AN ECONOMIC ANALYSIS OF THE IMPACT OF DECOUPLED PAYMENTS ON FARM SOLVENCY IN THE UNITED STATES

by

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ABSTRACT

This thesis evaluates the effects of decoupled agricultural support payments on the debt-to-asset ratio of farmers in the top five states producing corn, cotton, wheat and soybeans from 1996 to 2011. Building on existing literature, this study estimates the broader impacts of decoupled payments on farm solvency by considering all decoupled payments made since their establishment in 1996. A theoretical model of profit maximization identifies the factors predicted to influence solvency, which include farm assets, income, expenses, scale, production risk, decoupled payments and operator characteristics. Following the literature, the relationship between these factors and farm solvency are estimated empirically using a linear regression model with data from the Agricultural Resource Management Survey, Farm Service Agency and Risk Management Agency. The results indicate decoupled payments have a positive relationship with the debt-to-asset ratio and that the elimination of decoupled payments in the upcoming Farm Bill could lead to decreases in farmers' debt-to-asset ratios by an average of approximately ten percent. Furthermore, an analysis of the effects of decoupled payments by primary crop designation suggests that only corn soybean, corn and wheat farmers' debt-to-asset ratios are significantly responsive to changes in decoupled payments. This study also finds the effect of decoupled payments on solvency is uniform across farm size. In addition to these results, this thesis also contributes to current literature by providing preliminary evidence of an endogenous relationship between acres operated and the debt-to-asset ratio, which appears to introduce a positive bias on the parameter estimate for decoupled payments in the linear regression model. Furthermore, when a two-stage least squares model is used to control for this bias, the results estimate a negative relationship between decoupled payments and the debt-to-asset ratio. Due to the change in the coefficient of decoupled payments between the two models, this study suggests that results from research failing to account for a potential endogenous relationship between acres and the debt-to-asset ratio should be interpreted with caution.

CHAPTER 1

INTRODUCTION

The agricultural sector is an important element of the U.S. economy. According to the USDA Economic Research Service (ERS) in 2011, the agricultural sector employed over two million U.S. citizens. Agriculture and agriculture-related industries accounted for 4.8 percent of nominal GDP and provided over sixteen million jobs in 2011 (ERS, Bureau of Economic Analysis).[1] In addition, in 2009 an estimated seventy-six percent of the total value of U.S. agricultural production was not exported, contributing to the $1.21 trillion in U.S. food expenditures in that year (ERS). The remaining $98.5 billion in U.S. agricultural production was exported, making up eleven percent of total exports in that year (U.S. Census 2012 Statistical Abstract).[2] Since 2009, exports and total U.S. food expenditures have continued to grow indicating increased demand for U.S. agriculture.

The growth in the agricultural sector has been primarily driven by large farms. In the early 1980s, most cropland was operated by farms with less than six hundred crop acres, but today most cropland is on farms with at least 1,100 acres (White and Hoppe, 2012). In 2002, only 1.4 percent of total U.S. farms had a market value of a million dollars, but these farms contributed 47.5 percent of the total value of sales in that year. By 2007, farms with over a million dollars in market value consisted of 2.5 percent of the total U.S. farms, and contributed 59.1 percent of the total value of sales (U.S. Census

[1] Agricultural related industries include forestry, fishing, hunting, processed foods, beverages, tobacco produces, textile mills, apparel and leather products, and food service and drinking places (ERS).
[2] These data come from the 2012 Statistical Abstract of the U.S. Census Table 827 entitled Agricultural Exports and Imports- Value.

2012 Statistical Abstract).[3] This suggests the growth in the agricultural market has been driven primarily by large-scale farms. This shift in production poses an interesting economic question about what forces have accompanied and contributed to the shift towards larger farms in the United States, and what implications the shift has for farm financial stability.

The USDA ERS reports larger farms realize better financial performance. They find larger farms utilize labor and capital more intensively, which provide them with the primary source of their financial advantage (White and Hoppe, 2012). Additionally, they suggest technological advancements, increased specialization, and economies of scale resulting in lower production costs per unit contribute to the growth in large farms (White and Hoppe, 2012). However, federal agricultural support programs may also be contributing to the growth of large farms by increasing the financial stability of larger farms relative to smaller farms (Key and Roberts 2006, Yee and Ahearn 2005). One type of agricultural support potentially influencing farm financial stability through production and resource allocation decisions is decoupled payments (Foltz, Useche and Barham 2012; Olson and Vu 2009; Donnellan and Hennessy 2012; Katchova 2010).

This thesis seeks to determine if a relationship exists between decoupled payments and farm financial stability. Decoupled payments are defined as payments farmers receive that are not influenced by current production decisions. The payments are intended to provide income for farmers in an otherwise volatile agricultural market without influencing production decisions. The World Trade Organization (WTO)

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[3] These data come from the 2012 Statistical Abstract of the U.S. Census Table 835. Farms--Number, Acreage, and Value of Sales by Size of Sales

classifies one type of decoupled payment, direct payments, as a “green box” policy.[4] In order to be considered a “green box” policy by the WTO, direct payments cannot be linked to current production and production cannot be a requirement to receive payments. “Green box” policies are considered minimally trade distorting and do not undermine market access and export competition. In order to receive the exemption from reduction commitments and financial limitations allowed for “green box” policies, it is important that direct payments are decoupled from production.[5] If there is a relationship between all types of decoupled payments and farm financial stability, then that may have implications for WTO “green box” policy compliance.

It is also important to consider the relationship between decoupled payments and farm financial stability because currently the Senate and the House of Representatives Agriculture Committees propose the elimination of the current decoupled payment programs in the upcoming Farm Bill (Paulson, Woodard and Babcock, 2013). No matter which proposal is passed the current decoupled payments programs will likely be eliminated. Therefore, it is important to understand how decoupled payments impact farm’s financial stability in order to make an informed policy decision. This thesis seeks to identify how farm financial stability may be influenced by the proposed elimination of decoupled payments in the current Farm Bill.

To determine how decoupled payments affect farm financial stability, this thesis estimates the effect of decoupled payments on farm debt-to-asset ratios. The debt-to-asset

[4] Direct payments began in 2002 as part of the Direct and Counter Cyclical Payment (DCP) program. DCP payments are considered decoupled, however direct payments are the only payments classified as “green box” by the WTO, counter cyclical payments are not.
[5] Information on “green box” policies was retrieved from the World Trade Organization webpage under agriculture explanation: domestic support. www.wto.org

ratio is used to measure farm solvency, which is an element of financial stability.[6] The debt-to-asset ratio is defined as the ratio of total farm debt to total farm assets (Park et al., 2011). Thus, it measures a farm's decision to leverage their equity to take on debt. Low levels of debt relative to assets may indicate that the farm is better insulated from the risks associated with commodity production, changing macroeconomic conditions, and fluctuations in farm asset values (Morehart, 2013). Using the debt-to-asset ratio, this thesis seeks to investigate the factors affecting a farmer's decisions to leverage their equity to take on debt to provide a better understanding of how decoupled payments influence farm solvency.

Some economic literature argues that decoupled payments influence farm financial stability (Katchova 2010; Antoni, Mishra and Chintawar 2009; Kropp and Katchova 2011). Kropp and Katchova (2011) focus on the effects of decoupled payments on liquidity and repayment capacity. Their results suggest that decoupled payments alter a farmer's access to credit and current production decisions. This thesis differs from their work by considering the effect of decoupled payments on farm solvency. Katchova (2010) and Antoni et al. (2009) both analyze the factors affecting the solvency of new and beginning farmers.[7] Their research identifies a relationship between farm size and solvency. Katchova (2010) finds government payments improve all elements of financial stability for experienced farms, except for solvency. This thesis investigates whether a relationship exists between decoupled payments and farm solvency across all farmer

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[6] Liquidity, repayment capacity, efficiency, profitability and solvency are the elements of financial stability, measured by financial ratios (Ahrendsen and Katchova, 2012; Katchova, 2010; Mishra Wilson and Williams, 2008; Kropp and Katchova, 2011; Hadrich and Olson, 2011; Mishra El-Osta and Steele, 1999).
[7] New and beginning farmers are defined by the United States Department of Agricultural as farmers with ten or less years of experience operating a farm or ranch.

experience levels. In addition, this thesis includes all decoupled payments since they were first introduced in 1996 to provide a more comprehensive analysis of the effects of decoupled payments on the debt-to-asset ratio.

