it is not, then speculators buy or sell contracts to earn gains from the price movements, and the market forces drive the price to this best guess. Producers who do not hedge can use information from the market to predict harvest prices before they plant. The RMA uses the price of futures contracts during the "discovery period" to set established prices for insurance policies. Expected prices for this study were valued using the futures contract price.

Most corn crops in Illinois, Indiana, and Iowa are typically harvested in the months of October and November. The December futures contracts are used to value the expected post-harvest price of corn. Soybean crops in Illinois, Indiana, and Iowa are typically harvested in the earlier part of October. The November futures contracts are used to value the expected price of soybeans. In all the regions of this study, wheat is typically harvested during August. September contacts are used to determine the expected price of wheat. Corn and soybean prices were collected from the Chicago Mercantile Exchange group (CME group). CME group was formed in 2007 when the CBOT merged with the Chicago Mercantile Exchange (CME). Wheat prices were collected from the Minneapolis Grain Exchange.

Crop insurance data are available at the crop/county level from the USDA's Risk Management Agency (RMA). Premium, subsidy, and indemnity payment were provided along with the amount of liability for the policy. Summary statistics for all data is displayed in Table 1.6.

1.6 Estimation Results

General Method of Moments (GMM) estimation is preformed using SAS software's model procedure. Parameters estimated for the model of fertilizer and chemical expenses to produce corn in the Illinois, Indiana, and Iowa region are displayed by Table 1.7. Crop insurance participation is found to be statistically insignificant. This result meets a priori expectations and supports the null hypothesis that producers are not reducing inputs in response to insurance participation. Insurance elasticity estimates indicate insurance participation has a statistically insignificant influence on chemical and fertilizer expenses. Iowa State University Extension has found corn to have a large negative yield response to fertilizer application below a certain rate and a small positive yield response to fertilizer application above that rate. Although the particular rate is different depending on the crop rotation cycle, the large loss and small gain relationship remains the same (Sawyer, 2015). Economically this means a producer's output would decrease greatly from a small reduction in inputs. An intentional reduction that reduces costs by a small amount and thereby reduces revenue by a large amount is not rational behavior without insurance coverage near 100%.

Elasticity of planted acres to fertilizer and chemical expenditure indicate a 1% increase in planting will be associated with a 0.7% increase in fertilizer and chemical input use. An elasticity of one would indicate constant returns to scale for fertilizer and chemical use. Conventional wisdom is that perfectly competitive firms like a farm experience constant returns to scale. A report by Foreman (2001) supports the idea of possible economies of scale. She believes some producers are paying lower prices since they found no significant difference in fertilizer use but did find differences in expenditures between low cost and high cost producers (Foreman, 2001). It could be argued that the difference between constant returns and this result is from the buying power stated by Foreman. However, this is not very plausible because county level data are an aggregation of small and large farms.

Increasing marginal productivity through increased fertilizer and chemical use in response to high corn prices can be profitable. According to Iowa State University Extension, the marginal return from additional fertilizer use on corn or soybeans decreases at a decreasing rate. Therefore, significant positive price elasticity less than one matches a priori expectations. The price of oil is found to have a significant impact on expenses. This supports the a priori expectation that the price of fertilizer and chemicals respond to the price of oil. This result will be used elsewhere to support the price of oil as a valid instrument of fertilizer and chemical expense.

Overall the model has parameter estimates that are economically plausible, statistically significant, and supportive of the null hypothesis that subsidized crop insurance does not have a significant impact on fertilizer and chemical input decisions of corn producers. As discussed previously, it is necessary to determine the validity of the instruments. The results of the Hansen J test presented in Table 1.7 show orthogonality conditions are not met indicating invalid instruments. This will be discussed further after soybean and wheat results are presented.

Estimates of the soybean model are displayed in Table 1.8. Elasticity estimates show insurance participation has an insignificant association with chemical and fertilizer expenses. This again supports rejection of the null hypothesis that producers are not participating in moral hazard behavior involving reduced inputs in response to insurance participation. The coefficient for planted acres of soybeans, 0.7, is similar to the parameter found with corn. Expected price coefficient is positive as expected. Similar to corn, the model's parameters are economically plausible and instruments are found to not meet orthogonality conditions.

The results of wheat modeling are presented in Table 1.9. The main variable of interest, insurance participation, is negative and statistically significant. A 1% increase in insurance is associated with a 0.6% decrease in fertilizer and chemical expenditure. This rejects the null hypothesis that subsidized crop insurance does not impact chemical and fertilizer expenditures. An elasticity of 0.6% implies a producer moving from uninsured to 75% level of coverage would decrease fertilizer and chemical application by 45%. This is extremely large compared to the 1.5%-4.5% finding of Babcock and Hennessy (1996); the $4.23 reduction found by Smith and Goodwin (1993). These results are large even when comparing to results by Seo Mitchell and Leatham (2005) who estimated a 31% negative response in Texas sorghum. Overall the magnitude is not economically plausible. Parameters for planted acres, expected prices and oil prices are all significant with economically plausible sign and magnitude. The Hansen J over ID test indicates this model does not have an endogeneity problem.

Finding different results across two crops using identical economic methods is similar to Seo and Leatham's (1996) approach. Findings align with Smith and Goodwin (1996) whom were unable to reject the negative relationship between chemical inputs and insurance on Kansas dryland wheat farms. Different results from wheat models using the same modeling as with soybeans and corn indicate that the impact of insurance on input usage could be crop dependent. Walters, Shumway, Chouinard, and Wandschneider (2012) point to different agronomic conditions to explain why risks associated with crop insurance are unlikely to be symmetric across crops. As stated previously Iowa State University Extension has found corn and soybeans to have nonlinear responses to fertilizer application rates. Wheat fertilizer recommendations from Montana State University have a linear relationship with yield goals. They recommend a linear relationship of 3.3lbs/bu of expected wheat yield (Jacobsen, Jackson and Jones, 2005). This linear relationship could explain why the model estimated for wheat is different. A risk averse producer may not be willing to gamble the expense of additional fertilizer for additional gains in wheat productivity. Simultaneously, they may not be willing to gamble the loss of corn productivity for reduction in input expenses. Therefore, a risk averse producer's choice to participate in insurance, spend less on fertilizing wheat, and have average expenditures on corn and soybeans is possibly driven by agronomic differences not moral hazard.

The previous results for corn, soybeans, and wheat were found by implementing a pooled regression to estimate a model of the time series cross sectional data. Homoscedasticity and no serial correlation assumptions are necessary for consistent unbiased results from a pooled regression. The pooled model used previously may have unobserved cross section heterogeneity. Serial correlation in the errors of a panel data model may come from the error in each time period containing a time-constant omitted factor (Wooldridge, 2001). When data contain "different time periods for the same individual, the unobserved effect is often interpreted as capturing features of an individual, such as cognitive ability, motivation, or early family upbringing, that are given and do not change over time." (Wooldridge, 2001, p.248).

The balanced panel data for this study contains the same counties over the same time period. The unobserved effect may be capturing differences between the counties such as climate, soil, and management practices which are time invariant. By assuming the omitted variable is time constant, differencing can be used to remove any unobserved effect (Wooldridge, 2001). One approach to address unobserved time-constant omitted variables is the use of fixed effects. However, a key assumption to the efficiency of fixed effects is homoscedasticity and no of serial correlation in the error term (Wooldridge, 2001). "This assumption may be too strong. An alternative assumption is that first differences of the idiosyncratic errors are serially uncorrelated." (Wooldridge, 2001, p.281). The differencing approach to estimation with two stage GMM estimator using SAS will be used for further modeling of crop insurance participation.

Equation 1.3 shows the county level change in fertilizer expenditure between the prior year and the current year will be modeled as a function of the change in insurance participation, change in acres planted, change in futures price of the commodity between the prior year and the current year, and change in price of crude oil. As with the pooled model, the first difference model is instrumented.

(1.3) $\Delta lnw_{tz} = \beta_1 \Delta lnA_{itz} + \beta_2 \Delta lnI_{itz} + \beta_3 \Delta lnEP_{it} + \beta_4 \Delta lnoil_t + \varepsilon_{itz}$

Parameter coefficients from a first difference estimation using logged data show elasticity of growth rates; how much a 1% change in the parameter's growth rate causes the growth rate of the dependent variable to change. Negative coefficients can be associated with a decreasing positive growth rate and do not necessarily indicate a negative growth rate. A negative coefficient can be an indication of a mean reverting scenario where a coefficient is returning to its stable growth rate. For example, if inflation is at 7% heading to a mean rate of 3%, then the coefficient of the change in growth rate would be negative despite the positive growth rate.

Table 1.10 displays results of the corn, soybean, and wheat model estimations for their respective regions. Parameters estimates for corn and soybeans show a statistically significant positive elasticity of growth rate. Unlike the pooled models, the Hansen J score indicates no endogeneity concerns. An increase in the growth rate of insurance by 1% causes a small 0.2% increase in the growth rate of fertilizer and chemical expenses. An increase in fertilizer expense associated with an increase in insurance does not meet a priori economic expectations. The magnitude this small could indicate risk averse response to agronomical conditions. It is plausible that a risk averse producer attempts to avoid the great decrease in yield from slightly under fertilizing corn and soybeans while simultaneously chooses to purchase insurance.

A change in the growth rate of acres of corn planted by 1% is related to a 3.9% increase in the growth rate of fertilizer. This large positive estimate coincides with the large negative soybean model estimates,-3.3%. Iowa Extension states planting soybeans before corn reduces the amount of required nitrogen, and root worm control is not generally needed. This explains the large positive growth rate elasticity of acres planted of corn, and the large negative elasticity of growth rate of acres planted of soybeans. A producer foregoing crop rotation would increase in the growth rate of acres planted of corn and require an increase in expenses on chemicals and fertilizer. A county wide change in crop rotation is a reasonable response to a national change in crop prices.

Results from the first difference wheat estimation are consistent with the pooled regression model and indicate possible moral hazard. An increase in the insurance participation growth rate by 1% is found to cause a 0.5% decrease in the growth rate of chemical and fertilizer expenses. This is consistent with the pooled regression model. However, the magnitude is now economically plausible and is consistent with Kansas dryland wheat finding of Smith and Goodwin (1996). Results do not necessarily indicate moral hazard. As stated in the pooled regression results, a risk adverse wheat producer may lower their financial exposure by decreasing inputs costs, and simultaneously purchase insurance for further financial protection.

Price of wheat has a strong positive relationship with fertilizer, with a coefficient value of 1.2. The linear relationship of fertilizer to yield supports a large parameter estimate while corn and soybeans have a small positive result. Overall findings are supportive of producers having different responses for crops based on agronomical differences.

1.7 Conclusion

This study has shown that opportunity and motive for moral hazard behavior exists in production of corn, soybeans, and wheat when producers participate in the subsidized crop insurance program. When fertilizer and chemical expense is modeled, estimations of corn and soybean models do not reject the null hypothesis that subsidized crop insurance does not impact chemical and fertilizer expenditures. Models of wheat reject the null and indicate possible moral hazard. The model however does not support a large significant change in expenses due to insurance participation. This accords with the findings Weber, Key, and O'Donoghue (2015), Peckman and Kropp (2012), Smith and Goodwin's (1996), and Quiggin, Karagiannis, and Stanton (1993).

A possible reason for the different findings between crops is the agronomical impact of marginal applications of fertilizer along with characteristics of risk averse producers. Corn and soybeans realizes a large reduction in yield from a small decrease in fertilizer. This motivates producers of corn and soybeans to not reduce fertilizer and chemical inputs whereas risk averse producers are motivated to use slightly more. Fertilizer recommendations for wheat are linear relative to yields (Jacobsen, Jackson and Jones, 2005). A risk averse producer is motivated to use less inputs. A producer who is more risk averse than the average producer and does not engage in moral hazard behavior could slightly increase fertilizer use on corn and beans, use less fertilizer on wheat, and also participate in crop insurance. Fertilizer expenditures and insurance participation decisions are possibly independent responses to risk aversion.

Findings from this study are not supportive of large economic changes in fertilizer and chemical expense from participation in subsidized crop insurance by corn and soybean growers. Suppose automobile insurance were to be subsidized 100% but carried a $2,000 deducible. Most people would participate in the free insurance, but would still avoid damaging their vehicle so as to avoid the $2,000 loss because their cost to avoid damage is very low. Subsidization of crop insurance makes it actuarially advantageous to the producer to participate. Similar to the auto insurance scenario, the deductible of percentage of crop yield still exists. Producers will continue to use fertilizer and chemicals to avoid the large loss.

Large deductibles could explain the lack of large moral hazard behavior. The 2014 Farm Bill introduced subsidization of the supplemental coverage option which incentivizes a producer to purchase area coverage at the 86% level. If future legislation subsidizes individual farm policies at higher levels which are not area plans, then changes in the behavior of producers who select the higher coverage should be examined. At 100% coverage level on plans that are not at the area level, there would be no incentives to apply fertilizer or chemicals, except to fulfill requirements of the contract. Determination of the coverage level at which the producer is only just incentivized by the contract requirements would provide valuable information to policy makers considering changes. This would place an upward limit on coverage levels that do not motivate moral hazard.

Environmental impacts from agricultural run-off have become a more prevalent concern over time. Legislation often has unintended consequences despite good intentions. Subsidization of crop insurance is intended to provide an incentive for a producer to purchase protection from financial ruin. A theory by Carlson (1979) indicates that subsidizing insurance would have the unintended consequence of reducing other forms of crop insurance like fertilizer, pesticides and herbicides. A study by Horowitz and Lichtenberg (1993) found possible unintended negative consequences from crop insurance. This study has shown positive environmental consequences are possible from wheat crop insurance. Additional study several years after the implementation of 2014 Farm Bill would be valuable.

When reacting to the findings of this study, it is important to note the relative size of the liability for each crop. Corn and soybeans, which account for 63% of insurance liabilities, were not found to reduce fertilizer and chemical use. The reduction occurred in wheat production, which makes up 8% of all the crop insurance liabilities. The overwhelming majority of insurance was determined to not have had a significant change in behavior.

1.8 Tables

Table 1.3: Hausman test for endogeneity.

	DF	Hausman X^2 Stat	P-Value
Corn Fert/Area Planted	7	227	<.0001
Soybeans Fert/Area Planted	7	294	<.0001
Wheat Fert/Area Planted	7	169	<.0001
Corn Fert/Insurance	7	145	<.0001
Soybeans Fert/Insurance	7	463	<.0001
Wheat Fert/Insurance	7	768	<.0001

Table 1.4: First stage estimation of insurance instruments.

	Corn		Soybeans		Wheat	
Variable	Estimate	Pr>T	Estimate	Pr>T	Estimate	Pr>T
Premium rate	0.568	<.0001	0.33	<.0001	0.29	<.0001
% of livestock	-0.171	0.071	0.19	0.005	0.539	<.0001
Oil	0.46	<.0001	-0.012	0.739	0.14	0.008
Price	-0.407	<.0001	0.277	<.0001	0.01	0.901

Table 1.5: First stage estimation of area planted instrument.