According to the developed theoretical model for farm profit maximization, decoupled payments influence farm solvency by increasing farm income in the current period, which implies decoupled payments keep some farmers in business that would otherwise drop out of the market. Decoupled payments also influence the debt-to-asset ratio through the decision to acquire assets in the current period. The theoretical relationship between decoupled payments and the decision to acquire assets in the current period is ambiguous, thus no clear predictions are available for the effect of decoupled payments on farm solvency from the farm profit maximization model so empirical estimation is necessary.

Consistent with the literature, the primary empirical approach in this thesis is to estimate a linear regression model to characterize the effects of farm acres, assets, income, crop production, production risk, decoupled payments, expenses and operator characteristics on farm solvency as measured by the debt-to-asset ratio for farmers in the top five states producing corn, wheat, cotton and soybeans. This thesis uses farm-level data from the Agricultural Resource Management Survey (ARMS) from 1996 to 2011, where observations are weighted based on the probability of being selected from the total population of farmers. The ARMS is the only farm-level national survey that provides data about operator characteristics, farm business financial ratios, income and expense records, financial assets, and crop production information. These data are used in conjunction with county-level decoupled payments data from the Farm Service Agency and crop insurance premium and indemnity payment data from the Risk Management Agency.

Results from estimating the impacts of decoupled payments on farms' debt-to-asset ratio using a linear regression model indicate that decoupled payments have a positive relationship with the debt-to-asset ratio, which is suggestive of a negative relationship with farm solvency. Although the estimated positive relationship between decoupled payments and the debt-to-asset ratio is small in magnitude compared to most other explanatory variables, the results imply that the elimination of decoupled payments in the upcoming Farm Bill could lead to decreases in farmers' debt-to-asset ratios by an average of approximately ten percent. However, an analysis of the effects of decoupled payments by primary crop designation suggests that only corn soybean, corn and wheat farmers' debt-to-asset ratios are significantly responsive to changes in decoupled payments, implying they would be the farmers primarily impacted by the elimination of decoupled payments.[8]

A positive relationship is also estimated between farm size and the debt-to-asset ratio suggesting as farms grow they use a higher percentage of debt financing. The effect of decoupled payments on the debt-to-asset ratio is analyzed by farm size in an effort to understand whether decoupled payments have been a contributing factor in the growth of large farms. The results suggest that farm size does not affect the relationship between

[8] There are five farm designations defined by the primary crop produced in their state of location. Farm types consist of corn farmers, soybean farmers, cotton farmers, wheat farmers and corn soybean farmers.

decoupled payments and farm solvency. This finding lends support to the hypothesis that the effect of decoupled payments on farm solvency is uniform across farm size.

In addition to the linear regression results, this thesis contributes to current literature by providing preliminary evidence of an endogenous relationship between acres operated and the debt-to-asset ratio. Furthermore, the results from a two-stage least squares model, using state-level average temperature and total precipitation to identify acres operated, suggest there is a negative relationship between decoupled payments and the debt-to-asset ratio. This implies the elimination of decoupled payments in the upcoming Farm Bill will lead to increases in corn, wheat, cotton, and soybean farmers' debt-to-asset ratios on average.

According to the two-stage least squares results presented in this thesis, estimating the relationship between decoupled payments and the debt-to-asset ratio with an ordinary least squares model introduces a positive bias on the parameter estimate for decoupled payments. Although more research is necessary to identify the acres operated variable, this thesis serves as an important first step in properly modeling the relationship between decoupled payments and the debt-to-asset ratio. Due to the large difference in the parameter estimates of decoupled payments generated from the linear regression and two-stage least squares models, this study suggests that results from research failing to account for a potential endogenous relationship between acres and the debt-to-asset ratio are likely biased and should be interpreted with caution.

CHAPTER 2

HISTORY OF AGRICULTURAL SUPPORT PROGRAMS

From 1996 to 2011 decoupled payments, loan deficiency payments, federal crop insurance, and conservation payments were the primary sources of federal support received by corn, cotton, wheat and soybean producers.[9] In the past seven years, decoupled payments and crop insurance payments have become the primary source of federal support to agricultural producers (Glauber 2013). Decoupled payments are defined as payments farmers receive that are not influenced by their current production decisions. This includes Production Flexibility Contract (PFC) payments, Market Loss Assistance (MLA) payments and Direct and Counter Cyclical (DCP) payments. Considering the history of decoupled payments, loan deficiency payments, and crop insurance provides a better understanding of the variation in agricultural support payments potentially influencing farm solvency from 1996-2011.

Decoupled Payments

Federal Agricultural Improvement and Reform Act of 1996

The 1996 Federal Agricultural Improvement and Reform (FAIR) Act established Production Flexibility Contract (PFC) payments, which were the first form of decoupled payments. PFC payments were made based on a farmer's historical production area of

[9] Data from the Environmental Working Group (EWG) on total subsidy payments suggests decoupled payments, crop insurance premium subsidies, and loan deficiency payments make up 89.6 percent of total corn subsidies, 91.2 percent of total wheat subsidies, 75.4 percent of total cotton subsidies and 86 percent of total subsidies to soybean farmers since 1995. Although according to the EWG conservation payments totaled 38.9 billion between 1995 and 2012, they are not discussed in this study.

wheat, corn, grain sorghum, barley, oats, upland cotton, and rice to eligible landowners or producers with eligible cropland.[10] Under the FAIR Act, eligible producers and owners could opt into the seven-year Production Flexibility Contract during a one-time enrollment period. [11] Participants received annual contract payments based upon a predetermined total dollar amount for each year. The FAIR Act established an annual budget to distribute to farmers of eligible crops, and each crop received a percentage of the total budget. Table 2.1 shows the distribution of the total annual payments over the seven eligible crop types and the change in total annual budget from 1996 to 2002.

Table 2.1 Production Flexibility Contracts Payments by Crop from 1996 to 2002 (in millions of dollars)

Crop	Allocation	1996	1997	1998	1999	2000	2001	2002
Wheat	26.3%	1,462.7	1,414.1	1,523.1	1,471.4	1,347.1	1,084.5	1,052.5
Corn	46.2%	2,574.5	2,489.0	2,680.8	2,589.7	2,371.1	1,908.9	1,852.5
Sorghum	5.1%	284.6	275.2	296.4	286.3	262.1	211.0	204.8
Barley	2.2%	120.3	116.3	125.3	121.0	110.8	89.2	86.6
Oats	0.2%	8.4	8.1	8.7	8.4	7.7	6.2	6.0
Cotton	11.6%	647.8	626.3	674.5	651.6	596.6	480.3	466.1
Rice	8.5%	471.8	456.1	491.3	474.6	434.5	349.8	339.5
Total	100.0%	5,570.0	5,385.0	5,800.0	5,603.0	5,130.0	4,130.0	4,008.0

SOURCE: The Federal Agricultural Improvement and Reform Act of 1996 under Title I, subtitle B section 113 (a) and (b).

NOTES: The crop corn refers to corn for grain and cotton refers to upland cotton. The allocation percentage shown represents the percent of the total annual budget allocated to each crop rounded to the first decimal place. The values listed under the year represent the dollar value allocated to each crop in each year in millions rounded to the first decimal place.

[10] To be an eligible owner or producer, farmers had to assume all or part of the risk for crops produced on the land to which the PFC payment was tied, or be on eligible cropland with share-rent lease, or be on eligible cropland and cash rent the land. Eligible cropland is land that has contract acreage attributable to it. It must also have had either a portion of the land enrolled in the acreage reduction program authorized for a crop of a contract commodity for at least one of the 1991 through 1995 crops, or the land was subject to a conservation reserve contract under section 1231 of the Food Security Act of 1985.
[11] One-time enrollment period began 45 days after the enactment of the title until August 1, 1996.

Two calculations determined PFC payments made to farmers: the annual payment rate and the individual payment quantity. The annual payment rate is given by the ratio of total annual allocation to annual payment quantity, shown in equation (2.1). The total annual allocation is the dollar amount allocated to each crop for the year shown in Table 2.1. The annual payment quantity is the sum of all PFC payment acres for all farms producing the crop in that year.

$$Annual\ Payment\ Rate = \frac{Total\ Annual\ Allocation}{Annual\ Payment\ Quantity} \tag{2.1}$$

Equation (2.2) defines the individual payment quantity, where payment yield is the farm program payment yield established on the farm for the 1995 crop and base acres are eighty-five percent of the contract acreage for a farm. Multiplying the annual payment rate by the individual payment quantity generates the total dollar amount paid to an individual farmer in PFC payments.

$$Individual\ Payment\ Quantity = Payment\ Yield \times (Contract\ Acreage \times 85\%) \tag{2.2}$$

Production Flexibility Contract payments were subject to a few payment and planting limitations. The total amount of contract payments made to a person under one or more production flexibility contract during any fiscal year could not exceed $40,000.[12] In addition, farmers who enrolled in the PFC program could not plant fruits and

[12] Under the three-entity rule, an individual could receive directly from the government, up to $80,000 in contract payments on three separate entities so long as their stake in the second and third entities does not exceed fifty percent.

vegetables, other than lentils, mung beans and dry pea, on contract acreage.[13] They also had to meet certain conservation requirements and use contract acres for agricultural purposes. With the exception of some fruits and vegetables, PFC payments allowed participating producers to plant all of their total contract acreage plus additional acreage to any crop with no loss of payment. Thus, Production Flexibility Contract payments were designed to allow market conditions to guide a farmer's production decisions.

Under the FAIR Act, PFC payments were intended to decline each year until the act expired in 2002. However, in 1998 after periods of low prices and localized yield shortfalls, Congress passed supplemental ad hoc payments to farmers known as Market Loss Assistance payments (MLA) as a form of decoupled emergency disaster relief (Goodwin and Mishra 2005). The 1998 Agricultural Disaster and Market Loss Assistance Act established MLA payments to owners and producers who were eligible for final payments in 1998 under a Production Flexibility Contract. The act established $1.65 million for assistance to partially compensate the owners and producers for market losses for the 1998 crop of a commodity (US House, 1998). The amount of assistance made available to each farmer was proportional to the amount of the contract payment received by the farm for the 1998 fiscal year under a Production Flexibility Contract. Farmers received MLA payments until 2001, effectively doubling decoupled payments received by farmers from 1998 to 2001.

[13] Exceptions to this planting restriction include any region where there is a history of double cropping of contract commodities with fruits and vegetables or on a farm with a history of planting fruits and vegetables on contract acreage. In the second case, contract payments are reduced by an acre for each acre planted to the fruit or vegetable.

Farm Security and Rural Investment Act of 2002

The Farm Security and Rural Investment (FSRI) Act of 2002 established the Direct and Counter Cyclical Payment (DCP) program that replaced Production Flexibility Contract and Market Loss Assistance payments. The DCP program expanded eligible commodities to include soybeans, peanuts and other oilseeds. [14] The 2002 FSRI Act also altered the definition of an eligible farmer.[15] Direct payments replaced Production Flexibility Contract payments. Instead of fixing total expenditure levels for each fiscal year like PFC payments, direct payments fixed payment rates on a per unit basis for the entire contract. The direct payment rates established for each commodity for crop years 2002 to 2007 under the 2002 FSRI Act are presented in Table 2.2.

Table 2.2 Direct Payments Rates for the DCP Program from 2002 to 2007

Commodity	Measure	Payment Rate per Unit
Wheat	Bushels	$0.52
Corn	Bushels	$0.28
Grain Sorghum	Bushels	$0.35
Barley	Bushels	$0.24
Oats	Bushels	$0.02
Upland Cotton	Pounds	$0.07
Rice	Hundredweight	$2.35
Soybeans	Bushels	$0.44
Other Oilseed	Hundredweight	$0.80
Peanuts	Ton	$36.00

SOURCE: The Farm Security and Rural Investment Act of 2002 under title I, subtitle A section 1103(b)

[14] The FSRI Act established a payment yield for oilseed as the product of the farm's average yield from 1998 to 2001 and the ratio of the national average for the oilseed for the 1981 through 1985 crops over the national average yield for oilseed for the 1998 through 2001 crops. The average yield is equal to the average per planted acre for the 1998 through 2001 crop years, excluding any crop year when no acreage was planted to oilseed.

[15] An eligible farmer is an owner, operator, landlord, tenant or sharecropper who shares in the production risk of the program crop. An eligible farmer must annually report the use of the farm's cropland acres, comply with conservation and wetland protection requirements, comply with planting flexibility requirements, use the base acres for agricultural activities and protect all base acres from erosion and controlling weeds.

The total direct payment each farmer received equaled the product of the direct payment rate, the payment yield and the farmer's payment acres, where payment acres were defined as eighty-five percent of base acres. Under the FSRI Act, farmers had the opportunity to update their base acres in one of two ways. Base acres could be equal to the four-year average of acreage planted on the farm for the 1998 through 2001 crop years and any acreage on the farm that the producer was prevented from planting because of drought, flood or other natural disasters beyond the control of the producers. Alternatively, producer's base acres could equal the sum of the contract acreage used to calculate the 2002 payment for the covered commodities on the farm and the four-year average of eligible oilseed acreage on the farm for the 1998 through 2001 crop years, not excluding any crop year in which the covered commodity was not planted. The total direct payment made to a person during a crop year under FSRI could not exceed $40,000 and $80,000 under the two-entity rule. This was the same payment limitation imposed on the PFC payments in the 1996 Farm Bill.

Planting limitations and conservation compliance in the 1996 Farm Bill were also continued under the FSRI Act. Because farmers receiving direct payments could not plant fruits and vegetables on contract acreage under FSRI, the decoupled nature of direct payments came under question from the World Trade Organization (WTO). In 2005, the World Trade Organization ruled against the classification of Production Flexibility Contract and Direct Payments as green-box policies (Bhaskar and Beghin 2010). Green-box policies are considered minimally trade distorting and not subject to limits on overall domestic support because they are assumed to be decoupled from production (Goodwin and Mishra 2006). Although the classification system lacks a precise definition of minimally trade distorting, the ruling from the WTO suggests there may be some production effects of direct payments as it relates to planting and acreage decisions.

The Counter Cyclical payments program (CCP) of the 2002 Farm Bill institutionalized the Market Loss Assistance payments made each fall since 1998. CCP payments are similar to direct payments because they are decoupled from a farmer's production decisions. However, unlike direct payments, current market prices determined when farmers receive CCP payments and the amount of those payments. The CCP program established a target price for each covered crop. When the higher of the Marketing Assistance Loan rate found in Table 2.4 or the season average price plus the direct payment rate was below the target price, eligible famers received a counter-cyclical payment at a rate equal to that difference. Equation (2.3) generates the total CCP payment made to a farm under the FSRI Act. The maximum amount a farmer can receive in CCP payments is $130,000 under the two-entity rule.

$$\textit{CCP Payment} = \textit{Payment Rate} \times \textit{Payment Yield} \times (\textit{Contract Acreage} \times 85\%) \qquad (2.3)$$

The FSRI Act established the DCP program for the 2002 through 2007 crop years. The Food, Conservation and Energy Act of 2008 continued decoupled payments through the 2012 crop year, with some modifications to the DCP program. The 2008 Act changed the Counter Cyclical payment target prices for wheat, grain sorghum, barley, oats, soybeans, and other oilseed, beginning with the 2010 crop year. Table 2.3 shows the target prices established by crop for the years 2002 through 2012.