	Corn		Soybeans		Wheat	
Variable	Estimate	Pr>T	Estimate	Pr>T	Estimate	Pr>T
Pasture t-1	0.629	<.0001	0.713	<.0001	0.554	<.0001
Oil	1.89	<.0001	1.726	<.0001	1.26	<.0001
Price	-1.21	<.0001	-0.898	<.0001	-0.032	0.824

Table 1.6: Summary statistics for chemical and fertilizer use variables.

Variable description	Corn (N=3,689) Mean (Std Dev)	Soybeans (N=3,699) Mean (Std Dev)
County level total fertilizer and chemical expenses (w_{it})	$18,013 ($14,126)	$17,997 ($14,116)
County level planted acres (A_{it})	108,333 (66,079)	86,834 (46,021)
Insurance Participation as a function of actual and possible participation (I_{it})	79% (17%)	72% (17%)
Commodity futures price in February at CBOT and CME (EP_{it})	$3.83 ($1.38)	$8.48 ($3.30)
Oil futures price in February at CBOT (Oil_t)	$60 ($27)	$60 ($27)
Pasture land convertible to crop land with little improvement	4,848 (6,225)	4,837 (6,219)
Livestock Sales	31% (19%)	31% (19%)

Table 1.7: Fertilizer and chemical expenses modeled using corn data.

Variable	Estimate	Standard Error	T- Value	Pr>
Insurance Participation	0.012	0.039	0.31	0.758
Planted acres	0.716	0.009	79.53	<.0001
Expected Price	0.468	0.036	12.86	<.0001
Oil	0.23	0.028	8.11	<.0001
Hansen’s J over-ID stat	57.84		Prob <.0001	

Table 1.8: Fertilizer and chemical expenses modeled using soybean data.

Variable	Estimate	Standard Error	T- Value	Pr>T
Insurance Participation	-0.111	0.072	-1.53	0.126
Planted acres	0.682	0.009	74.83	<.0001
Expected Price	0.922	0.046	20.08	<.0001
Oil	0.006	0.027	0.21	0.837
Hansen's J over-ID stat	32.66		Prob <.0001	

Table 1.9: Fertilizer and chemical expenses modeled using wheat data.

Variable	Estimate	Standard Error	T- Value	Pr>T
Insurance Participation	-0.592	0.118	-5.00	<.0001
Planted acres	0.7322	0.022	33.2	<.0001
Expected Price	0.392	0.107	3.66	0.0003
Oil	0.203	0.081	2.50	0.023
Hansen's J score	0.82		Prob =0.663	

Table 1.10: First difference estimation of fertilizer and chemical expenses.

	Corn		Soybeans		Wheat	
Variable	Estimate	Pr>T	Estimate	Pr>T	Estimate	Pr>T
Insurance	0.181	<.0001	0.23	<.0001	-0.536	0.061
Planted acres	3.92	<.0001	-3.329	<.0001	-1.27	0.022
Expected Price	0.256	<.0001	0.387	<.0001	1.15	0.004
Oil	0.137	<.0001	0.098	<.0001	-0.563	0.067
Hansen-J score	1.17	0.279	1.4	0.236	6.19	0.012

Chapter 2. Impact of Crop Insurance on Land Use

2.1 Introduction

Government intervention in markets often creates unintended consequences. These could be positive externalities such as parents with baby strollers benefiting from curb cuts mandated for wheelchair access. They could also be negative externalities such as noise pollution from an audio crosswalk for the visually impaired. Externalities from legislation that provides agricultural support, such as Farm Bills, need to be evaluated. Subsidies have been provided to producers who participate in crop insurance. This could have provided incentives for producers to alter their planting decisions in a way that would be environmentally harmful. This study examines the extent to which subsidized insurance participation has influenced producers' acreage decisions for corn, soybean and wheat production.

Asymmetric information allows for adverse selection and moral hazard in insurance. Adverse selection occurs when the firms or individuals with greater risk than is known to the insurance company select insurance in greater numbers than those who do not. Moral hazard can occur from increased use of marginal land that is unprofitable and by shifting toward riskier crops. If a piece of land or crop cannot consistently produce profitable yields and an insurance policy exists that is actuarially advantageous for a producer in lieu of insurance then the producer may choose to produce on more marginal acreage after purchasing insurance. This study hypothesizes that subsidized crop insurance influences planting decisions by producers

Subsidization allows crop insurance policies to be purchased below actuarially fair rates. Until 2013 large subsidies were only available up to the 75% level, so few policies were written above this level of coverage. By insuring only 50%-75% of a crop, moral hazard is less attractive. If this behavior has been occurring, then it could be magnified by subsidization of higher coverage levels. This could result in large financial losses to insurance companies. Either the U.S. taxpayers would offset the unexpected insurance losses or the insurance companies would be driven out of the market. If no insurance is offered in a market that would have otherwise had participants at actuarially fair rates, then overall societal welfare maybe reduced.

A policy that would incentivize production on marginal farm lands could have a negative impact on the environment. Marginal farm lands often serve as buffers for chemical run-off and reduce sediment in waterways. Often these areas have vegetation that prevents erosion and provides a biodiversity refuge next to land that has been treated with herbicide and pesticides. The loss of these marginal lands could offset the positive environmental impact from fertilizer and chemical reduction discussed in Chapter 1. Determining the validity of these proposed unintended consequences of subsidization is important for future policy discussions.

Government policies can distort markets by distorting incentives to produce goods. Agricultural price supports can encourage producers to grow crops that have a market price lower than production costs. The result is inefficient allocation of resources which decreases total welfare. In addition, for a government's policy to be considered "green-box[1]", the World Trade Organization (WTO) requires the intervention to cause no or minimal distortion. Programs that target particular products or include direct income supports are considered "coupled" and are restricted by WTO agreements. Policy makers would be interested in knowing if the insurance subsidies to corn, soybeans, and wheat were causing significant changes in production in a way that may influence the world supply of these goods.

This study is organized in the following manner. Section 2 provides a brief overview of insurance. Section 3 reviews past literature that discusses insurance and governmental programs that impact marginal land use. The model is described in section 4 followed by a discussion of the data in section 5. Section 6 presents the empirical results. Influence of unit size subsidies are considered in section 7. The conclusion is discussed in Section 8. Section 9 contains tables.

[1] WTO classifies subsidies into 3 main categories or "boxes." Green-box subsidies are permitted. Amber-box subsidies should be reduced. Red box subsidies are forbidden. Agriculture has no red-box, although not adhering to commitments of amber-box subsidies is not permitted.

2.2 Insurance Overview

Insurance is an economically interesting product built around a risk averse individual's decreasing marginal utility relative to a linear probability. Often consumers of insurance are discussed as maximizing a Neumann-Morgenstern (1944) utility function under conditions of uncertainty. A person who is risk averse will refuse a fair game of chance because they experience a greater drop in utility from a loss than they receive from a gain of equal value. That is, their expected utility from the fair gamble is less than their utility from the guaranteed outcome. Figure 2.1 represents a risk averse individual receiving a greater utility from a guaranteed $5 than from a 50% chance at $10 due to the bow in the utility curve. The more risk averse an individual is the greater bow in the utility curve.

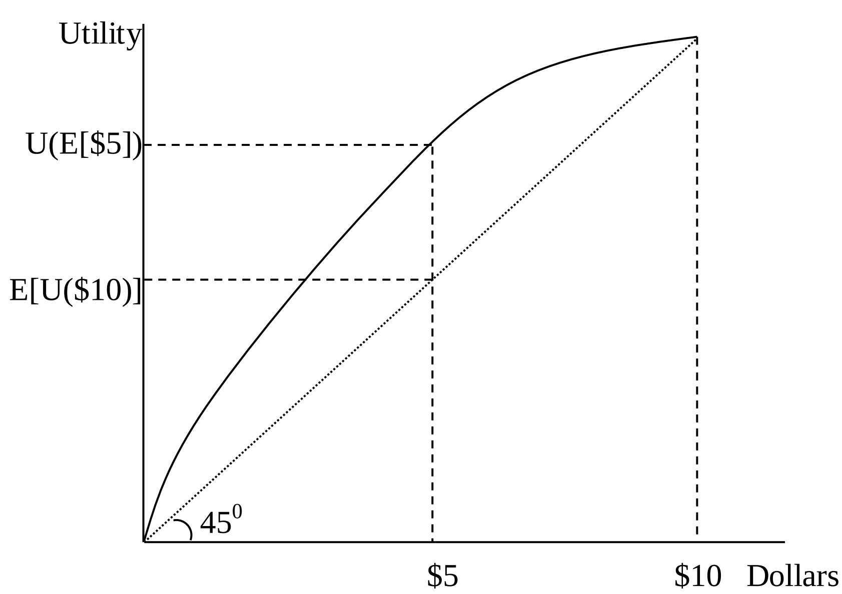

Figure 2.1: Utility from insuring.

Consider the case of a risk averse farmer facing a probability, π, of loss, L, to wealth, W, and the opportunity to insure against the loss at a premium, α. In a perfectly competitive market with zero transaction costs the total premium is the product of the probability of loss and the potential loss; $\alpha = \pi L$. The per unit cost, q, must equal the probability, π. The farmer will choose to maximize utility $[(1-\pi)U(W-qz) + \pi U(W-L+z-qz)]$ where z is the units of insurance purchased. First order conditions imply $U'(W-qz) = U'(W-l+z-qz)$. The optimal level of insurance is when $z = l$. In the face of actuarially fair premiums, risk adverse individuals will completely insure because their marginal utility is decreasing. (Goodwin and Smith, 1995)

Now suppose some individuals have a low risk, π_l, and others have a high risk, π_h. If the insurance company cannot determine the difference between the potential customers due to asymmetric information, then the insurance premium would be determined using their average risk, $q = \frac{(\pi_l + \pi_h)}{2}$. The low risk individuals would face a per unit rate greater than their individual probability of loss while high risk individuals would have the opportunity to purchase insurance at a rate lower than their probability of loss. Both parties maximizing their individual utility could result in only the high risk farmers purchasing insurance. In this scenario, an insurance company would most likely sell a policy only when there is a high likelihood of the policy needing to be paid out. Insurance companies would pay out indemnities greater than premiums on average because the premiums were based on the average risk of all potential customers. These losses would require insurance companies to increase premiums to an average of the high risk group, $q = \pi_h$. The high risk group would separate into high risk and very high risk. The process, known as a “death spiral”, would repeat until the insurance industry collapses.

To overcome the death spiral, insurance companies can look for characteristics of adverse selection such as a high number of claims for an individual choose not to insure those individuals. As stated in section 1.2, crop insurance companies in the U.S. are not permitted to do this. Insurance companies must offer everybody insurance to all plots on all farms in a state where they do any business. To prevent crop insurance collapse, farms with lower than average expected risk need to be enticed to join the insurance pool. If all farms joined, no adverse selection would occur. The U.S. government does this through insurance subsidization. A similar argument was used in favor of the 2010 Affordable Healthcare Act. Supporters claimed that only sick people were purchasing insurance and by encouraging healthy people to join the average cost would decrease. The Affordable Healthcare Act enticed people to purchase insurance by offering subsidies to some citizens and placing a financial penalty on those who were not insured.

Crop insurance is heavily subsidized at the 50%-70% coverage level as shown in Table 2.1. Insurance above 70% was subsidized, but at lower rates as coverage levels increased. The lower subsidization greatly influenced producers’ expected profit maximization decisions, and most did not purchase the higher coverage. Since not all producers chose to purchase insurance even with the subsidy, adverse selection may still be occurring with very low risk farms.

Table 2.1: Crop insurance premium subsidies paid by government as a percent of total.

Coverage Level (%)	CAT	50	55	60	65	70	75	80	85
Most policies	100	67	64	64	59	59	55	48	38
Enterprise units	n/a	80	80	80	80	80	77	68	53
Whole farm units	n/a	80	80	80	80	80	80	71	56

Source: Congressional Research Service.

With crop insurance subsidized, Goodwin and Smith (2013) proposed "producers may elect to grow risker cops and bring additional risker land into production" (p. 493). If a piece of land or crop cannot consistently produce profitable yields, then a risk neutral producer paying insurance premiums which are actuarially fair and include administrative costs will not cultivate that plot; E [marginal cost] + premium > E [marginal revenue + indemnity payment]. With a subsidy, the previously unprofitable land or overly risky crop could be put into production by an insured producer despite the expected loss; E [marginal cost] + premium-subsidy < E [marginal revenue + indemnity payment]. Cornaggia (2013) discusses a third motive which will not be considered in this study but merits mention. Banks may view insured farmers as less risky. This would allow farmers to be offered lower interest rates which would encourage investments in equipment or inputs that increase yields, or to expand production on unutilized land.

The insurance companies are aware of the land and crop decisions at the time insurance is sold. This is not moral hazard because the producer is not changing behavior after becoming insured, nor is it adverse selection. This behavior is simply a distortion caused by the subsidy. This study examines the extent to which subsidized crop insurance has influenced producers' crop choices due to the distortion. These choices negatively impact the net U.S. social welfare because subsidies are paid from the collection of distortionary U.S. taxes. Assuming a balanced budget, more distortionary taxes would need to be collected to offset this distortion. More planted acres of high risk crops in the U.S. lead to higher output which decreases the world price (Young, Vandeveer, and Schnepf, 2001). This lower price maintains the expectation of negative profit. Producers then claim insurance is necessary for viable production the following year and the cycle repeats.

2.3 Past Literature

Chavas and Holt (1990) developed an acreage response supply model to study corn and soybean acreages. The model truncates the probability distribution when a government program installs a price floor. The truncation impacts expected revenue which influences production decisions. Crop insurance behaves in a similar way, but was not popular at the time of that study. Chavas and Holt concluded that increasing support price for a commodity will increase the expected price, causing acreage substitution toward that commodity. Twenty years later with a larger data set this hypothesis was tested and was not rejected (Serra, Zilberman, Gil, and Featherstone, 2009). Applied to insurance, farms would have a tendency to move away from uninsured crops and toward insured crops.

Wu (1999) performed one of the first empirical studies of crop insurance impact on the mix of crops. Studying the central Nebraska basin, the results showed farms with crop insurance reallocated hay and pasture land to corn and soybeans. The effect of this reallocation was greater on farms with less than 500 acres. Wu (1999) hypothesizes that small farms may not have wanted to plant on marginal lands without insurance due to risk of crop failure. This complements Hennessy's (1998) conclusion that producers with declining absolute risk aversion (DARA) preferences would be willing to assume more risk as wealth increases. Individuals with less risk aversion have a flatter marginal utility curve which causes insurance to be less appealing.

Wu and Adams (2001) found that when corn alone was insured, the acres of soybeans and other crops fell as expected. When soybeans alone were insured, corn acres increased slightly and acres planted to other crops declined. The rise in corn acres was hypothesized to be due to rotational cropping. The interesting result was from simultaneous insurance. Producers with simultaneous insurance had corn revenue increase only slightly, while soybean and other revenue decreased compared to the corn only insurance (Wu and Adams, 2001). This indicates that the cropping patterns for a farm with both corn and soybean insurance are similar to that of a farm with only corn insurance.