Table 2.3 Counter Cyclical Target Price by Crop from 2002 to 2012

Crop	Unit	2002-03	2004-07	2008	2009	2010-12
Wheat	Bushel	$3.86	$3.92	$3.92	$3.92	$4.17
Corn	Bushel	$2.60	$2.63	$2.63	$2.63	$2.63
Sorghum	Bushel	$2.54	$2.57	$2.57	$2.57	$2.63
Barley	Bushel	$2.21	$2.24	$2.24	$2.24	$2.63
Oats	Bushel	$1.40	$1.44	$1.44	$1.44	$1.79
Cotton	Pound	$0.72	$0.72	$0.71	$0.71	$0.71
Rice	Hundredweight	$10.50	$10.50	$10.50	$10.50	$10.50
Soybeans	Bushel	$5.80	$5.80	$5.80	$5.80	$6.00
Other Oilseed	Pound	$0.10	$0.10	$0.101	$0.101	$0.13

SOURCE: Title I subtitle A section 1104 (c)(1) of the Farm Security and Rural Investment (FSRI) Act of 2002 lists target prices for the Counter-Cyclical program for 2002 and 2003. Title I subtitle A section 1104 (c)(2) of FSRI lists target prices for 2004 through 2007. The Food Conservation and Energy Act of 2008 established target prices for counter cyclical payments under title I subtitle A section 1104 (c)(1) for 2008, section 1104(c)(2) for 2009 and section 1104(c)(3) for 2010 through 2012.

NOTES: The crop corn refers to corn for grain and cotton refers to upland cotton. The target price may differ from the price listed in the FSRI Act because prices listed in the FSRI Act with more than two decimal places were rounded to two decimal places.

Food, Conservation and Energy Act of 2008

The 2008 Farm Bill did not change the direct payment rates shown in Table 2.3, but it allowed farmers to forego a portion of their direct payments to obtain Average Crop Revenue Election (ACRE) payments. The ACRE program provides farmers of eligible crops with a guaranteed revenue flow based on both national market price and state average yields (Peckham and Kropp, 2010).[16] Farmers who enrolled in the program receive ACRE payments totaling ninety percent of the product of the five-year benchmarked state yield and the two-year ACRE program guarantee price.[17] Producers that enrolled in the ACRE program had to remain enrolled until 2012, regardless of the year in which they enrolled. ACRE enrollment reduces the direct payment rate by twenty percent and farmers are no longer eligible for CCP payments.

[16] Eligible crops under the ACRE program include wheat, corn, barley, grain sorghum, oats, upland cotton, rice, soybeans, other oilseeds, peanuts, dry peas, lentils, small chickpeas, and large chickpeas.
[17] The ACRE price is the national commodity specific two-year average market price.

The ACRE program differs from CCP payments because states yields and per state acre revenues trigger payments rather than farm yields. It differs from DCP payments because payments are based on moving averages of crop yields and are triggered by current year shortfalls in statewide crop yields and or national average prices. Because ACRE payments are likely to be made on all planted acres for a crop, ACRE payments are not decoupled from current production decisions (Smith and Goodwin, 2011). This study defines decoupled payments as PFC, MLA and DCP payments from 1996 to 2011. Figure 2.1 shows changes in decoupled payment from 1996 to 2011 by year and program type.[18]

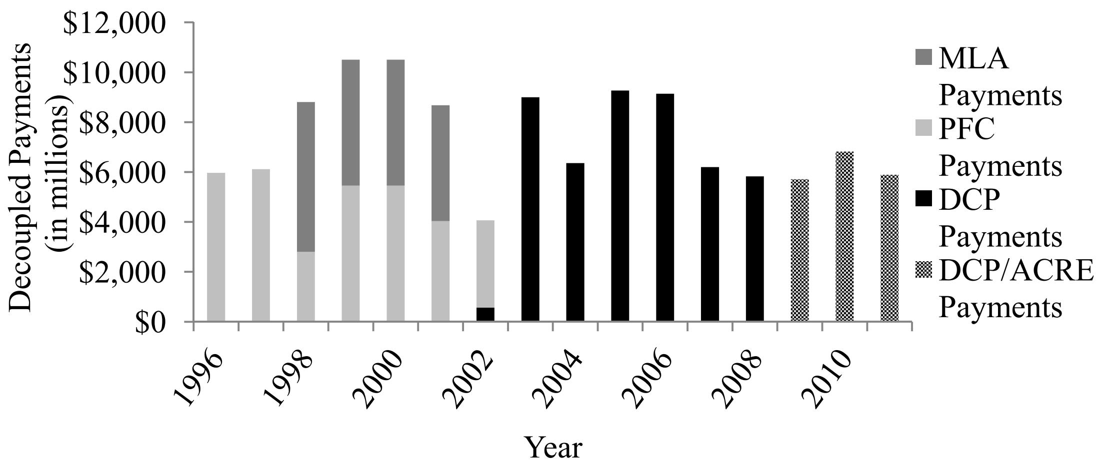

Figure 2.1 Decoupled Payments Made to Farmers from 1996 to 2011

SOURCES: The Farm Service Agency (FSA) provided records of Production Flexibility, Market Loss Assistance and Direct and Counter Cyclical Payments made to farmers from 1996 to 2008 under the Producer Payment Reporting System (PPRS) Payment Files. From 2009 to 2011, the FSA recorded the sum of DCP and ACRE payments made in the Direct Attribution (DA) Database.

NOTES: FSA reported individual transactions made to counties in a given calendar year by program type. Data for this figure come from aggregating individual payments by program type for all crops to every U.S. state in a given year as recorded by the FSA.

[18] Although ACRE payments are not decoupled payments, they are included in Figure 2.1 from 2009 to 2011 because the Farm Service Agency recorded the sum of DCP and ACRE payments for those years. However, according to the Environmental Working Group from 2009 to 2011 only 2.5 billion in total ACRE payments were made to farmers compared to the 75 billion in DCP payments over the same time.

According to Figure 2.1, decoupled payments provided the most support to farmers from 1998 to 2001 with the introduction of MLA payments and after 2003, 2005 and 2006 with the implementation of the DCP program. The largest drop in decoupled payments occurred in 2002 when MLA payments were no longer available to farmers, but Counter Cyclical payments had not yet replaced the MLA program. By defining decoupled payments as all payments farmers receive that are not influenced by their current production decisions, this thesis seeks to identify how decoupled payments have influenced the solvency of corn, cotton, wheat, and soybean farmers since decoupled payments were introduced in 1996.

Marketing Assistance Loans and Loan Deficiency Payments

According to the Federal Agricultural Improvement and Reform (FAIR) Act of 1996, any production by a producer on a farm containing eligible cropland covered by a PFC is eligible for a Marketing Assistance Loan. The Commodity Credit Corporation (CCC) administers Marketing Assistance Loans to help facilitate the distribution of commodities throughout the year and to provide price support to agricultural producers (Cooper, Effland and O'Donoghue, 2013). Marketing Assistance Loans allow eligible producers to store their production after harvest when prices are lowest using their harvest as collateral. Then, when market conditions are more favorable, producers can sell their crops and repay the loan (Cooper, Effland and O'Donoghue, 2013).

The 1996 FAIR Act established loan rates for Marketing Assistance Loans available to producers of wheat, feed grains, upland cotton, extra-long staple cotton, rice, soybeans, sunflower seed, and other oilseed. When the loan comes due, the FAIR Act states that producers of wheat, feed grains and oilseeds repay the loan at the established loan rate.[19] A producer also can deliver to the CCC the quantity of a commodity pledged as collateral for a loan as full payment for that loan at maturity. In order to discourage forfeiture, a producer may repay the loan at a rate less than the original loan principle and interest thus receiving a marketing gain equal to the difference between the original loan principle and the repayment amount. In lieu of entering into a marketing assistance loan with the CCC, eligible producers can receive a Loan Deficiency payment (LDP) equal to the amount of the marketing gain (Cooper, Effland and O'Donoghue, 2013).

LDPs are available to producers who are eligible to obtain a Marketing Assistance Loan, but agree to forgo obtaining the loan for the LDP. The LDP for a producer is equal to the product of the loan payment rate and the quantity of the loan commodity that the producers on a farm are eligible to place under the loan. The deficiency payment rate is equal to the difference between the established loan rate and the repayments rate for the commodity. The payments are designed to minimize potential loan forfeitures and government accumulation of stock. However, when market prices fell from 1998 to 2001 for corn, cotton, wheat and soybean farmers, LDPs became a source of income support.

The Farm Security and Rural Investment Act (FSRI) of 2002 continued Marketing Assistance Loans and LDPs for 2002-2007 crop years. The 2002 Farm Bill reinstated non-recourse loan rate programs for wool, mohair and honey that had been

[19] Repayment rate can also be equal to a rate that will minimize potential loan forfeitures, minimize the accumulation of stocks of the commodity, minimize costs incurred by the Federal Government, or allow the commodity produced to be marketed freely and competitively. Upland cotton producers have a repayment rate equal to the lesser of the loan rate or the prevailing world market price for the commodity.

discontinued in 1996 and added dried peas, lentils, and small chickpeas. The loan rate increased for wheat, feed grains, and soybeans.[20] The Food, Conservation and Energy Act of 2008 continued the Marketing Assistance Loans and LDPs through 2012. The 2008 Farm Bill kept loan rates the same in 2008 as they were from 2004-2007, but in 2009 loan rates for dried peas was reduced. For 2010-2012 crop years, the marketing assistance loan rates for wheat, barley, oats, other oilseed and graded wool were increased. Table 2.4 shows the changes in the crop specific loan rates from 2002 to 2012.

Table 2.4 Loan Rates for Nonrecourse Marketing Assistance Loans from 2002 to 2012

Crop	Unit	2002-03	2004-07	2008	2009	2010-12
Wheat	Bushel	$2.80	$2.75	$2.75	$2.75	$2.94
Corn	Bushel	$1.98	$1.95	$1.95	$1.95	$1.95
Grain Sorghum	Bushel	$1.98	$1.95	$1.95	$1.95	$1.95
Barley	Bushel	$1.88	$1.85	$1.85	$1.85	$1.95
Oats	Bushel	$1.35	$1.33	$1.33	$1.33	$1.39
Upland Cotton	Pound	$0.52	$0.52	$0.52	$0.52	$0.52
Ex-Long Cotton	Pound	$0.80	$0.80	$0.80	$0.80	$0.80
Rice	Hundredweight	$6.50	$6.50	$6.50	$6.50	$6.50
Soybeans	Bushel	$5.00	$5.00	$5.00	$5.00	$5.00
Other Oilseed	Pound	$0.10	$0.09	$0.09	$0.09	$0.10
Graded Wool	Pound	$1.00	$1.00	$1.00	$1.00	$1.15
N Graded Wool	Pound	$0.40	$0.40	$0.40	$0.40	$0.40
Mohair	Pound	$4.20	$4.20	$4.20	$4.20	$4.20
Honey	Pound	$0.60	$0.60	$0.60	$0.60	$0.69
Dry Peas	Hundredweight	$6.33	$6.22	$6.22	$5.40	$5.40
Lentils	Hundredweight	$11.94	$11.72	$11.72	$11.28	$11.28
Small Chickpeas	Hundredweight	$7.56	$7.43	$7.43	$7.43	$7.43

SOURCE: Title 1 subtitle B of the Farm Security and Rural Investment Act establishes the loan rates for the 2002 and 2003 crop years in section 1202(a) and for 2004 through 2007 in section 1202(b). The 2008 Food Conservation and Energy Act under title 1 subtitle B establishes loan rates for the 2008 crop year in section 1202(a) for 2009 in section 1202(b) and for 2010 through 2012 in section 1202(c).

NOTES: The ex-long cotton refers to extra-long staple cotton and n graded wool refers to non-graded wool. The loan rates listed in the FSRI Act were rounded to two decimal places.

[20] The FSRI Act reinstated loans for wool, mohair and honey that had been cut in 1996, and added dried peas, lentils, and small chickpeas to the list of eligible crops. The loan rate for wheat, feed grains, and soybeans increased from the 1996 rate of $2.58, $1.89 and $4.92 respectively.

Farmers who opt to receive a Loan Deficiency payment do so when the prevailing market price is less than the established loan rate. Thus, Loan Deficiency payments provide counter-cyclical support to farmers. This support has been greatest in years where market prices have fallen, specifically between the years 1998 and 2001. Loan Deficiency payments have not provided agricultural producers with as much support in more recent years because market prices have been higher, but they remain a source of counter-cyclical support for farmers.

Federal Crop Insurance

Title V of the Agricultural Adjustment Act of 1938 first authorized federal crop insurance and by 1980, only about half of the nation's counties and twenty-six crops were eligible for insurance coverage (Smith and Glauber 2012). The Federal Crop Insurance Act of 1980 intended to make Multiple Peril Crop Insurance (MPCI) the primary source of catastrophic risk protection available to agricultural producers.[21] MPCI provides yield-risk protection to crop producers through indemnity payments made whenever yields fall below a predetermined level (Knight and Coble 1997). Because of adverse selection issues, Knight and Coble (1997) suggest that in order for MPCI to be an effective substitute for other forms of federal crop disaster relief a large portion of famers must be insured.[22] To encourage participation, the 1980 Act eliminated standing disaster

[21] General agricultural insurance policies fall into three broad categories. First, specific or named peril products provide coverage against "named perils" like hail or range fires. Second is multiple peril that cover a farm's crop losses from many perils. Finally, index-based products insure against shortfalls in weather-based, area yield, or satellite based plant growth index (Smith and Glauber 2012).

[22] Adverse selection issues arise because the people who are the most likely to need insurance are the most likely to buy it. Therefore, if the crop insurance program has lower levels of participation the farmers who choose to participate are likely to be the most costly farmers to insure (Knight and Coble 1997).

programs in counties where crop insurance was available, subsidized premiums up to thirty percent and established a private-public reinsurance agreements allowing private companies to sell MPCI coverage with the Federal Crop Insurance Corporation (FCIC) acting as a reinsurer (Glauber 2013). Table 2.5 summarizes the history of subsidy and participation levels from 1980 to 2008.

Table 2.5 History of Crop Insurance Subsidies and Participation

Year	Federal Act	Subsidy Level	Participation Rates
1980	The Federal Crop Insurance Act	30%	25%
1994	Crop Insurance Reform Act	40%	50-60%
2000	Agricultural Risk Protection Act	62%	80%
2008	Food Conservation Energy Act	62%	80% +

SOURCE: Glauber, J.W. (2013). The Growth of the Federal Crop Insurance Program 1990-2011. American Journal of Agricultural Economics, 95(2),482-488. Smith, V.H., & Glauber, J.W. (2012). Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going? *Applied Economic Perspectives and Policy*, *34*(3), 363–390.

Under the Federal Crop Insurance Act of 1980, the FCIC had authority to expand coverage to insure all crops in counties where sufficient actuarial data existed to establish sound rates (Knight and Coble 1997). Because of the 1980 Act, participation in crop insurance grew from about sixteen to twenty-five percent of the total eligible area by 1988 (Glauber 2013). The 1990 Farm Bill moved toward the adoption of actuarially sound rates and experimented with other insurance designs. MPCI participation rates continued to climb to thirty-eight percent by 1994 (Knight and Coble 1997).

To provide producers of insurable crops with a base level of coverage, the Crop Insurance Reform Act of 1994 established catastrophic risk protection (CAT) that initially covered fifty percent of producers’ approved yield at sixty percent of the expected market price (Glauber 2013). The 1994 act also provided additional subsidies for coverage levels greater than fifty percent. Under the Crop Insurance Reform Act, subsidies increased to about forty percent and participation rates increased to between fifty and sixty percent (Smith and Glauber 2012). CAT coverage was initially required for producers to participate in other farm programs but the compulsory provisions were eliminated in 1996 (Glauber 2013). Because of the mandate, the FCIC liability rose from $13.5 billion in 1994 to $25.2 billion in 1995 (Knight and Coble 1997).

Subsidies increased again in 2000 to about sixty percent in the Agricultural Risk Protection Act (Smith and Glauber 2012). As a result, enrollment in the crop insurance program rose from 182 million acres insured in 1998 to over 265 million in 2011, a forty-five percent increase (Glauber 2013). In 2002, with nearly an eighty percent participation rate and over fifty percent of acres insured at coverage levels of seventy percent or higher, Congress provided $2.1 billion in disaster assistance. Disaster costs of fiscal years 2001-09 totaled almost $10 billion (Glauber 2013). The 2008 Food, Conservation and Energy Act established several programs providing supplemental disaster assistance. The Supplemental Revenue Assistance Payments (SURE) program provided assistance based on a farm's crop insurance liability and covered losses that effectively formed the crop insurance deductible. With the addition programs, current shallow loss proposals effectively locked in levels of coverage near ninety percent compared to thirty percent of expected losses in the 1970s and 80s (Smith and Glauber 2012).