The increase in corn acreage associated with increase in soybean acreage was also found by Goodwin, Vandeveer, and Deal (2004), although they point toward comparative advantage as a possible cause. They investigated insurance impacts on corn and soybeans from 1985-1993. Crop insurance is found to have statistically significant acreage responses in corn but not soybeans. They note that when converted into elasticities these impacts are quite small, approaching zero for soybeans (Goodwin, Vandeveer, and Deal, 2004). The results are much smaller than those predicted by earlier models. Walters, Shumway, Chouinard, and Wandschneider (2012) reaffirm that the interaction is small if anything. They found corn to be negative in one region, whereas barley was positive in another. Insurance impacts on all other regions and crops in the study were found to be insignificant (Walters, Shumway, Chouinard, and Wandschneider, 2012).

Lin and Dismukes (2007) replicated Chavas and Holt's (1990) study using acreage response to the government subsidy payments from the countercyclical payment (CCP) program. Two scenarios are simulated to compare market conditions with and without CCP's. Their simulation concludes there will be no negligible difference in production share in Illinois (Lin and Dismukes, 2007).

Goodwin and Smith (2013) examined possible distortions using a simple OLS model. They found higher subsidy rates and greater insurance participation rates are associated with increases in acreage of corn, soybeans, cotton and wheat. They also found that higher returns to insurance do not correspond to increase in planted acres.

The past literature indicates there is little to no distortion of land use from crop insurance. This study seeks to test further using a larger data set over a different period of study. Few other studies have used instrumented GMM models to account for joint determination in the producer's welfare optimization problem when addressing this area of research. This study will add the use of the Arellano and Bond method to account for autocorrelation of lagged dependent variables in a dynamic panel data model.

2.4 Model

As discussed in Chapter 1, Goodwin and Mishra (2006) characterize producers' current wealth as: $P_{it}Q_{it}\left(A_{it}, X_{it}, A_{it-1,}e_t\right) - wX + C\left(A_{it-1,}\right) + G_t + PS(P_{it}) + W_{t-1}$ where P_{it} is the price of crop i at time t, Q_{it} $(\cdot)$ is output, A_{it} is planted acreage, X_{it} is a vector of variable inputs, e_t is exogenous shock, w is the price of those inputs, C is fixed costs, G_t is decoupled government payments, PS are government payments effected by price such as market loss assistance, and W_{t-t} is wealth the previous period. To maximize the expected utility, the producer will select acreage and other inputs yielding the reduced form equation $A_{it} = f(\, A_{it-1}, P_t, w_t, G_t, PS_t, W_{t-1})$ (Goodwin and Mishra, 2006, p.75). Their model of wealth and reduced form equation will be loosely followed. The producer's welfare problem will be characterized as maximizing expected utility of wealth.

$$(2.1)\quad V_t = \sum_0^T U\{P_{it}Q_{it}(A_{it}(A_{it-1}, pasture_{t-1}), w_{it}, I_{it}(I\_prate_{it-1}, lvstk_{t},)\; e_t) - w_{it}(Oil_t)\}$$

where P_{it} is price of crop i at time t, Q_{it} $(\cdot)$ is output, which is assumed to be a function of planted acreage, A_{it}, fertilizer and chemical expenses, w_{it}, insurance participation, I_{it}, and an exogenous shock, e_t, w_{it} is fertilizer and chemical expenses which are influenced by oil prices, Oil_t. A_{it} is influenced by lagged acres planted, A_{it-1}, and pasture land, $pasture_{t-1}$.

I_{it} is influenced by net farmer paid premium percentage rate, I_prate_{it-1}, and livestock sales, $lvstk_t$. The main parameter of interest, insurance participation (I_{it}), will show the changes in planting choices due to participation in the subsidized crop insurance program. Insurance participation is defined in Chapter 1 as the actual insurance liability divided by total possible liability, $I_{it} = ALib_{it}/PossLib_{it}$.

The cost of fertilizer and chemical inputs may incentivize a producer to adjust their crop mix to low input crops. Often the price of an input is positively correlated with its effectiveness. As explained by Horowitz and Lichtenberg (1993), this makes input expenditures a better aggregate indicator of fertilizer and chemical usage than a measure of application because it does not adjust for effectiveness. Planted acreage is the dependent variable; therefore, county level fertilizer and chemical expenses on a per acre basis are not as good of a measure as total expenses.

Current acreage planted in a county is influenced by previous years' plantings, A_{it-1z}, through fixed capital, and producer experience. A producer who planted the previous period may already own much of the capital equipment needed for production. They may also have an established relationship with land owners which allow them more land leasing opportunities. The producer may also have a knowledge base about the best farming practices for that crop.

The harvest price of a crop provides incentives for producers to select certain crop mixes based on expected profitability. However, the actual harvest price is unknown to producers at the time when planting decisions must be made. Their decisions are based on the price they expect to receive for crop i, EP_{it}. The price of futures contracts at the time of planting provides producers an expected price at harvest as discussed in Chapter 1.

To allow for linear modeling of suspected nonlinear relationships, the model will be of double log form. The double log form is useful when many outliers exist and generates coefficients in easy-to-read elasticity form.

(2.2) $lnA_{itz} = \beta_1 lnI_{itz} + \beta_2 lnw_{tz} + \beta_3 lnA_{t-1z} + \beta_4 lnpasture_{t-1z} + \beta_5 lnEP_{it} + \varepsilon_{it}$

where: A_{itz} is planted acreage of crop i in time z in county z, I_{itz} is Insurance participation of crop i at time t in county z, w_{it} is fertilizer and chemical inputs at time t in county z, $lnpasture_{t-1z}$is acres of pasture land at time t-1 in county z, EP_{it} is expected price of crop i at time t, ε_{itz} is the error term.

Smith and Goodwin (1996) found that Kansas wheat producers make a decision on insurance and input usage jointly. This joint determination causes a simultaneity problem when the basic OLS model is implemented (Smith and Goodwin, 1996). To obtain valid estimates for the model's parameters an instrumental variable technique within the GMM framework is used as discussed in Chapter 1.

Coble, Knight, Pope, and Williams (1993) suggest that producers are responsive to subsidy and premium changes. Insurance participation of crop i at year t in county z will be instrumented with net farmer paid premium percentage rate lagged on period, $I\_prate_{it-1z} =$

$(premium_{it-1z} - subsidy_{it-1z})/libility_{it-1z}$. Lagging premium rate one period reduces the endogeneity problem with insurance coverage levels. Insurance rates and subsidies are explanatory variables of insurance. They are exogenous to land use allocation and fertilizer application decisions. Therefore, they meet the requirements discussed by Wooldridge (2001). As discussed in Chapter 1, Goodwin, Vandeveer, and Deal (2004) found farm income from livestock sales to have a significant relationship with insurance. Table 1.4 shows statistically significant first stage results for both instruments of insurance participation. This study uses the percentage of receipts from livestock sales as an instrument of insurance participation.

Oil prices will be used to instrument chemical and fertilizer input expenditures. Oil prices were shown in Chapter 1 to be a significant explanatory variable of fertilizer and chemical expense. Fuel use for field operations and application of fertilizer and pesticide are nearly the same for corn and soybeans (Hanna, 2012). Therefore, it does not directly impact a producer's crop mix decision. Table 2.2 shows statistically significant first stage results for oil prices modeling fertilizer and chemical expenses.

2.5 Data

Corn, soybean, and wheat production between 2000 and 2014 will be the main focus of this study. These crops were selected for their importance in U.S. agriculture and they make up over 70% of crop insurance liability. Corn and soybeans will be studied in Illinois, Indiana, and Iowa, three of the four top corn and soybean producing states in the U.S. Corn accounts for 35% to 55% of cash farm receipts in this region and soybeans accounts for 20% to 26% (USDA-NASS). Wheat will be modeled in Montana, North Dakota, and South Dakota. Wheat provides 39% of cash farm receipts in Montana and 34% in North Dakota (USDA-NASS). These regions were also selected for the large proportion of the respective crops they produce in the U.S. as discussed in Chapter 1. Figures 1.1, 1.2, and 1.3 show the harvested acres in the United States.

The time period was selected due to natural structural breaks created by legislation in 2000 and the 2014 Farm Bill. County level crop acreage data were available from the National Agricultural Statistical Service (NASS) County Estimates Survey (CES). Aggregated chemical and fertilizer expenses were available at the county level through the BEA's Regional Economics Information System. Chapter 1 presents a detailed explanation of these agencies.

Expected prices of corn and soybeans were valued using the February price of futures contracts at the Chicago Board of Trade. Wheat prices were valued using futures contracts at the Minneapolis Grain Exchange. Expected corn price was based on December contracts, soybeans were based on November contracts, and wheat prices were based on September contracts. Contracts were selected based on harvest dates of the regions being modeled as discussed in Chapter 1. As discussed in Chapter 1, premium, subsidy, indemnity payment, and amount of liability for insurance policies were made available at the crop/county level from the USDA's Risk Management Agency (RMA). Summary statistics for all data is displayed in Table 2.3.

2.6 Estimation Results

General Method of Moments (GMM) estimation was performed using SAS software's model procedure. Parameters estimated for corn are reported in Table 2.4. The insurance participation parameter for corn has an expected positive sign and is considered significant. The impact of 0.02% in acreage for a 1% change in insurance participation is extremely small and can be argued to be economically insignificant. The magnitude accords with Walters Shumway, Chouinard, and Wandschneider (2012) whom found results varied between -8% and +9% for corn. These results support the null hypothesis that subsidized crop insurance does not have an economically significant impact on the decision of acreage of corn planted.

Parameter estimates indicate an increase in fertilizer and chemical expenditure by 1% when acres of corn planted increase by 0.08%. An increase in planting is expected to require more inputs. The low magnitude of the elasticity indicates possible economies of scale which is plausible; however this low is not very likely complete explanation for such a small magnitude. The elasticity estimate for lagged acres planted is significant, positive, and near one indicating growth is increasing at a constant rate. Increasing plantings at a constant rate is not a stable path given there is limited amounts of land. There is possibly a serial correlation problem which will be discussed later in this chapter.

The positive elasticity found for lagged pasture land is expected. The magnitude of the elasticity estimate for pasture land, 0.02 can be misleading if the large difference between acres of cropland and acres of pasture land is not considered. On average in the dataset used, pasture land was only 3.5% of the combined total of the two. A county with 5,000 acres of corn and 5,000 acres of soybeans would have reported 10,000 acres of cropland and 350 acres of pasture land. The elasticity estimate of 0.02 applied to this example county would imply a 10% increase, 35 acres, in pasture land last year would be related with a 0.2% increase, 10 acres, of corn planted this year. Hansen J statistics indicates possible orthogonality problems with instruments in the model which will be discussed later in this chapter.

Soybean model estimations are reported by Table 2.5. Insurance participation in production of soybeans in Illinois, Indiana, and Iowa is found to be small yet statistically significant. This finding is similar to the findings of Goodwin, Vandeveer, and Deal (2004) who found impacts existed but were extremely small. Walters Shumway, Chouinard, and Wandschneider (2012) found a 1% change for soybeans. Sometimes the impacts from a policy change take time to emerge as participants learn the new rules and how to maximize utility within them. A consistent finding between studies using different time periods provides confidence that even with consideration for learning; producers are not making large marginal land use changes due to participation in crop insurance. These results support the null hypothesis that subsidized crop insurance does not have an economically significant impact on soybean production.

Table 2.5 shows fertilizer and chemical expenditures have an unexpected negative relationship with acres of soybeans planted. Given fertilizer and chemical expenditures could not be separated by crop, the reduction in expenses could come from a reduction in fertilizer on corn crops. Soybeans are used as a rotational crop which increases yield and decreases fertilizer expenses of corn production. Price movements sometimes make it profitable to plant corn two or more continuous years. Iowa Extension calculated that continuous corn would net a producer 160% more profit per acre than continuous soybeans. However, rotating corn with soybeans produces higher corn yields. Planting soybean before corn also reduces cost as less nitrogen fertilizer is needed and control for root worm is not generally needed for the corn. Using county level aggregate data, this would show up in estimations as increased soybean production decreases fertilizer expenses. These finding are also consistent with the corn results.

Duffy (2011) states that reduced cost and higher yield allow a corn-soybean rotation to net a producer 20% more per acre due than continuous corn. The 2012 estimates of net returns per acre were calculated using $6 corn, $12 soybeans, and a yield increase of 15bu per acre. The advantage of crop rotation is not constant. This implies about one-third of corn was grown continuously. If no rotation corn yields increase by only 3% or soybean prices fall 8%, then rotation does not provide any additional net income (Duffy, 2011).

Commodity price movements impact all regions, so the change in crop rotation, and hence fertilizer usage from crop rotation, would show in county level data.

Acres of soybeans planted in the previous year have a significant influence on the acres of soybeans planted in the current year. An elasticity of near 1% is consistent with farms expanding at a linear rate. This is inconsistent with limited land use. As farms expand, the remaining land is often the least productive, or most expensive to prepare. The a priori expectation is a positive elasticity less than one. The previous year's pasture land is found to be significant, yet small in soybean plantings. The Hansen J test suggests the instruments do not meet orthogonality conditions and are invalid. Overall estimations from the soybean model support that acres of soybeans planted in Illinois, Indiana and Iowa are not significantly changing due to participation in subsidized crop insurance.

Table 2.6 presents results when wheat was modeled in Montana, North Dakota, and South Dakota. An increase in insurance participation is found to be insignificant in modeling acres of wheat planted. Similar to soybeans, this is supportive of the null hypothesis that subsidized crop insurance does not influence land allocation. The elasticity estimate for lagged acres planted is significant, positive, and less than one indicating growth is increasing at a decreasing rate. Increasing plantings at a decreasing rate is a stable path and consistent with expectations.

All three crops; corn, wheat, and soybeans; have shown that marginal plantings of a crop are not greatly influenced by insurance participation. Expected returns provide an explanation to this behavior. Unless the producer selects to fallow the land, crops with the highest expected return will be produced. Actuarially advantageous insurance would only have impacted planted acreage where it changed the return of negative or zero from that marginal land to a positive return. Insurance in this case would incentivize producers to plant. The results of this study coincide with very few acres having a negative expected return without insurance and positive expected return with insurance are very few. Most land is either already profitable or too unprofitable for insurance to offset. No valid model in any region for any crop studied found crop insurance to have a statistically significant positive impact on planting decisions.

The previous results were found by implementing a pooled regression to estimate a model of the time series cross sectional data. As discussed in Chapter 1, the pooled model used previously may have unobserved cross section heterogeneity. To address this concern first differencing as suggested by Wooldridge (2001) could be used as it was in Chapter 1. However, this model contains a lag dependent variable, A_{it-1} causing concern that fixed effects could be correlated. Anderson and Hsiao (1981) addressed this by using instruments that were linear combinations of the regressors' matrix. The methodology was effective at reducing serial correlation, but estimators were inefficient (Arellano and Bond, 1991). The Arellano and Bond approach transforms the model into first differences. This eliminates the individual effects and focuses only on changes in variables. This allows the use of all past information in instruments. The Arellano and Bond approach to estimation with two stage GMM estimator using SAS will be used for further modeling of crop insurance participation.

Equation 2.3 shows the county level change in acres planted between the prior year and the current year will be modeled at the county level as a function of the change in insurance participation, change in chemical and fertilizer expenditures, and change in futures price of the commodity between the prior year and the current year. The change from the prior year and two years prior of acres planted will also be used as explanatory variables.

(2.3) $\Delta lnA_{itz} = \beta_1 \Delta lnI_{itz} + \beta_2 \Delta lnw_{tz} + \beta_3 \Delta lnA_{it-1z} + \beta_4 \Delta lnEP_{it} + \varepsilon_{itz}$

Table 2.7 displays results of the corn, soybean, and wheat model estimations for their respective regions. Parameter estimates for corn and soybean insurance participation are found to be statistically insignificant. This is supportive of the null hypothesis that subsidized crop insurance does not influence land allocation. Results are consistent with the earlier pooled regression results that indicated impacts that were negligible. They are also consistent with Goodwin, Vandeveer, and Deal (2004) and Walters, Shumway, Chouinard, and Wandschneider (2012) whom found no large influence. Insurance participation is not found to have a large impact on land allocation decisions.

Lagged acres planted have negative elasticity. This indicates an operation that expands planting of a crop by 1% the previous year decreases plantings by 4% the current year. This could indicate crop rotation, but this explanation is not very plausible when using county level data as individual producer's rotation cycles would be aggregated. If all producers in a county respond to a national price increase for a commodity then a change could be seen with county level data. The negative elasticity could be producers responding to higher corn prices by reducing their soybean rotation in the previous period and then returning to a normal rotation cycle the current period. A levels model was performed using non logged data. Positive coefficients were estimated for lagged acres planted. This indicates the negative estimation of the logged model is a decreasing positive growth rate.

Fertilizer and chemical expenses continue to follow the explanation of crop rotation due to market prices. A 1% increase in the growth rate of acreage of planted corn is associated with a 0.2% increase in the growth rate of fertilizer and chemical expense, while a 1% increase in growth rate of acreage planted of soybeans is associated with a 0.2% decrease in the growth rate of fertilizer and chemical expense.

Wheat insurance participation is found significant. A 1% change in the growth rate of acres planted of wheat is associated with a nearly 1% change in the growth rate of insurance participation. Participation in crop insurance may change the expected profit of wheat on the marginal land from negative to positive. In this case, subsidized crop insurance would have a significant impact on marginal land use. These results conflict with those of the earlier pooled model, but the Hansen J score of the Arellano and Bond model indicates there is no bias.

2.7 Unit Size

Crop insurance has many aspects for a producer to select. The type of protection such as revenue, yield, and area is one aspect. A producer may also select their level of coverage such as 50%, 65% or 80%. A third aspect of the crop insurance decision is the unit structure. An insurance unit is a parcel of land that is insured independently of other parcels. A producer may receive an indemnity payment for one unit that experiences a loss, while simultaneously reaping the benefits of high yields on an adjacent parcel insured under a different unit. The type of unit structure chosen in essence determines the number independently insured parcels and consequently the number of acres in each parcel. The producer's unit type decision is a balance between maximizing the number of independent units to increase the likelihood and size of an indemnity payment and minimizing the number of units to reduce premiums. Similar to type of protection and coverage level options, the opportunity for moral hazard varies based on the unit type.

Producers may choose to structure their insurance units as basic, optional, and enterprise. Basic units are all acres of a crop in a county under single ownership. A single operation could have all land owned by the producer as one basic unit, and two different plots of land that are share rented with two different landlords each as a separate basic units for a total for 3 basic units. A producer is automatically qualified for basic units without exception. Optional units are basic units that have been further divided and may not be available in certain circumstances. Divisions can occur by location, or if growing practices are distinctly different such as the case of organic farming or irrigation. Special rules apply for nonirrigated corners of a center pivot irrigated field. Enterprise units combine all acres of a single crop within a county for which a policy holder has financial interest (Edwards, 2014). The 2014 Farm Bill allows for enterprise units to be split into irrigated and non-irrigated units. Selection of enterprise unit structure may results in a producer having only one unit per crop

Indemnity payments are more likely to be paid if a farm selects optional unit insurance. A producer with enterprise unit insurance at 80% coverage level on 200 acres within a single county would receive no indemnity payment if they experience an equivalent of a 30 acre loss. That same producer with two optional units of insurance at 100acres each would receive an indemnity payment if the loss was concentrated in one of the units. By combining the optional units into one enterprise unit, the farm is less risky to insure due to "the risk reduction implied by standard portfolio theory." (Knight, Coble, Goodwin, Rejesus, and Seo, 2010). Fraud can also be committed more easily with optional insurance by simply moving harvested yields from one field to another within a county. Enterprise unit insurance is not as susceptible to these problems or adverse selection.

Knight and Coble (1999) examined the difference in loss-cost ratios. They found that farms with optional unit insurance did experience higher loss-cost ratios than farms with basic unit insurance, but the difference was not greater than the 10% premium being paid at that time. Therefore, larger indemnity payments from insurance would not justify the decision of farmers to select optional unit insurance over basic. In a later study Knight, Coble, Goodwin, Rejesus, and Seo (2010) found the actuarially fair discount rate of non optional unit insurance at the 75% coverage level for corn and soybeans was not far from the current discount rate at that time, 10%. They also found that the median discounts decrease as coverage level decreases. At 50% coverage a corn producer would need a 30% discount to be actuarially indifferent between option unit and non optional unit. They concluded that a single fixed discount rate was inadequate to reflect all levels of coverage.

Basic unit insurance received a 10% discount over optional unit premiums since 1988. To encourage the use of enterprise unit insurance, the 2008 Farm Bill dramatically increased the premium discount for enterprise unit insurance. For example, 75% coverage level received a 55% subsidy in 2008 and 77% in 2009. The particular premium discount for the enterprise unit depended on the coverage level.

Data detailing the number of insurance policies that were enterprise, basic or optional was unavailable. A change in number of acres per insurance unit can be used as proxy for changes from basic unit to enterprise unit insurance. Figure 2.2 and 2.3 display the increase in the average number of acres per insurance unit of corn and soybeans after the 2008 Farm Bill. This is indicative of farms responding to the economic incentives of the premium discount by moving away from insuring with many optional units toward insuring with few enterprise units.

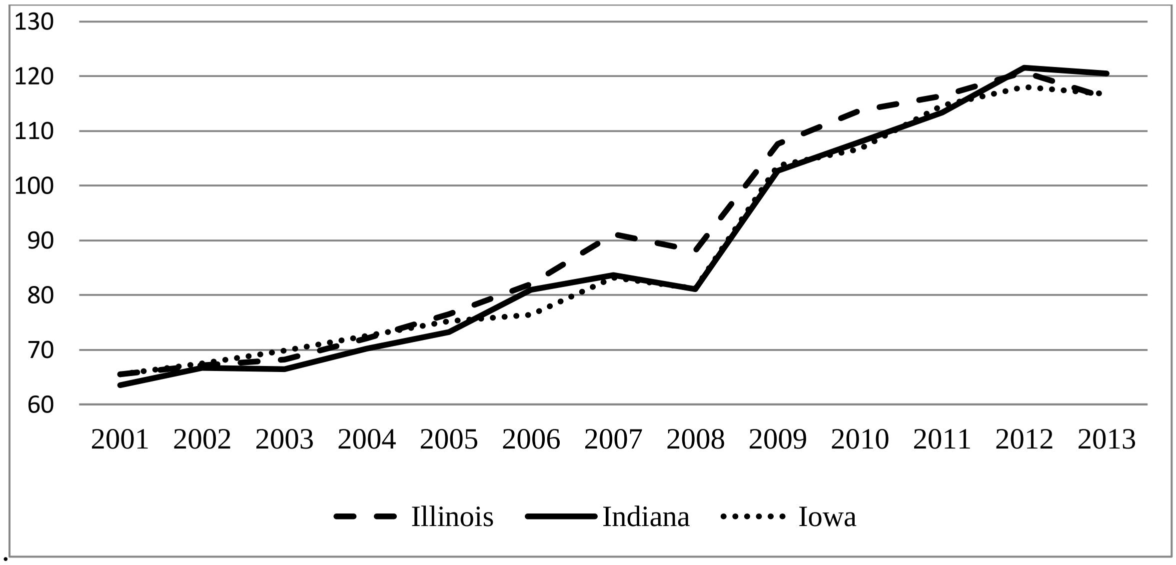

Figure 2.2: Acreage of corn insured per insurance unit. Source: USDA, RMA

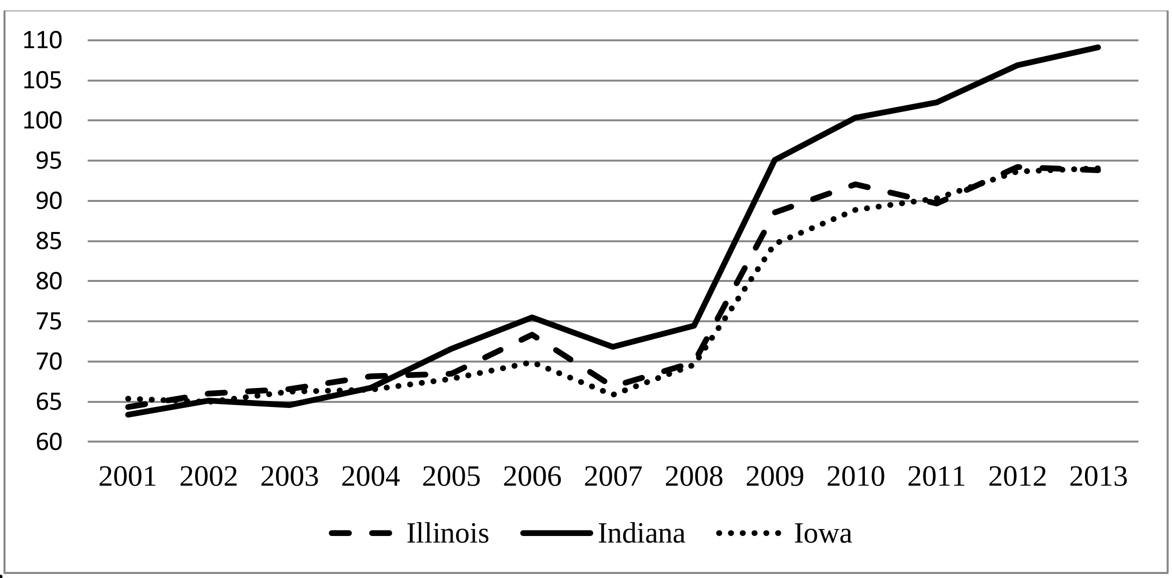

Figure 2.3: Acreage of soybeans insured per insurance unit. Source: USDA, RMA

This study will examine two aspects of crop insurance unit type. First, if the risk reduction from larger insurance units decreases indemnity payments. Results can be used to compare with earlier studies using pre 2001 data. Second, if the farmer paid loss ratio of an insurance policy is related to unit size. If premiums and subsidies are correct, then no significant relationship should exist.

Risk reduction is examined by modeling indemnity payments with insurance unit size and commodity price. Unit type purchased by producers is unavailable from the RMA. As a proxy to unit type unit size will be used. Unit size is determined by dividing the number of insured acres of a commodity in a county by the number of insurance units sold for that commodity. Price of the commodity during the insurance discovery period is included as an explanatory variable in the model. There is a direct connection between these prices and indemnity payments for revenue and area protection plans and an indirect connection with yield protection insurance. As discussed in Chapter 1, the balanced panel data for this study contains the same counties over the same time period and the unobserved effect may be capturing differences between the counties which are time invariant. The first difference form will remove these fixed effects. The double log form generates coefficients in easy-to-read elasticity form.

(2.4) $\Delta lnIndem_{it} = \Delta lnacres\_per\_unit_{it} + \Delta lnEP_{it}$

where: $\Delta lnIndem_{it}$ is the change in the indemnity payments of crop i at time t, $\Delta lnacres\_per\_unit_{it}$ is the change in acres per unit, and ΔEP_{it} is the change in expected price.

Corn and soybean production between 2000 and 2014 will be used for modeling. A wide spread atypical drought occurred in 2008 causing large indemnity payments. This outlier data from 2008 is not used in the model. Indemnity payments and unit size were available from the RMA. February price of futures contracts at the Chicago Board of Trade is used for expected price.

The negative relationship shown on Table 2.8 between unit size and indemnity payments was expected. As the growth rate in the number of acres per unit increased; growth rate of indemnity payments decreased. This is consistent with Knight, Coble, Goodwin, Rejesus, and Seo, 2010 whom stated risk would decrease if optional units were combined. Price had a positive relationship which meets a priori expectations.

Larger indemnity payments are an indication of higher risk, but do not imply smaller unit size is financially more favorable for either the insurer or the insured because price paid for insurance was not assessed. The relationship between loss ratio and unit size will be examined so that premiums and subsidies are considered. The loss ratio of a for-profit insurance firm must be less than one so they may earn enough revenue to cover expenses and earn returns for company stake holders. Crop insurance companies receive administrative and operating payments from the government so they may offer crop insurance at actuarially fair rates. Statistically the loss ratio, $indem/premium$, should be close to one in a large sample size spanning several years for actuarially fair insurance. The mean loss ratio of insurance policies in Illinois, Indiana, and Iowa between 2001 and 2013 was 0.95 for corn and 0.65 for soybeans. The ratio less than one signals that on average more premiums were received by the insurance company than indemnity payments were paid to policy holders.

An insurance policy which correctly accounts for risk level relative to unit size would have a loss ratio that is consistent for all unit sizes. If large unit size has too great of a discount, then as unit size increased the loss ratio would increase. Consequently a positive relationship would exist. This is examined by modeling with equation 2.5. As discussed previously, a difference approach is used to remove fixed effects.

(2.5) $\Delta lnloss\_ratio_{itz} = \Delta lnacres\_per\_unit_{itz} + \Delta lnEP_{it}$.

where: $\Delta lnloss\_ratio_{itz}$ is the change in loss ratio of crop i at time t in county z, $\Delta lnacres\_per\_unit_{itz}$ is the change in acres per unit of crop i at time t in county z, and ΔEP_{it} is the change in expected price of crop i at time t.

Results displayed in Table 2.9 show a negative relationship, which indicates as units contain more acres the loss ratio becomes lower. The lower probability of an indemnity payment occurring from insuring larger units is not being reflected in unsubsidized premiums. These findings indicate that premiums for enterprise unit insurance may not be priced correctly relative to optional units. Availability of data prevents this studying from concluding if enterprise units are possibly over priced or if optional units are under priced.

The loss ratio with consideration for the subsidy is evaluated using the farmer paid loss ratio, $indem_{it}/(premium_{it} - subsidy_{it})$. A producer will be indifferent between unit sizes if the risk differential is reflected in net premiums paid. Prior to the 2008 subsidy increase, the loss ratio is expected to have a negative relationship with acres per unit. If the subsidy correctly adjusted for risk differences, then acres per unit would have no relationship to loss ratio post 2008. Equation 2.6 is used to model these impacts.