As farm prices have risen, crop insurance coverage based on expected prices have offered more protection compared to fixed price supports, which has caused a change in the distribution of benefits among commodity groups (Glauber 2013). Corn and soybean producers make up a higher percentage of total crop insurance premium payments than net indemnities. Corn and soybean producers account for thirty-eight and twenty-two percent of total crop insurance premiums, but less than seventeen and sixteen percent of net indemnities respectively. Wheat producers receive about sixteen percent of total premium subsidies and almost twenty-nine percent of net indemnities. Cotton producers have low participation rates in crop insurance, making up less than six percent of premium subsidies from 1990 to 2011 (Smith and Glauber 2012).

As subsidy levels have increased over time so has the marginal cost to the government of enrolling additional acres in the federal crop insurance program. Glauber (2004) shows that because subsides are applied to all participating areas, it becomes more expensive to coax additional acreage at the margin. Premium subsidy costs in 2011 were almost $7.5 billion, which exceeds the nearly $5 billion paid to producers in direct payments for 2011. Although the total loss ratio was 0.82, because of the subsidies available to producers, producers received $1.90 in indemnity payments for every $1 they paid in premium (Smith and Glauber 2012).

Studies indicate that farmers are not willing to pay the actuarially fair premium rate because of the availability of less expensive ways of managing risk (Smith and Glauber 2012). With an increase in crop insurance subsidization producers have dramatically increased their participation since 1980. This has mitigated some of the adverse selection issues, but the issue of moral hazard in farm production decisions is still contested (Knight and Coble 1997). Analysis by Atwood, Watts and Baquet (1996) indicates provisions of subsidized crop insurance have probably reduced the use of these traditional risk management tools, and caused farmers to make more risky investments. These riskier investment decisions could translate to higher levels of debt or other elements of a farm's business operations and financial stability.

From 1996 to 2011, agricultural support programs have been characterized by increasing crop insurance premium subsidies and increased participation rates. During this time, decoupled payments have also provided income support to farms, with increased support during periods of low market prices. Loan deficiency payments have also provided counter-cyclical relief to farmers in the years 1998 to 2001. This thesis focuses on the effect of decoupled payments on farm financial solvency, as measured by the debt-to-asset ratio, to provide a better understanding of the impacts these payments have had on farm financial stability and how those effects may vary across farmers.

CHAPTER 3

LITERATURE REVIEW

There are two strands of economic literature identifying the impacts of decoupled government payments on farmers in the United States that influence this thesis. The first is the effect of government payments on a farmer's current production and input allocation decisions. This strand of literature identifies the factors influencing a farmer's production and allocation decisions, which directly influence a farm's financial performance. Secondly, there is a growing body of literature investigating the effect of decoupled payments on the financial stability of farmers. Financial stability has been defined to consist of liquidity, solvency, repayment capacity, profitability and efficiency (Katchova 2010). The study of agricultural policy effects on farm financial performance using financial ratio analysis is relatively limited, and economic literature has primarily focused on the financial performance of new and beginning farmers (Katchova, 2010; Mishra, Wilson and Williams, 2008; Kropp and Katchova, 2011; Antoni Mishra and Chintawar, 2011; Mishra El-Osta and Steele, 1999).[23] Building upon the existing body of literature, this thesis seeks to investigate the effects of decoupled government payments on farm financial solvency since decoupled payments were established in 1996.

This chapter begins by reviewing the economic literature examining the effect of government payments on a farmer's optimal production and allocation decisions. Particular attention is given to the allocation decision between farm and off-farm

[23] The USDA defines new and beginning farmers as farmers operating a farm that has been in existence for ten years or less.

investment. The second section reviews current literature regarding the effect of government payments on farm financial performance and stability. This strand of literature primarily focuses on new and beginning farmers. This emphasis is driven by the hypothesis that new and beginning farmers are adversely affected by government subsidies, contributing to the growth of large existing farms in the United States (Key and Roberts 2006).

Farm Production and Resource Allocation Effects

The individual farm household decision model is founded in expected utility maximization theory (Moschini and Hennessey 2001). It is assumed that farmers act as economic agents who strive to maximize their expected utility level subject to stochastic error from production, technological, price and policy uncertainty. The existing literature finds evidence that farmers act as risk averse agents who maximize their utility by creating a diversified, financially stable portfolio of assets (Mishra and El-Osta, 2005).[24] Within this theoretical framework, agricultural subsidies directly affect a farm's production decision as well as a farm's optimal capital and labor allocation decision.

The effect of government payments on a farm's optimal production has been discussed in economic literature without consensus. Just (1975) outlined a theoretical model for risk aversion under profit maximization suggesting that government payments that stabilize income will provide the incentive for profit maximizing producers to

[24] Expected utility maximization models are most commonly used to model a farm household's risk preferences (Goodwin 2003, Moschini and Hennessy 2002, Tomek and Peterson 2001*)*. However, Arrow-Pratt Risk Aversion model, expect profit maximization and Value-at-Risk Analysis have also been used to examine a farmer's risk preferences (Manfredo and Leuthold 1999, Moschini and Hennessy 2002).

increase production (Just 1975). Hennessy (1998) characterizes the farm household decision through a model of support decoupled under uncertainty. The comparative statics results from this model suggest optimal production decreases with increased risk aversion (Hennessy 1998). The empirical results find that policy intervention reduces the effective marginal product perceived by the decision maker and the optimal production level, assuming risk neutrality. More recently, Just and Kropp (2013) find that over time decoupled payments can impact current production decisions. They suggest decoupled payments may lead to production and trade distortions similar to those of direct production subsidies. Understanding the relationship between government payments and farm production decisions is important because farm production affects financial stability and performance.

Past literature suggests that the effect of decoupled payments on farm production varies with farm size (Roberts and Key 2008, Key and Roberts 2007, Key and Roberts 2006, Yee and Ahearn 2005, Yee Ahearn and Huffman 2004). Ahem, Yee and Korb (2005) find commodity payments lead to a reduction in the share of small farms, and increased farm exits from 1982 to 1996. Similarly, the research of Key and Roberts (2006) suggests an increase in government payments has a small but significant negative effect on the rate of business failure, and the magnitude of the effect increases with farm size.[25] Yee, Ahearn, and Huffman (2004) find that government payments have a positive impact on farm productivity. Although economic literature does not identify the direction

[25] They also find similar results in 2007 using farm level agricultural census data to estimate a reduced form relationship between government payments per acre of farmland and the likelihood of survival and subsequent farm size. Their results indicate that past per acre payments have a significant positive effect on farm survival and a smaller significant effect on the size of continuing farms.

of the relationship between government payments and farm production, it does suggest the effect is dependent on farm size.

There is also little consensus in the literature about the effects of government payments on farm capital and labor allocation decisions. The research in this area emphasizes the decision between farm and off-farm allocation of capital and labor. Assuming that risk averse farm households seek to maximize expected income, some research suggests that government payments increase off farm investment in an attempt to diversify assets (Mishra and Morehart 2003, Mishra and El-Osta 2005).[26] Other studies suggest that government payments stimulate farm investment by increasing the marginal return to farming through increases in revenue (Olson and Vu 2009; Donnellan and Hennessy 2012; Katchova 2010).

The effects of government payments on the allocation decision between farm and off-farm investment also appear to vary with farm size and structure. Mishra and Morehart (2001) find that larger farms are more diversified than smaller farms.[27] They find that farm diversification in production and high debt levels reduced the likelihood of off-farm investment, by estimating the probability of off-farm investment with a Logit model using the 1996 ARMS data. These results lend support to the hypothesis that good

[26] Mishra and Morehart (2003) identify the decision to invest in retirement as significantly determined by age, total income, marginal tax rate, farm location, and participation in government programs. Mishra and El-Osta (2005) propose that farms seek to minimize the variability of farm household assets. In order to stabilize assets they find farm households use non-farm investments as the primary source of diversification (Mishra and El-Osta, 2005). However, they do not differentiate between different types of farms in their research, which may lead to an oversimplification of a farmer's allocation decision.