(2.6) $\Delta lnfp\_loss\_ratio_{itz} = \Delta lnacres\_per\_unit_{itz} + \Delta lnEP_{itz}$

Results are displayed in Table 2.10 are as anticipated. Prior to 2008 a significant negative relationship between unit size and the farmer paid loss ratio for both corn and soybean insurance exists. The relationship in corn post 2008 is drastically decreased while a significant relationship can no longer be found with soybeans. These results provide strong evidence that the 2008 Farm Bill subsidy for enterprise units caused producers to become more indifferent between their insurance options. The continued existence of a negative relationship may be a result of the premium rate.

Overall results examining risk and insurance unit size are consistent with the prior study by Knight and Coble (1999). The greater number of acres a unit has the less likelihood of an indemnity payment. Focus was given in the 2008 Farm Bill to encouraging producers to have larger unit size by increasing the subsidy. Results from this study indicate that the change did provide enough economic incentive for producers to move toward larger unit size.

However, findings also indicate the premium itself may have been actuality incorrect without regard to the subsidy.

2.8 Conclusion

The theoretical motivation for a producer to increase marginal land use was discussed and production on marginal land could be occurring. This study fails to reject the null hypothesis that subsidized crop insurance has no impact on acres planted of wheat in Montana, North Dakota, and South Dakota. Results for corn and soybeans are supportive of the null, crop insurance has no impact on acres planted, and are consistent with previous studies. The impact of insurance is insignificant or very small, approaching zero, as was found by Goodwin, Vandeveer, and Deal (2004), and Walters, Shumway, Chouinard, and Wandschneider (2012). The number of acres per insurance unit chosen by producers was also examined. Indemnity payments and the loss ratio were found to have a significant relationship with unit size. Market forces may be an explanation for these results.

If an uninsured crop becomes less desirable due to relative increases in risk, then producers may begin to shift away. As they shift to other crops, market forces will increase the price of the uninsured riskier crop until production shifts back. No significant marginal land use change was found in corn, or soybeans. A change in the relative price difference between insured and uninsured crops would be an interesting study.

Producers are incentivized to avoid losses despite insurance policies being actuarially advantageous. A producer may have an expectation that the indemnity payment will on average be larger than the premium paid. However, this positive expectation does not imply they have an expectation of positive profit when they make a claim. Producers have a great deal of variable inputs invested in the production of a crop. Indemnity payments do not necessarily completely cover the producer's invested input costs.

Findings for wheat were considerably different than finding from corn and soybean models. This could be due to various factors. Agronomical differences between the marginal impacts of fertilizer have been previously discussed. The availability of marginal land has not been addressed. Pasture land makes up 4% of the total sum of all cropland and pasture in the wheat region studied. The Corn Belt region has 2% of the total in pasture land (USDA-NASS). This difference in the make up of land may explain the different results across regions. Further investigation finds that although the percentage of all agricultural cash receipts from livestock is similar between the regions, the type of livestock is not. Cattle which require large areas to graze bring in 19% of receipts in Montana and the Dakotas, where they only bring in 6.5% of receipts in the Corn Belt (USDA-NASS). Pasture land may provide more opportunity for producers in the wheat growing region than in the Corn Belt.

In the time period studied, only policies at the 85% level or less were subsidized. Few producers chose policies above the subsidization level. Results from this study show producers did not expand planted acres of corn or soybeans. Producers will become less concerned with crop loss as coverage levels approach 100%. Determination of the coverage level at which the producers become unconcerned with crop loss would provide valuable information to policy makers.

Environmental impacts from agriculture have become a more prevalent concern over time. Any subsidy that incentivizes the market to make choices which have negative environmental impacts will face tough opposition by environmental protection activists. Increased planting on erodible land near waterways, removal of cropland from conservation programs, and shrinking biodiversity are not supported by environmental protection groups. Some have proposed that crop insurance encourages all of these activities by reducing the production risk producers face. They propose that buffer land which was unprofitable will be cultivated if it can be insured at an actuarially advantageous rate. Therefore, subsidization of crop insurance could result in greater amounts of sediment and fertilizer in our waterways along with less biodiversity. Findings from this research do not show subsidized crop insurance induces corn or soybean producers to plant closer to waterways, take land out of conservation, or convert pasture land to intensive row crops. Results from Chapter 1 combined with these results indicate no significant negative environmental impacts from subsidized crop insurance.

There are possible acreage increases in wheat as a response to subsidized crop insurance are occurring near waterways. This potential negative environmental impact should be considered in conjunction with Chapter 1 results that indicate a possible positive environmental impact from the reduction of fertilizer and chemicals in the same region.

When reacting to the findings of wheat in this study, it is important to note the relative size of the liability. Corn and soybeans, which account for 63% of insurance liabilities, were not found to changes acreage decisions. Failure to reject the null hypothesis only occurs in wheat production, which makes up 8% of all the crop insurance liabilities. The overwhelming majority of insurance was determined to not have had a significant change in behavior. Expansion of other crops or in other regions could be occurring. However, the overall impact would be quite low given the large proportion of the insurance market and farming regions used in this study.

The economic health of a county is dependent on allocation of resources to their most efficient use. Market forces often help with efficient allocation through pricing mechanisms. If more of a crop is produced than is needed, then prices fall providing less incentive for production. This causes producers to move resources to produce goods that have a greater price due to their scarcity. Governmental policies can distort markets by providing incentives to produce goods already in high supply. The result is the use of resources to produce something which is not desired and failure to produce items which are scarce. Chavas and Holt (1990) and Serra, Zilberman, Gil, and Featherstone (2009) conclude this to be true with agricultural price supports. Market distortion is a popular argument against legislation that provides support to individual sectors, particularly agriculture. This study finds corn and soybean producers have not significantly altered plantings to collect indemnity payments. Subsidization of crop insurance has not been shown to distort the economically efficient use of natural resources. Further research into using subsidized insurance to provide sector support without causing market distortions would be valuable to policy makers.

Choices within insurance options have been shown to be influenced by subsidies. Prior to 2008 producers chose to insure many small units of insurance which was shown to increase the odds of an indemnity payment. When premium discounts were established in the 2008 Farm Bill to offset the lower risk of enterprise units, soybean producers were found to have no relationship between loss ratios and insurance unit size. The relationship continued with corn producers however it was greatly diminished. The continuation of that relationship may be due to the unsubsidized premiums strong relationship with loss.

Subsidized crop insurance has been shown to not have an economically significant impact on corn and soybean planting choices. An insignificant finding reduces concerns of unintended negative impacts on water quality, societal welfare, or trade relations. Subsidies were shown to influence choices within insurance products. Market forces and producer incentives have explained these results.

2.9 Tables

Table 2.2: Summary statistics for land use variables.

Variable description	Corn (N=3,689) Mean (Std Dev)	Soybeans (N=3,699) Mean (Std Dev)
County level total fertilizer and chemical expenses (w_{it})	\$18,013 (\$14,126)	\$17,997 (\$14,116)
County level planted acres (A_{it})	108,333 (66,079)	86,834 (46,021)
Insurance Participation as a function of actual and possible participation (I_{it})	79% (17%)	72% (17%)
Commodity futures price in February at CBOT and CME (EP_{it})	\$3.83 (\$1.38)	\$8.48 (\$3.30)
Oil futures price in February at CBOT (Oil_t)	\$60 (\$27)	\$60 (\$27)
Livestock Sales	31% (19%)	31% (19%)

Table 2.3: First stage estimation of fertilizer and chemical instrument.

	Corn			Soybeans			Wheat	
Variable	Estimate	Pr>T		Estimate	Pr>T		Estimate	Pr>T
Oil price	0.117	<.0001		-0.193	<.0001		0.444	<.0001
Acres Planted $_{t-1}$	0.817	<.0001		0.835	<.0001		0.47	<.0001
Pasture land $_{t-1}$	-0.092	<.0001		-0.107	<.0001		0.109	<.0001
Expected Price	0.551	<.0001		0.925	<.0001		0.822	<.0001

Table 2.4: Corn acres planted model estimation

Variable	Estimate	Standard Error	T- Value	Pr>T
Insurance Participation	0.021	0.01	1.99	0.05
Fertilizer	0.084	0.033	2.51	0.012
Acres Planted $_{t-1}$	0.918	0.027	34.45	<.0001
Pasture land $_{t-1}$	0.019	0.004	4.71	<.0001
Expected Price	0.023	0.027	0.85	0.395
Hansen's J over-ID stat	21.06		Prob= <.0001	

Table 2.5: Soybeans acres planted model estimation

Variable	Estimate	Standard Error	T- Value	Pr>T
Insurance Participation	0.041	0.015	2.8	0.005
Fertilizer	-0.109	0.01	-2.71	0.007
Acres Planted $_{t-1}$	1.066	0.033	32.55	<.0001
Pasture land $_{t-1}$	0.026	0.006	4.05	<.0001
Expected Price	0.029	0.033	0.87	0.384
Hansen's J over-ID stat	10.63		Prob= 0.005	

Table 2.6: Wheat acres planted model estimation

Variable	Estimate	Standard Error	T- Value	Pr>T
Insurance Participation	-0.017	0.095	-0.18	0.855
Fertilizer	0.308	0.058	5.29	<.0001
Acres Planted $_{t-1}$	0.678	0.045	15.2	<.0001
Pasture land $_{t-1}$	0.055	0.018	3.14	0.002
Expected Price	0.019	0.089	0.22	0.826
Hansen's J over-ID stat	41.68		Prob =<.0001	

Table 2.7: Arellano and Bond estimation of acres planted for corn soybean and wheat.

	Corn			Soybeans			Wheat	
Variable	Estimate	Pr>T		Estimate	Pr>T		Estimate	Pr>T
Insurance	-0.016	0.351		0.043	0.171		0.954	0.004
Fertilizer	0.179	0.031		-0.159	<.0001		-0.112	0.798
Acres Planted $_{t-1}$	-0.417	<.0001		-0.417	<.0001		-1.215	0.0003
Expected Price	-0.01	0.697		0.007	0.022		0.397	0.041
Hansen-J score	10.08	0.002		1.81	0.178		0.51	0.473

Table 2.8: Indemnity payments modeled by unit size.

	Corn		Soybeans	
Variable	Estimate (Std Error)	Pr>t (T- Value)	Estimate (Std Error)	Pr>t (T- Value)
Acres per unit	-1.736 (0.345)	<.0001 (-5.03)	-0.598 (0.315)	0.057 (-1.90)
Expected Price	2.439 (0.151)	<.0001 (16.07)	4.105 (0.127)	<.0001 (32.39)

Table 2.9; Loss ratio modeled by unit size.

	Corn		Soybeans	
Variable	Estimate (Std Error)	Pr>t (T- Value)	Estimate (Std Error)	Pr>t (T- Value)
Acres per unit	-2.08 (0.363)	<.0001 (-5.73)	-1.588 (0.315)	<.0001 (-5.03)
Expected Price	1.24 (0.161)	<.0001 (7.71)	2.925 (0.127)	<.0001 (23.1)

Table 2.10: Farmer paid insurance loss ratio corn model.

	Corn prior 2008		Corn post 2008	
Variable	Estimate (Std Error)	Pr>t (T- Value)	Estimate (Std Error)	Pr>t (T- Value)
Acres per unit	-4.457 (0.664)	<.0001 (-6.71)	-1.753 (0.416)	<.0001 (-4.21)
Expected Price	2.379 (0.233)	<.0001 (10.21)	2.218 (0.195)	<.0001 (11.35)

Table 2.11: Farmer paid insurance loss ratio soybean model.

	Soybean prior 2008		Soybean post 2008	
Variable	Estimate (Std Error)	Pr>t (T- Value)	Estimate (Std Error)	Pr>t (T- Value)
Acres per unit	-1.227 (0.369)	0.0009 (-3.32)	-0.448 (0.554)	0.419 (-0.81)
Expected Price	3.412 (0.146)	<.0001 (23.41)	3.097 (0.17)	<.0001 (18.18)

Chapter 3. The Elasticity of U.S. Import Prices with Respect to Tariffs

3.1 Introduction

Tariffs are a tax placed on a good as it crosses international borders. Transit duties are taxes levied on products that are transported through a country which is neither the exporter nor importer. These duties were popular in the 16th-18th centuries for countries along active trade routes in order to generate revenues for the country in which the products were being transported. Export tariffs, first introduced in 1275, were taxes levied on products leaving a country. These were intended to protect domestic supplies of raw materials and encouraged domestic manufacturing that used the domestic raw materials. Import tariffs are the most common form of tariffs. This tax is levied on goods that are brought into a country. Originally import tariffs were often used to generate funds for the ruling government. In 1808, revenue from import taxes was twice the size of total U.S. government expenditures; in contrast, by World War II tariffs only provided six percent of government expenditures. In modern day, tariffs are more often used by countries to stimulate growth of their domestic industry, particularly infant industries. Tariffs are often criticized for protecting inefficient industries and decreasing welfare. Tariffs are well known for inhibiting trade between countries and causing inefficiencies in markets.

Free trade agreements between countries are intended to remove these barriers in order to make trading partners better off. At the end of World War II the General Agreement on Tariffs and Trade (GATT) was established. The purpose of GATT was to substantially reduce tariffs and other trade barriers that would be advantageous for trading countries. Since the GATT was established, seven rounds of negotiations have been finalized. The most recent finalized round of negotiations, known as the Uruguay round, established the World Trade Organization (WTO) in 1995. The Doha round of negotiations began in 2001 and in 2008 negotiations broke down. At the time of this writing the Doha round is still considered unresolved, but a significant "Nairobi Package" was agreed upon in 2016.

Whereas GATT is a forum with a set of rules, the WTO is an organization. WTO's 160 member countries established a multilateral trading system that, unlike GATT, includes intellectual property rights. The WTO is used to peacefully settle trade disputes. Disputes are examined by an independent panel. If a country has been found operating outside of the rules, the country is required to discontinue the offending actions. In some cases, compensation and counter measures are levied on the offending country. The WTO can be used to foster new regional trade agreements outside of all-inclusive trade agreements such as the North American Free Trade Agreement (NAFTA) and the United States Australia Free Trade Agreement (AUSFTA).

The empirical work of this paper focuses on U.S. agricultural trade. Analysis of trade with Australia after AUSFTA and analysis of U.S. imports from many trading partners will be performed to determine the elasticity of U.S. import prices with respect to U.S. tariffs. The hypothesis is that U.S. importers have a nearly perfectly inelastic price and exporters earn no tariff rents due to U.S. importers' market power.

Section 3.2 lays out a theoretical framework of trade and discusses previous literature showing that market power can lead to non-unitary elasticity of tariffs; Section 3.3 presents previous literature on import tariffs. A brief description of AUSFTA and a description of data are presented in Section 3.4. A Difference-in-Differences econometric approach is applied to determine price impacts from lower trade barriers between the U.S. and Australia in Section 3.5. Section 3.6 presents the results from the OLS model estimating the impacts of the AUSFTA on import prices. Section 3.7 and 3.8 discuss the impacts on U.S. import prices from reduced tariffs. The conclusion is presented in Section 3.10.

3.2 Overview of Trade Theory

The Heckscher-Ohlin (H-O) trade model is an extension of Heckscher's article "The Effect of Foreign Trade on the Distribution of Income" (1919) and Ohlin's book *Interregional and International Trade* (1933). The H-O theorem shows that each country will export the good that uses the locally abundant factor intensely. The key H-O assumption for countries with equal productivity yet different factor endowments as the reason for trade is a significant difference from the prior work of David Ricardo. The original version of the H-O theorem with two factors, two goods, and two countries was too restrictive. Vanek (1968) generalized the model to a many goods and many factors market. The resulting Heckscher-Ohlin-Vanek (H-O-V) trade model shows that if a country is endowed with more of a factor relative to the world endowment, then that country will export the goods that embody the abundant factor of production, or more generally it will export the services of that factor. Factor price equalization between the two countries may occur under the assumption of free and frictionless trade.

It is difficult for the H-O-V model to explain trade between countries with similar endowments such as the U.S., Australia, and many others. The model cannot explain why the U.S. imports and exports the same good (i.e. meat or grains). Using the Dixit-Stiglitz (1977) love-of-variety utility function, Krugman (1980) introduced a model of trade with imperfect competition that can rationalize trade flows between countries that are alike (in terms of factor endowments). In the price comparisons performed in the preliminary empirical section of this paper, this notion of variety becomes essential. This study will assume that the quality of goods in a defined product classification is constant across exporter countries. On the supply side Krugman assumed increasing returns to scale, which deliver lower average total cost as output expands after trade liberalization.

An import tariff can be welfare reducing as shown in Figure 3.1. Let an importing country be a price taker with no world market power. Under free trade, the country's total welfare is the sum of consumer surplus, areas A-G, and producer surplus, area H as depicted for the importing country in Figure 3.1. Often the domestic producers lobby their government to impose an import tax to protect their industry. When a tariff is imposed, the domestic price rises to the level of the trade with tariff. Producer surplus increases a small amount from area H to the sum of area H and D. Simultaneously, consumer surplus decreases by areas D, E, F, and G. The government is able to earn the product of the per unit tariff and import quantity which is equal to area F. Overall country welfare decreases by areas E and G.

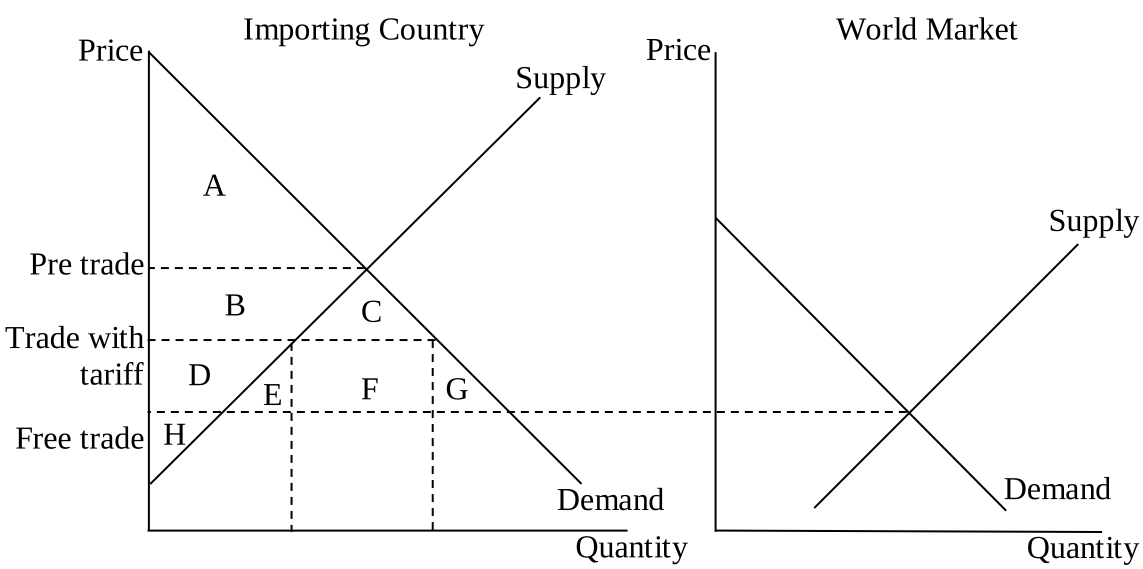

Figure 3.1: Surplus changes from trade tariffs

3.3 Previous Literature

The theory described in Figure 3.1 has been studied and results have shown positive impacts on a country's welfare when tariffs are lifted. Using Hicksian equivalent income measures for welfare, Clarete and Whalley (1988) show that interactions of trade policies with domestic distortions significantly change the welfare impact of trade policies. Removal of trade tariffs increased welfare by 3.4% of income in their model of the Philippines using

1978 data. A 5.2% increase in welfare could be gained upon removal of tariffs and quotas. Clarete (1989) found that raising the agricultural tariff to protect that industry provided less welfare gains than other options. The productivity of U.S. workers was reported to have increased significantly during the 1995-2010 time period. Feenstra, Mandel, Reinsdorf, and Slaughter (2013) found that 20% of this productivity increase was actually from gains in terms of trade due to tariff reductions. They note the large productivity rate increase from 1948-1973 was potentially being driven by the fast growth in U.S. trade and substantial trade liberalization.

Helpman and Krugman (1989) provide a theoretical explanation. They designate the social welfare function as $W(p^d, L + p^d y - C + tm)$, where L is labor income, the wage is equal to 1, the domestic price, $p^d = p^w + t$, with p^w being the world price, t being the tariff , y being domestic production, C being the cost of domestic production, and m being imports, with $m = d(p^d) - y$. Totally differentiating W yields $\frac{dw}{dt} = t\frac{dm}{dp^d}\frac{dp^d}{dt} - m\frac{dp^w}{dt} + (p^d - C')\frac{dy}{dt}$. The impact of the tariff on the world price is $\frac{dp^w}{dt}$. If the importing country is small, then it will have no impact on world price and the term will therefore be zero. The impact of changes in output times the profit margin is represented by $(p^d - C')\frac{dy}{dt}$. Perfectly competitive markets are assumed to earn zero profit margin. Therefore, if the industry is assumed to be perfectly competitive, then the impact of $(p^d - C')\frac{dy}{dt}$ will be zero. The efficiency cost of the tariff is represented by $t\frac{dm}{dp^d}\frac{dp^d}{dt}$ and it is smaller than zero. Using this, Helpman and Krugman (1989) conclude that a small country with a perfectly competitive industry will maximize welfare with a zero tariff. In the case of a large country, ($m\frac{dp^w}{dt}$)>0, and therefore the optimal tariff is not necessarily zero. Brander and Spencer (1984) prove that a small specific tariff increases welfare of the home country when the importing firm is a monopoly with constant marginal cost and marginal revenue steeper than demand. Feenstra (2004) notes a monopolistic competition assumption will cause efficiency loss through the term $(p^d - C')\frac{dy}{dt}$. In the case of the United States, country size and market conditions could impact the elasticity of the tariff which would then influence the impact of tariff removal on welfare.

Clarete and Dela Peña (1992) used the 50-sector Agricultural Policy Experiments (APEX) CGE model to examine four options for tariff policy for the Philippine economy. The following options reduced tariffs nearly 14%: a uniform percentage cut in tariff rates equal to a weighted average; a uniform 10 percent tariff rate; and a uniform 10 percent on value added. They conclude that all policies have positive changes on consumption and aggregate income. They note the value added tariff would cause production resources to move toward the production with high value added. Normally this would be good, but in this case it is driven by a distortive tax and not by patterns of market demand. For this reason their model finds the uniform tariff has higher benefits than the value added tariff (Clarete and Dela Peña, 1992).

Welfare changes due to reduction in agricultural trade restrictions were less than 1% of national income in the Philippines (Clarete and Rousmasset, 1990). The authors indicate the small change could be due to inelastic supply and demand; the tariff originally only created a small deadweight loss. Helpman (1990) points out that for small tariffs, the term $m\frac{dp^w}{dt}$ is close to zero. Therefore, tariffs only affect welfare through changes in output per brand. If a tariff is placed on one brand, the welfare impacts depend on the size of opposing forces. The tariff has no impact on the country to which the brand is exported. The only way the tariff helps the domestic producer is if domestic consumers change from the imported brand to the domestic brand. This is offset by higher prices overall for all brands, and consumers may substitute toward another good (Helpman, 1990).

The availability of substitutes has a significant impact on price elasticity. Pre-AUSFTA tariffs between the U.S. and Austria were small. Applying Helpman (1990), the U.S. consumers may have switched to a lamb substitute such as domestic chicken or pork in response to a tariff placed on imported lamb. Removal of the tariff should lead to an increase in lamb consumption in the U.S. as a response to the decrease in price. However, a tariff rent may exist that prevents prices from fully adjusting. Tariff rent would be equal to any post tariff price minus the free trade world price. This would prevent the market from fully adjusting imports from Q_{dt}-Q_{st} to Q_d-Q_s and prices from decreasing from P_t to P_w (see Figure 3.2)

An absolute case would be if wholesalers continued to charge retailers the tariff price while importers dropped the price to P_w. Wholesalers need to have market power or customers would need to experience large search costs to do this. Another possibility would be if all intermediaries took a small part of the tariff rent, leaving producers and consumers with no change in price paid or received. With no access to comprehensive data of intermediaries, only a theoretical discussion of market power can be made. The focus of this research is to estimate the elasticity of import prices with regards to the importer, not the chain of intermediaries. An exporter with market power may raise their price to P_t such that importers pay the same price after the tariff is removed. This would maintain quantity sold at $Q_{st,}$ and exporters would receive the producer surplus (tariff rent) equal to the shaded area in Figure 3.2.

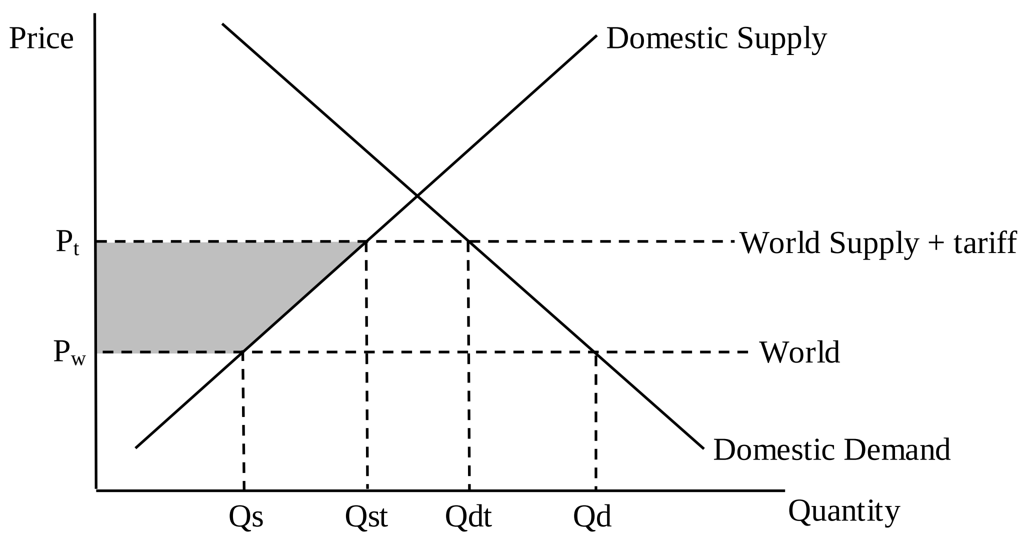

Figure 3.2: Tariff rent

Slaughter (2001) investigates factor price convergence in the H-O theory by looking at the U.S. between 1820 and 1860. During this period, physical trade barriers (transportation costs) were dramatically reduced due to construction of an extensive transportation network. They found prices across regions converged but not wages. One reasoning stated is factor price convergence may have occurred, but mainly on non-labor factor prices such as capital and land rent. This paper will consider this possibility that trade can lead to different changes in land rents and rents to (transportation) intermediaries of the exporter, which may result in a large response of import prices to reduction in tariffs.

Extensive literature shows agricultural land rent capitalizes policy shifts, thus returning the market toward zero profit. Goodwin and Mishra (2003) state, "The current value of a parcel of land is the sum of expected future cash flows discounted according to the risk of these cash flows. Farmland in the United States gives rights not only to cash flows from the market (sale of the crop), but also to payments from the government" (p. 745). They found the Market Loss Assistance (MLA) program, which was not expected by land owners in 1998, increased land value in 1999 by $6.50 per acre for every $1 of payment. This is a 650% capitalization of the change in government policy. Response of agricultural input suppliers to a free trade policy could be similar. Perfect competition among producers would indicate profits would be driven to zero such that producers, intermediaries, and consumers would all experience a change.

Barnard, Whittaker, Westenbarger, and Ahern (1997) studied the Corn Belt and found a 1% reduction in government programs resulting in a 0.3% reduction in farm land value. Shaik, Helmers, and Atwood (2005) included 48 states from 1940-2002 and found nearly identical results, reporting a 10% reduction in government program payments resulted in a

3% reduction in land values. They also concluded that government programs made up 15%-20% of land values in 1980-2002.

Evidence of inequitable distribution following free trade has been shown in the literature on tariff rents. Cirera (2014) examines the European Union's preferential trade agreements with a number of developing countries so these countries can increase exports, attract investment, and develop efficient industries. The preferred country has the opportunity to extract a price rent by selling their item at the same price as a close substitute from a country that must pay a tariff. Prices for preferred nations are lower on average, but not by the full extent of the tariff. Tariff incidence is estimated to be low and positive. Exporters and importers do earn price rents from the preference margins. Exporters receive up to 59% of the preference margin (Cirera 2014).

Chang and Winters (2002) studied Brazilian tariffs. They found that lower tariffs on preferred countries actually push down the prices of non-preferred. They also find that the incidence of tariffs on U.S. imports is very strong. Hellerstein (2006) shows markup adjustments by manufacturers and retailers are responsible for some of the tariff rent from shocks to import prices in the United States. Preferred trade agreements with the textiles industry in Africa only allowed for 1/3 of price rent from the full tariff (Olarreaga and Ozden, 2005). Two thirds of the tariff was captured by Caribbean apparel exporters (Ozden and Sharma, 2004). These papers are a strong indicator that participants in the U.S. trade markets could earn price-rent when tariffs are lifted by not allowing prices to reach world market levels.

Previous literature has shown free trade can improve welfare. However a change in government policy can be capitalized by individual participants in the market, and tariff rents can be inequitably distributed. This study will focus on prices, but it is important to note that a price decline from a reduction in tariffs does not necessarily improve welfare. Factors such as how or if the reduction is passed along to consumers is important. Reductions in welfare from other international trade agreements should also be considered in evaluating changes in overall aggregate welfare.