[27] Mishra and Morehart (2001) measure farm diversification as an index that considers the number of enterprises in which a farm participates and the relative importance of the enterprise. Higher index numbers go to operators who distribute their production more equally across enterprises.

managers with well-established farms are more likely to use government payments to invest in their farm because large farms are more diversified.

The effect of decoupled payments on the resource allocation decision also varies with a farmer's risk preferences. The assumption that farmers act as risk averse agents is generally supported by the literature (Goodwin 2003, Moschini and Hennessy 2001, Tomek and Peterson 2001, Manfredo and Leuthold 1999). It is also shown that reduction in agricultural yield and price risk results in increased farm size and increased expected profitability under certain circumstances (Kuethe and Morehart 2012, Just 1974). Because of the effect of risk on farm profitability, it is important to control for production risks across farms when analyzing the effects of decoupled payments on financial stability. Donnellan and Hennessey (2012) find that if farmers display risk aversion then decoupled payments can induce them to take riskier decisions. However, research supports the hypothesis that farmers have different levels of risk aversion and thus government subsidies will have different effects on their financial stability.

In general, expected utility maximization theory is used to identify the effect of government policy on a farm's optimal production, and capital and labor allocation decisions (Moschini and Hennessey 2001). The effect of government payments on farm production is found to be dependent on farm size and structure (Roberts and Key 2008, Key and Roberts 2007, Key and Roberts 2006, Yee and Ahearn 2005, Yee Ahearn and Huffman 2004). The resource allocation decision is most commonly analyzed as a choice between farm and off-farm investment in an attempt to stabilize income through diversification. Research suggests small farms use off farm investment to diversify income and large farms tend to investment more heavily in farm assets as a form of income diversification (Mishra and El-Osta 2005). Therefore, government payments have differing impacts on labor and capital allocation decisions depending on the structure of the farm and the individual's risk preferences. This literature identifies the importance of farm size, structure, operator experience, and production risk in determining how decoupled payments affect farm solvency.

Farm Financial Stability and Stress

This thesis contributes most substantially to the area of research investigating the effects of government payments on farm financial stability. To measure financial stability, economic literature typically uses financial ratio analysis (Katchova, 2010; Mishra Wilson and Williams, 2008; Kropp and Katchova, 2011; Hadrich and Olson, 2011; Mishra El-Osta and Steele, 1999; Ahrendsen and Katchova, 2012). Katchova (2010) uses financial ratios to quantify five elements of financial stability: liquidity, repayment capacity, solvency, profitability and efficiency. The current ratio is used to measure liquidity, debt-to-asset ratio to measure solvency, return on assets to measure profitability, operating expense ratio as a measure of efficiency, and term debt coverage ratio to measure repayment capacity (Ahrendsen and Katchova, 2012).

Using financial ratio analysis, Katchova (2010) estimated two probit models one for experienced and one for new and beginning farmers to determine the factors affecting their financial performance and the probability of financial stress.[28] Katchova (2010)

[28] In this study, Katchova (2010) defines new and beginning farmers as farmers with ten years or less of experience.

defined financial stress according to the financial stability ratios. A dummy variable was created for financial stress equal to one if the financial ratio was above a critical value, and then used a probit model to estimate the effect of operator and farm characteristics like age, education, household size, farm size, income, crop type, and legal status on the probability of a financial ratio being in the critical zone. According to Katchova (2010), the classification of financial ratios into critical zones was done to be consistent with the current lender practices of using credit scores to determine credit worthiness. This thesis deviates from the work of Katchova by allowing the debt-to-asset ratio to be a continuous variable. Thus, the dependent variable exhibits more variation, providing more information, and the results do not rely on a specific characterization of financial ratios as critical or not critical.

The results from Katchova's study indicate operator age and education as well as farm size, crop type, gross value of sales, government payments and off-farm income significantly affect the likelihood of farmers experiencing financial stress as measured by their financial ratios falling into the critical zones.[29] Katchova finds government payments increase the financial stability of farms in all categories, except for solvency. This result could be caused in part by the finding that larger farms are more likely to take on larger amounts of debt. For new and beginning farmers, the results indicate financial management strategies to improve liquidity and solvency will have the greatest impact on reducing financial stress (Katchova, 2010). Katchova's study noted that government payments have a different impact on farm solvency than on the other elements of

[29] Katchova finds the legal structure of the farm and the household size does not affect the likelihood of experiencing financial stress.

financial stability. This thesis builds of this finding by considering specifically the impacts of decoupled government payments on farm solvency, as measured by the debt-to-asset ratio.

Antoni, Mishra and Chintawar (2009) conducted a study on the factors affecting financial stress of new and beginning farmers.[30] They define financial stress as a mismatch between a farm's currently available liquid assets and its current obligations under financial contracts. Farms were categorized into four different groups based on their level of financial stress, as measured by the debt-to-asset ratio.[31] Using a multinomial logit model, they find that as farmers age the likelihood of being vulnerable lowers, meaning they are less likely to experience high debt-to-asset ratios. New and beginning farmers who are tenants are also more likely to experience financial stress compared to full owners. Increasing farm income also reduces the likelihood of vulnerability, and a high debt-to-asset ratio (Antoni et al., 2009). This study identifies operator age, experience, farm size, crop type and income as factors that affect a farmer's debt-to-asset ratio. Using these factors, this thesis considers specifically the impacts of decoupled payments on farm solvency.

New and beginning farmers often experience higher levels of financial stress. Thus, researchers have examined the factors that can lower the likelihood of financial stress among these farmers. Mishra, Wilson and Williams (2009) find that management strategies such as increasing the number of decision makers, engaging in value-added

[30] Antoni, Mishra and Chintawar (2009) define new and beginning farmers as farmers under the age of 35 who have 10 years or less of experience.

[31] Antoni et al. (2009) identify four classifications of financial stress. Favorable farms have debts less than forty percent of their assets, and positive income. Marginal solvency farms have positive income but high debt levels. Marginal income farms have debt less than forty percent of assets but negative income. Venerable farms have both negative income and high debt levels.

farming, and having a written business plan correlates with higher financial performance for new and beginning farmers. Their theoretical model differs slightly from most literature by assuming a farm's goal is to maximize household income for a farm business operation, instead of household utility. They model the farm household's decision through profit maximization subject to labor and knowledge constraints. This is an extension of the unconstrained profit maximization model used by Mishra, El-Osta and Steele (1999) to determine the factors affecting the profitability of limited resource and other small farms.[32] They find that profitability of limited resource farms depends on the operator's age, soil productivity, debt-to-asset ratio, and ratios of variable and fixed costs to value of agricultural production. Profitability of other small farms depends on operator's age, farm size, farm diversification, and participation in crop insurance.

This thesis is particularly influenced by the work of Kropp and Katchova (2011) who measure the impacts of direct payments on two elements of financial stability, liquidity and solvency. They measure liquidity by the current ratio and repayment capacity by the term debt coverage ratio. [33] Their analysis focuses on comparing the effects for new and beginning farmers to experienced farmers. Using the ARMS from 2005 to 2007, they study how direct payments influence liquidity and repayment capacity with an ordinary least squares model where farm-level observations are weighted based on the probability of selection from the total population of farmers.[34] Their analysis is

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[32] A limited resources farm is a farm with gross sales under $100,000, farm assets under $150,000 and farm operator household income under $20,000 (Mishra, El-Osta and Steele, 1999).
[33] Kropp and Katchova (2011) define the current ratio as total current assets over current liabilities. They define the term debt coverage ratio as the net farm income plus depreciation and interest divided by the interest and principle on term debt.
[34] The weights are determined by USDA-NASS and are adjusted to ensure sample data are representative of US agriculture. Kropp and Katchova calculate standard errors using a jackknife procedure.

limited to the years 2005 to 2007 because the ARMS recorded base acres in those years. They excluded from their study farmers without debt and limited their analysis to current ratios and term debt coverage ratios above the 5th percentile and below the 95th.[35]

The explanatory variables in Kropp and Katchova's study include direct payments, base acres, other government payments, tenure, off farm income, gross sales, revenue, revenue on assets, farm debt-to-asset ratio, operator age and education, and indicator variables for hobby farms, sole proprietorships, primary program crops, and regional and year fixed effects.[36] They define direct payments as payments made to farmers under the Direct and Counter Cyclical Program (DCP) payments established under the 2002 Farm Bill, excluding counter-cyclical payments. This thesis expands on their definition to include all payments made since 1996 that are not influenced by a farmer's current production. By defining decoupled payments in this manner, this thesis will attempt to identify the long-term implications of decoupled payments on farm solvency. Other government payments considered by Kropp and Katchova include conservation payments, disaster assistance, market loss assistance, and counter cyclical payments, but not crop insurance indemnity payments. This thesis also includes county-level expected loss ratios to control for the effects of temporary production shocks on farm solvency.