3.4 AUSFTA

A free trade agreement between Australia and the U.S. had been attempted in the 1980s and was proposed by George H. Bush in 1992. In 2001, U.S. President George W. Bush and the Australian Prime Minister John Howard began taking steps toward a free trade agreement. The result of their negotiations was the AUSFTA which came into effect January 1, 2005. AUSFTA eliminated many tariffs on items traded between the U.S. and Australia. The Office of the United States Trade Representative reports that within four years U.S. exports to Australia increased by 33%. Australian exports to the U.S. increased by 3.5%.

AUSFTA was selected as the country of interest to eliminate several issues. Being a modern trade agreement, data before and after the structural break was readily available. Only two nations were involved, which allows for simpler econometric modeling. Trefler (1995) showed H-O-V can perform poorly when countries are very different in terms of productivity of technology and human capital. The U.S. and Australia have many similarities as presented in Table 3.1.

Table 3.1: Comparison of U.S. and Australia. Source: World Bank

	Life expectancy	GDP per Capita	Education in years	Value Added per worker	Land area in Agriculture	Language
U.S.	79	$53,042	13.5	$63,269	44%	English
Australia	82	$67,458	10.5	$50,334	52%	English

Schott (2004) showed product quality difference within a single item from a trade classification can lead to differences in unit values. The more raw materials are manipulated and processed to add value to a product, the more room exists for quality differences. To minimize these effects, this study will focus on agricultural products which generally are less processed than manufactured goods. If trade continues after the tariff is removed, then quality and variety will be assumed to have changed little if at all. A nearly perfectly inelastic price is hypothesized and exporter retention of almost none of the tariff rent is expected.

All agricultural commodities were considered for this study. The commodities for which no tariff shock occurred due to AUSFTA were removed from the data set. Remaining commodities were evaluated for volume to prevent outliers. Commodities for which zero, little, or sporadic trade volume occurred were removed from the data set. The remaining commodities were evaluated for consistent data over the desired time period. Table 3.2 and

Table 3.3 report the Australia and U.S. product groups used in the evaluation of AUSFTA. Note that most Australian imports (from the U.S.) used in this study are fruits, vegetables, or plant products, while U.S. imports (from Australia) are mainly meat.

Harmonized Schedule (HS) codes are used to identify the products. They define internationally agreed upon product groups and are a common way to identify products in academic research. The data for the quality and makeup of items exported within the single commodity code is unavailable. For example, HS code 110520 contains potato flakes, potato granules and potato pellets. When the tariff was removed the change in relative price could have come from an increased proportion of 110520 being potato flakes as opposed to potato pellets. However, with using a 6 digit HS code, HS-6, the relative make up and quality changes will be smaller than if a broad HS-4 code is used.

A number of different types of tariffs exist, and comparing the same type across commodities is important. Tariff rate quotas allow a certain amount of products to be imported and then charge a tax on imports over the quota limit. For example, the U.S. charges a 4% tariff on some beef imports from Australia over the quota. Suppose in one year only 1% of imports were over the quota, and the following year 50% of all imports were over the quota. Using 4% as the tariff rate in both years would not provide results that could be compared with products that had a 4% tax on all imports. Countries negotiate for the highest possible allowable tariffs during WTO meetings. Very often after these meetings, countries negotiate lower applied tariffs they actually charge. It would not be uncommon for a 15% tariff to exist in official agreements for two products, but instead a country chooses to apply a low 3% tax to one of those products. Using a 15% tariff rate for modeling would not generate accurate results. For these reasons, the tariff rates used for this study will be the effectively applied tariffs (AHS tariffs). AHS tariffs produce comparable results that are meaningful. AHS tariffs convert tariff rate quotas and quota limits into comparable ad-valorem tariff rates. In addition, AHS tariff data use the tariff rate that is actually charged. In some cases the AHS tariff reported for a HS-6 code is actually the average of the two different tariffs at the underlying HS-8 level. The average weighted AHS tariff accounts for any trade volume differences when determining the average at the HS-6 level. Average weighted AHS tariff data from 1997-2013 was obtained from WITS Worldbank TRAINS data set.

Retail prices could be biased by markups of distributors, wholesalers, and retailers as previously discussed. To employ data which account for those types of bias would require extensive data collection similar to that done by Atkin & Donaldson (2015) in Africa which is not feasible within the constraints of this paper. Instead, in this paper I use the customs value of products (unit values). This value is the price paid by the importer for commodities and does not include tariffs, freight or insurance. The value should not decrease from a removal of tariffs since they are not included.

3.5 AUSFTA- Difference in Difference

As shown in Figure 3.2, there is a wedge between the world price and the tariff price. Empirically this wedge can be calculated by taking the ratio of the average price the importer paid from the world, P_{iw}, and comparing it with the average price the importer paid the exporting country of interest, P_{ij}. The difference of the two ratios will be impacted by the relative transaction costs between the trading partner of interest and the trading cost of all other partners. The relative quality of the import from the country of interest will also impact the magnitude and sign of the wedge between the price paid to the world and the price paid the country of interest. Any changes in transaction cost or product quality are assumed to be similar for all trading partners. In particular, the relative transaction costs and product quality are assumed constant over time between the U.S. and Australia.

If customs unit value remains constant after tariffs are removed, then exporters do not have enough market power to extract tariff rents. Importers will be said to have an elastic demand. In this case, the hypothesis that the exporter was able to receive no tariff rent will not be rejected. If the customs value paid increases after tariff reduction, then it can be concluded that exporters earn tariff rents by increasing the price towards what the market previously was bearing with a tariff. Because the proportion of the difference between the world price and the price paid by the importer that is due to transaction costs and quality difference is not known, it is assumed that it remains constant after the change in tariffs. It is, however, possible that some of the price change after the tariff removal is due to changes in transaction costs or changes in product quality. Also, no conclusion can be made about the elasticity of the wholesale, or retail price given the data used in this study.

The Difference-in-Differences econometric approach removes hard to measure price indices and home bias effects from the importing country (Hanson and Xiang, 2004). This approach removes many unobservable shocks that could cause bias. Wolf, Schulze, and Heinemeyer (2011),Topalova (2010), Hakro (2009), Wacziarg and Welch (2008) and Hanson and Xiang (2004) all used the Difference-in-Differences methodology to study impacts from changes in trade.

The first difference is determined by comparing the price ratio of a good imported from the world and the country of interest. Ratios are necessary because various products imported have large differences in value. Ratios are calculated annually by taking the customs unit value paid for a good from the country of interest and dividing it by the average customs unit value paid for the good from all countries. For example, if Australian unit value for a product imported in the U.S. is $1.20, while the average unit value for this product is $1.00, then Australia's price is calculated to be 120% of the world price. The 20 percent premium could be influenced by a large number of factors which are differenced out using the second step in this methodology.

The average price ratio of the product is calculated pre AUSFTA; $APRpre_x = (\sum_{t=1997}^{2004} P_{xt})/8$ where $P_{xt}$is price of product x at year t. This is compared with the average ratio of that product post tariff decline; $APRpost_x = (\sum_{t=2006}^{2013} P_{xt})/8$. To avoid learning and sticky prices, 2005 data are not included. The difference between the average price ratios of each product is calculated to determine if a change occurred; $\Delta APR_x = APRpre_x - APRpost_x$. The average change over all products is then determined; $AVG\Delta = (\sum_{x=1}^{n} \Delta APR_x)/n$.

Calculations show that Australian importers paid an average of 0.05 percentage points more for U.S. goods after import tariffs were removed. This supports the notion that exporters earned tariff rents. However, the magnitude of the increase is economically insignificant considering the average tariff decreased by nearly five percentage points. Hence, the import price is found to be inelastic with respect to changes in tariff rates. An increase in the price of U.S. goods could have resulted in Australia purchasing goods from other countries such that a reduction in the price would not have increased U.S. producers' revenue. This indicates that Australian consumers likely have some market power. The U.S. exporters do not gain significant tariff rents from removal of the Australian import tariffs.

On the other hand, prices paid by U.S. importers to Australian exporters relative to what the rest of the world paid fell by 0.23 percentage points after AUSFTA. Note that customs values do not include tariffs, so a decrease in this price is not consistent with theory. A possible, but perhaps unlikely, explanation is economies of scale or volume negotiation. Greater quantities could have results in economies of scale for the exporter or greater negotiating power for the importer. Both would allow for lower prices. To check this, trade volume was examined. There was greater trade volume for 75% of the products which had a lower price ratio after 2005, and lower trade volume for 100% of products with a greater price ratio after 2005. A more plausible explanation is there was a shock to the market for these products that was unrelated to trade but was not differenced out in the econometric specification. The price and trade volume changes do indicate the U.S. has some market power in these products.

Difference-in-Differences modeling indicates that Australian and U.S. importers have some market power in the commodities studied. The large market size of Australia and the U.S. make these results consistent with the findings in the existing literature. The results fail to reject the hypothesis that these exporting counties are unable to earn tariff rents from these importers. However, the rents are extremely small and economically insignificant.

3.6 AUSFTA- OLS estimation

Following Schott (2004), a model is estimated to determine the U.S. price elasticity of imports with respect to tariff changes following AUSFTA. As discussed in Chapter 1, modeling using the double log will allow linear modeling of non-linear relationships, generate elasticity results, reduce the impact of outliers, and alleviate heteroscedasticity concerns.

$$(3.1)\quad \ln(\mathrm{P}_{xit}) = \beta_0 + \beta_1 Tariff_{xjt} + \beta_2 lnGDP_{it} + \beta_3 Year_t + \beta_4 Product_x + \varepsilon_{xit}$$

where P_{xit} is the of unit price of product *x* paid by U.S. importer *i* in year *t*. $Tariff_{xjt}$ is the tariff placed on county *j*'s product *x* in year *t*; tariff data are in percentage points and therefore will not be logged. The coefficient β_1 estimates the percent change in unit values resulting from a one-percentage point change in the tariff. For example, a β_1 of 0.9 would imply that a tariff rate change from 5% to 6% would generate a 0.9% increase in the import price of good x. If the tariff rate were placed into log form, then a 1% change in the tariff rate, from 5% to 5.05%, would generate a 0.9% change in the price of good x. GDP_{it} is country *i*'s (the importer) gross domestic product in year *t*. Hence, the coefficient β_2 estimates the response of the import price resulting from a change in the buyer's income. A dummy variable, $Year_t$, will be used for each year to account for changes in transportation cost and insurance cost common to all countries exporting to the U.S. $Year_t$ will also account for changes in quality or variety over time within the HS code and other unobservable factors. A dummy variable, $Product_x$, is used for each good in order to capture product-specific heterogeneity that is time invariant.

Table 3.4 reports the results for Australia as an importer. The coefficient on the tariff is significant at the 10% level with an expected negative sign. β_1 implies when the tariff was reduced by one percentage point, U.S. producers' prices of exports to Australia rose by 0.16%. Given this price response, one could conclude that the demand is not perfectly inelastic, yet still quite inelastic. This result is not completely inconsistent with the findings from the Difference-in-Differences approach. Australian importers have some market power as they can keep 0.84% of every 1 percentage point reduction in the tariff. U.S exporters may extract a small amount of tariff rent by charging a higher purchase price, knowing the market was able to bear the price plus tariff prior to AUSFTA.

The results of the U.S. model are presented in Table 3.5. The coefficient on the tariff influence, β_1, is positive and significant at the 10% level. This indicates U.S. importers paid lower prices as a result of lower tariffs. The coefficient, 0.035, is not economically significant. This supports the hypothesis that Australian exporters cannot earn tariff rents in the U.S. market. Similar to the results for Australian imports in table 3.4, the U.S. model is consistent with the Difference-in-Differences approach. Both found a small positive relationship between tariff rate and price paid. Note that the data analyzed in this case consisted mainly of trade in meats. An unknown shock to this one undiversified category is a plausible explanation the counterintuitive finding.

AUSFTA provided a convenient structural break which allowed both a Difference-in-Differences approach and OLS regression using actual tariff rates. The two sets of results from each specification are broadly consistent with each other and they suggest that neither country has complete lack of market power in the commodities they imported. Differences in market size and power between the U.S. and Australia may be a cause for the slight difference in results between the countries. Unfortunately, our estimates cannot be generalized due to the small number of commodities that were considered in the empirical analysis.

3.7 World Trade

Reductions of agricultural tariffs were generally not considered in GATT negotiations. It was not until the Uruguay round ending in 1994 that trade agreements included the agricultural sector. This section will investigate the impact on the price U.S. importers pay in response to a reduction in tariff rates on nearly all agricultural commodities imported from the top trading partners of the U.S. Results will be useful to policymakers in determining the welfare impacts from trade liberalization.

The top 2/3 of trading partners that import into the U.S. will be modeled. China, Mexico, Canada, Japan, South Korea, Germany, and the United Kingdom have consistently been the top seven exporters to the U.S. since 1995. France and Italy moved ranks between 1995 and 2012 but were consistently in the top 12. Table 3.6 presents percentage of U.S. imports that originated from these countries.

All Agricultural goods in the HS categories 01-24 are used in the empirical analysis. A description of each of the categories is presented in Table 3.7. HS6 aggregation was determined appropriate for this study. Simple average and weighted average tariffs were identical for all observations. This indicates that at the higher level of disaggregation, tariffs were either identical or most products were categorized identically. Less aggregated 8-digit and 10-digit level HS classifications were considered. This level of data would reduce impacts from differences in quality within codes. However, the data were found to be too specific such that a single HS code only had a few data points. In addition, HS-8 and HS-10 are not standardized across countries' tariff schedules (USIT). This creates challenges to obtaining consistent results that are comparable across the entire sample of countries and over time. Greater levels of product aggregation, HS-4, were found to be too general with large quality differences within a single code.

HS codes change over time to allow for new products and changes in existing products. This study uses 1992 HS codes such that the data set includes years both pre- and post-Uruguay round, NAFTA, AUSFTA, and the Korea free trade agreement. The use of older HS codes comes at the expense of some data loss due to aggregation of modern HS definitions. 1992 HS codes that are disaggregated into different HS codes will be assigned the average of the tariffs from the new codes. For example, HS-010519 -- live ducks, geese, and turkeys -- was split in 1996 into 010519 live ducks, geese, and heavy turkeys and 010512 light turkeys. From 1996 forward HS-010519 was the sum of 010519 and 010512 with a tariff equal to the average of the two tariffs. There will be some loss of accuracy; however, many of these averages had zero tariff before their split and zero on both HS codes afterwards. Therefore, potential inaccuracies are minimized. HS codes that are aggregated over time cannot be separated without manual manipulation, estimation, and removal of data. This creates the opportunity for human errors and poor estimation, so such codes were excluded from the empirical analysis.

Conversion of 2012 HS codes to 1992 HS codes would require the average tariffs for 340 of 1,077 total product codes (32%) and inaccurate manual manipulation on 286 of 1,077 product codes (27%). In total, 59% of the data would need some form of adjustment. Upon inspection, it was found that most of the conversion problems occurred with the aggregation and disaggregation after 2011. By limiting the data set to 2011, only 116 of the remaining

723 product codes (16%) would use the average tariff approach and only 11 of the 723 product codes (1.5%) would require a potentially inaccurate conversion. In total, 17% of the data would need adjustment. The marginal loss of data by using 19 years of data (1992-2011) as opposed to 22 years (1992-2014) far offset the marginal gain of fewer potential data issues, 27% vs. 1.5%. With the restricted data, 1991-2011, only 7% of all observations needed the average tariff approach and only 0.5% of all observations needed manual manipulation because of non-zero tariff when HS codes are combined. Hence, this study will use 1992 HS-6 product codes from 1992-2011.

The customs value of products is used. This represents the value the importer pays to the exporter for the good. It does not contain the tariff paid, so a reduction in tariff should not decrease this value. Also, this value does not provide information to how prices along the marketing chain to the consumer will be impacted. As discussed previously, the average weighted HS tariffs (AHS) are used. Data were obtained using the World Integrated Trade Solution (WITS) which accesses data from the Trade Analysis Information System (TRAINS) and United Nations Commodity trade (UN Comtrade) data. STATA software was used to import and merge the TRAINS data with UN Comtade data.

3.8 World Trade Estimation Results

There was no single free trade agreement which impacted all trading partners simultaneously, so a Difference-in-Differences methodology cannot be employed. Elasticity of the price with respect to tariff changes will be estimated using the OLS model similar to Schott (2004) and shown to be robust in modeling the AUSFTA above.

(3.2) $\ln(\mathrm{P}_{xt}) = \beta_0 + \beta_1 Tariff_{xjt} + \beta_2 lnGDP_t + \beta_3 Year_t + \beta_4 Country_j + \varepsilon_{xt}$

P_{xt} is the unit price of product *x* paid by the U.S. importer, in year *t*. $Tariff_{xjt}$ is the tariff placed on country *j*'s product *x* in year *t* by the U.S. Tariff data are in percentage points and therefore not logged. The coefficient β_1 estimates the percent change in unit values resulting from a change in the tariff by one percentage point. GDP_t is the U.S. gross domestic product in year *t*. The coefficient β_2 will estimate the import price response from a change in the buyer's income. Dummy variables for years ($Year_t$) and trading partners ($Country_j$) will be used to account for differences in transportation cost, foreign productivity, and product quality or variety over time (but fixed across partners) or across partners (but fixed over time). The vast number of different products does not allow for product dummy variables. Also, STATA was used to create 690 clusters of HS codes for HS fixed effects.

The results support the hypothesis that exporters retained no significant tariff rent and the U.S. importer had market power. Tariffs are found to be statistically significant at the 95% confidence level as reported in Table 3.8. The elasticity implies a one percentage point reduction in tariff rates resulted in an increase of 0.002 percent in the price received by foreign exporters to the U.S. Although statistically significant, this is not economically significant. Demand is estimated to be almost perfectly inelastic with respect to changes in tariffs. On average, foreign exporters to the U.S. are not able to extract tariff rents on agricultural products. This confirms the conventional wisdom that as a whole the U.S. has international market power in agriculture.

The lack of price response to a tariff reduction as a result of market power could vary across trading partners or products. This cannot be seen in the aggregated model, so each trading partner is modeled separately with results presented in Table 3.9. France, Germany, and Japan have statistically significant positive coefficients at the 5% level for β_1. However, none of the coefficients for any of the countries are economically significant. Other countries were estimated to have insignificant coefficients. This is supportive of the hypothesis that none of the top 2/3 of exporters to the United States earn tariff rents, as customs value prices U.S. importers pay are unaffected by changes in tariff rates.

Market power could vary across product categories, as well. This could cause a few commodities to overwhelm the majority and skew results. Fish and shell fish make up approximately 18% of U.S. imports between 1999 and 2011. Fruits and beverages make up the next largest component at 12 each%. These three categories along with liquor comprise nearly 50% of U.S agricultural imports.

To further study tariff rents, products are modeled separately within their HS-2 categories across all countries. Results are presented in Table 3.10. All categories except tobacco had the anticipated positive relationship indicating an increase in customs value price when the tariff was removed. The magnitudes of the elasticities were not economically different from zero. Most indicated less than a 0.1% response to a one percentage point change in the tariff. This provides further support that prices exporters to the U.S. received were not responsive to changes in tariffs. HS-01 (live animals) was an exception. Manual inspection of the data showed that HS-010600 was significantly influencing the live animal category. This code is for all live animals not listed elsewhere. Note that horses, mules, bovine, swine, sheep, goats, chickens, turkeys, ducks, and geese are listed elsewhere. This category contains unusual animals such as parrots, turtles, dolphins, rabbits, pigeons, and primates. Given the unique market for such live animals, the increase in customs value may be driven by a factor that is unobserved but correlated with tariffs. Or alternatively, foreign sellers of these animals do have market power. Overall, the U.S. importers were found to have market power in 23 of the 24 agricultural categories that were analyzed which include the four categories that make up nearly 50% of imports.

Country of origin labeling (COOL) requirement took effect March 2009. These rules require the county of origin of fresh fruit, vegetables, shellfish, fish, certain nuts, and certain cuts of beef, pork, chicken, lamb and goat to be made obvious to consumers. The strict guidelines meant that a calf that had been born in Canada and imported to the U.S. to be grown and slaughtered in the U.S. was excluded from being labeled with U.S origin. The beef from this animal would be labeled the same as beef that had been born, raised and slaughtered in China. In addition to potential impacts on consumer demand, costly tracking requirements were put in place. In response to complaints made by Canada Mexico and other countries, a WTO panel examined COOL requirements and in 2011 concluded that COOL caused a trade distorting impact placing imported livestock at a less favorable position to domestically born, raised and slaughter livestock. In 2013 the USDA revised COOL such that the required labeling disclosed the location of each production step; born, raised, slaughtered. In 2014 a WTO compliance panel found the revised county of origin requirements continued to treat imported livestock less favorably. As a result, an arbitration panel set retaliation measures against imports of products from the U.S. at nearly $3 billion for Canada and Mexico. The U.S. repealed beef, pork, and chicken from the COOL statue in 2015 and a voluntary labeling act was introduced. (Greene. 2015)

COOL is not a tariff so the impacts could not be directly integrated into this study. Fixed year effects used in modeling should have accounted for some of the impact. The overall impact of COOL on these results is believed to be small because it only began to take effect in the last three years of a nineteen year data set. To confirm this, analysis was performed using only data prior to 2009. The difference in results was negligible.

3.9 Conclusion

In conclusion, this research supports the hypothesis that prices paid by U.S. importers to foreign sellers of agricultural products are not responsive to changes in tariff rates, i.e. product demand is inelastic. Exporters to the United States are unable to earn tariff rents. Unlike previous studies, the exporters in this study were developed countries with potential for market power. It is possible the U.S. does not necessarily have market power. Instead exporters could simply be facing a perfectly competitive market. If one exporter attempts to capture a tariff rent, then U.S. importers will simply purchase all their products from other sellers. Most agricultural products have similar qualities allowing importers to have only a minor preference for a particular supplier.

These findings have policy implications as to the impact on U.S. welfare from a reduction in tariffs. This study has shown when tariffs are removed; foreign exporters to the U.S. continue to receive the same price and are unable to capture any tariff rents. This could lead to a welfare increase in the U.S. However, it cannot be concluded that the U.S. should remove tariffs. The impact on prices received by U.S. producers who compete with imports has not been studied in this paper. The impact on developing or infant agricultural industries has not been considered either. The possibility of additional increase in welfare that may stem from effects on intermediaries along the marketing chain to consumers has not been examined. Prices U.S. exporters received from the reciprocal free trade have not been considered, nor have any positive welfare effects that may occur from other concessions in exchange for tariff removal.

3.10 Tables

Table 3.2: Commodities the U.S. imports from Australia

Commodity	HS	2004 Tariff	2005 Tariff
Meat of bovine, fresh/chilled, bone-in	020120	Varies over sub category. 4%, 10%, 26.4%, 4.4 cents/kg	Tariff rate quota. Increasing limits until elimination in 2024
Meat of bovine, fresh/chilled, boneless	020130		
Sheep (excl. lamb) fresh bone-in cuts	020422	2.8 cents/kg	$0
Sheep (excl. lamb) fresh boneless cuts	020423	2.8 cents/kg	$0
Lamb carcass frozen	020430	0.7 cents/kg	$0
Sheep carcass frozen	020441	2.8 cents/kg	$0
Sheep (excl. lamb), frozen, bone-in	020442	2.8 cents/kg	$0
Sheep (excl. lamb), frozen, boneless	020443	2.8 cents/kg	$0
Crab meat frozen	030614	7.5%	$0
Crab meat not frozen	030624	7.5%	$0
Sunflower oil crude	151211	1.7 cents/kg+ 3.4%	Decrease .425 cents/kg + .85% every year. Until $0 in 2009

Table 3.3: Commodities Australia imports from U.S.

Commodity	HS	2004 Tariff	2005 Tariff
Grapes, fresh	080610	5%	0%
Strawberries, dried	081110	4%	0%
Prunes, dried	081320	5%	0%
Apples, dried	081330	5%	0%
Fruits, dried	081340	5%	0%
Potato Flour, meal	110510	5%	0%
Potato flakes, granules, pellets	110520	5%	0%
Sunflower seed or safflower oil, other	151219	5%	0%
Cotton seed oil, crude	151221	5%	0%
Linseed, crude	151511	5%	0%

Table 3.4: Australia imports from U.S.

	F-score 19.9	R-Square 0.72	Obs 130
	Coefficient	Std. Err.	t-score, P>|t|
β_1, Tariff	-0.16	0.09	-1.77, 0.080
β_2, Ln GDP Importer	-1.22	1.81	-0.95, 0.346
β_0, Constant	14.27	18.24	0.78, 0.436

Table 3.5: U.S. imports from Australia

	F-score 87.72	R-Square 0.92	Obs 180
	Coefficient	Std. Err.	t-score, P>|t|
β_1, Tariff	0.035	0.02	1.76, 0.080
β_2, Ln GDP Importer	0.665	0.15	4.24, 0.000
β_0, Constant	-5.404	1.62	-3.34, 0.001

Table 3.6: Percentage of origin of U.S. imports

	China	Mexico	Canada	Japan	Germ.	South Korea	UK	France	Italy	Sum
1995	6%	10%	17%	18%	6%	4%	4%	3%	2%	70%
2000	8%	11%	18%	12%	5%	4%	4%	2%	2%	66%
2005	13%	11%	17%	8%	5%	3%	3%	2%	2%	64%
2010	18%	12%	15%	7%	5%	3%	3%	2%	2%	67%
2012	22%	14%	10%	8%	6%	4%	3%	2%	2%	71%

Table 3.7: HS2 classifications

HS 01	Live Animals
HS 02	Meat and edible meat offal
HS 03	Fish and crustaceans, mollusks and other aquatic invertebrates
HS 04	Dairy Produce, birds eggs, natural honey
HS 05	Products of animal origin not elsewhere specified
HS 06	Live trees and other plants, bulbs, roots
HS 07	Edible vegetables and certain roots and tubers
HS 08	Edible fruit and nuts, peel of citrus fruit or melons
HS 09	Coffee, tea, mate and spices
HS 10	Cereals
HS 11	Products of milling industry, malt starches
HS 12	Oil seeds and oleaginous fruits, miscellaneous grains
HS 13	Lac, gums, resins and other vegetable saps
HS 14	Vegetable planting material, vegetable products not edible
HS 15	Animal and vegetable fats and oils
HS 16	Preparations of meat, fish, crustaceans
HS 17	Sugars and sugar confectionery
HS 18	Cocoa and cocoa preparations
HS 19	Preparations of cereals, flour, starch or pastry
HS 20	Preparations of vegetables, fruit, nuts
HS 21	Miscellaneous edible preparations
HS 22	Beverages, spirits, and vinegar
HS 23	Residues and waste from food industries
HS 24	Tobacco and manufactured tobacco substitute

Table 3.8: U.S. imports from world

	F-score 49.5	R-Square 0.176	Obs 46,539
	Coefficient	Std. Err.	t-score, P>|t|
β_1, Tariff	-0.0024	0.001	-2.30, 0.02
β_2, LnGDP	0.455	0.035	12.8, 0.00
β_0, Constant	-5.44	0.495	-10.9, 0.00

Table 3.9: U.S. imports by country

Exporter	β_1, Tariff coefficient	Std. Err.	t-score, P>|t|
Canada	-0.0003	0.0008	-0.36, 0.72
China	0.009	0.0056	1.62, 0.106
France	0.002	0.0007	2.31, 0.021
Germany	0.002	0.0009	2.04, 0.042
Italy	0.015	0.0096	1.58, 0.114
Japan	0.014	0.0065	2.10, 0.036
Korea	0.034	0.0206	1.67, 0.096
Mexico	-0.000005	0.0009	-0.00, 0.996
United Kingdom	0.001	0.0022	0.62, 0.537

Table 3.10: U.S. imports from world modeled by product category

	Product description	β_1, Tariff coefficient	Std. Err.	t-score, P>|t|
HS 01	Live Animals	0.44	0.109	4.11, 0.001
HS 02	Meat and edible meat offal	0.052	0.036	1.43, 0.161
HS 03	Fish and crustaceans, mollusks and other	0.109	0.022	4.85, 0.000
HS 04	Dairy Produce, birds eggs, natural honey	0.030	0.005	5.69, 0.000
HS 05	Products of animal origin not elsewhere	0.341	0.279	1.22, 0.241
HS 06	Live trees and other plants, bulbs, roots	0.069	0.048	1.43, 0.178
HS 07	Edible vegetables and certain roots and tubers	0.047	0.009	5.17, 0.000
HS 08	Edible fruit and nuts, peel of citrus fruit, melons	0.040	0.014	2.83, 0.007
HS 09	Coffee, tea, mate and spices	0.052	0.042	1.23, 0.226
HS 10	Cereals	0.087	0.031	2.78, 0.014
HS 11	Products of milling industry, malt starches	0.126	0.027	4.62, 0.000
HS 12	Oil seeds and oleaginous fruits, misc. grains	0.005	0.004	1.03, 0.307
HS 13	Lac, gums, resins and other vegetable saps	0.040	0.040	1.00, 0.338
HS 14	Vegetable planting material, products, inedible	0.140	0.043	3.23, 0.009
HS 15	Animal and vegetable fats and oils	0.129	0.022	5.88, 0.000
HS 16	Preparations of meat, fish, crustaceans	0.063	0.020	3.14, 0.004
HS 17	Sugars and sugar confectionery	0.053	0.028	1.85, 0.085
HS 18	Cocoa and cocoa preparations	0.101	0.013	7.98, 0.000
HS 19	Preparations of cereals, flour, starch or pastry	0.042	0.008	5.53, 0.000
HS 20	Preparations of vegetables, fruit, nuts	0.023	0.012	1.95, 0.058
HS 21	Miscellaneous edible preparations	0.097	0.021	4.53, 0.000
HS 22	Beverages, spirits, and vinegar	0.025	0.013	1.92, 0.071
HS 23	Residues and waste from food industries	0.204	0.074	2.75, 0.011
HS 24	Tobacco and manufactured tobacco substitute	-.001	0.001	-0.55, 0.599

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