Kropp and Katchova (2011) find a positive significant relationship between the level of direct payments and the term debt coverage ratio for experienced farmers, suggesting direct payments improve repayment capacity. They also find a negative

[35] The resulting data set contains 6,074 observations (Kropp and Katchova 2011).
[36] Kropp and Katchova (2011) define tenure as the number of acres rented to the number of acres operated.

relationship between base acres and the current ratio. However, these relationships were not significant for beginning farmers. Kropp and Katchova (2011) investigate the effect of direct payments on farmer's access to credit. Their results suggest that decoupled payments alter a farmer's access to credit and current production decisions. Building off the framework established by Kropp and Katchova, this thesis seeks to determine if decoupled payments also affect farm solvency, as measured by the debt-to-asset ratio.

Decoupled payments were designed to be independent of a farmer's production decisions, but recent economic literature suggests there is a relationship (Foltz, Useche and Barham 2012; Olson and Vu 2009; Donnellan and Hennessy 2012; Katchova 2010). The direction of the relationship is inconclusive, but some studies suggest that it depends on farm size, structure, and operator experience (Roberts and Key 2008, Key and Roberts 2007, Key and Roberts 2006, Yee and Ahearn 2005, Yee Ahearn and Huffman 2004). Decoupled payments are also found to affect a farmer's financial stability. Determinates of farm financial stability include operator age, education, farm size, farm income, off-farm income, government payments, and production risk (Katchova 2010; Antoni, Mishra and Chintawar, 2009; Kropp and Katchova, 2011). Building on the current literature, this thesis seeks to identify how farm solvency was influence by the introduction of decoupled payments in 1996, as well as the proposed elimination of the payments in the current Farm Bill (Paulson, Woodard and Babcock, 2013). By considering all decoupled payments since their establishment in 1996, this thesis hopes to identify the broader relationship between decoupled payments and farm solvency.

CHAPTER 4

THEORETICAL METHODOLOGY

An expected profit maximization model is used to consider the effect of decoupled payments on the financial stability of farms. Farmers are assumed to make asset and input allocation decisions to maximize expected profit.[37] Equation (4.1) characterizes the expected profit maximization problem of a typical farmer, where additional assets (L_{it}) and quantity of inputs (X_{ijt}) are choice variables.

$$\underset{\{L_{it},X_{ijt}\}}{\text{Max}} \quad \pi = \text{E}\left[\sum_{t=1}^{T}\delta^{t}\left(\sum_{i=1}^{I}P_{it}\,F\left(X_{it},A_{it},\varepsilon_{it}\right) - \sum_{j=1}^{J}w_{ijt}X_{ijt} - r_{it}A_{it} - C_{it}(A_{it-1}) + DP_{t}\right)\right] \tag{4.1}$$

where, $$DP_t = \alpha_{it}S_{it}\psi_{iH}\left(F_{iH}\left(X_{iH},A_{iH}\right)\right)B_{iH}(A_{iH})$$

$$A_{it} = A_{it-1} + L_{it}\left(DP, w_{ijt}, P_{it}, W_{t-1}\right)$$

Let X_{ijt} be the quantity of inputs j associated with producing crop i in time t, and let L_{it} be land and capital assets dedicated to the production of crop i bought or sold in time t. Expected profit is equal to the discounted value of the difference between revenue and costs from period t to the terminal time T, where E is the expectation operator and δ is the time discount rate. The price of the i^{th} crop at time t (P_{it}) reflects the market price

[37] A utility maximization problem has also been used in the literature (Goodwin Mishra 2006, Bhaskar Beghin 2010, Packham and Kropp 2010). The utility maximization problem makes assumptions about a farmer's risk preferences that are not made in the profit maximization model. The implications for the effect of decoupled payments on financial stability are the same in both models and therefore, an expected profit maximization model is considered here for simplicity.

for the crop as well as support mechanisms such as loan deficiency payments and per unit production subsidies.[38] The function $F(\cdot)$ represents total yield, which is a function of inputs (X_{it}), land and capital assets dedicated to the production of crop i in time t (A_{it}), and a stochastic element (ε_{it}), which represents deviations in yield that cannot be controlled by the farmer, or observed ex-ante by researchers.

Costs are a summation of variable and fixed costs associated with each crop i. Variable costs include asset and input costs. The cost of input j associated with the i^{th} crop at time t is the product of the unit cost of input j (w_{ijt}) and the amount of input j associated with the i^{th} crop (X_{ijt}). Let r_{it} be the per-unit cost of an asset (A_{it}) or the opportunity cost associated with allocating the asset to the next best alternative. Fixed costs are represented by C_{it} which are the costs associated with the i^{th} crop at time t and are a function of the assets in the previous period (A_{it-1}), meaning that asset decisions are inter-temporal.

Decoupled payments enter the profit maximization model as additional income in each period. Following Peckham and Kropp (2010), the function $DP_t(\cdot)$ represents decoupled payments shown in equation (4.1).[39] Decoupled payments are a function of the payment per unit (S_{it}), the historical yield per acre (ψ_{iH}), the historical base acres (B_{iH}), and the percent of the base acres used to calculate payments (α_{it}). Thus, payments are not

[38] Packham and Kropp (2010) consider per-unit production subsidies and market prices as separately. This model combines the prices without any loss of generality.

[39] This model does not differentiate between payments decoupled from current production and prices and payments triggered by market conditions. Goodwin and Mishra (2006) represent payments triggered by current prices separately using the function $PS(P_{it})$. This function models Market Loss Assistance payments from 1998 to 2001 and Counter Cyclical payments made from 2002 to 2011. These payments are a function of current market conditions, thus $PS(P_{it})$ is a function of current market prices P_{it}. Because this caveat does not change the theoretical implications of this model for the purposes of this study, decoupled payments are represented by a single function $DP_t(\cdot)$.

a function of current prices, yields, or inputs. Changes in decoupled payments come from policy changes that effect the percent of base acres used to calculate the payment (α_{it}) and the payment per unit (S_{it}). The variables S_{it} and α_{it} are the only parameters in the decoupled payments function that vary over time.[40] Decoupled payments also affect the asset response function as shown in equation (4.1).

The asset response function $A_{it}(\cdot)$ shown in equation (4.1) is a modification of the acreage response function outlined by Goodwin and Mishra (2006). The assets possessed by a farm in time t for crop i are a function of the assets held in the previous period (A_{it-1}) and any assets purchased or sold in the current period (L_{it}), such as farmland and capital used in the production of crop i. The decision to increase or decrease assets in any period is a function of input costs (w_{ijt}), output price (P_{it}), off farm assets and income in the previous period (W_{t-1}) and decoupled payments (DP_t).

As shown in the model, decoupled payments enter directly into the expected profit function as exogenous increases in income in period t. Therefore, decoupled payments serve as a lump sum increase in farm income. Decoupled payments also effect a farmer's decision to acquire assets in the current period. It is through the effect on the asset response function that decoupled payments enter a farmer's marginal decisions. Goodwin and Mishra (2006) suggest that decoupled payments may be relevant to production in cases where farmers have reached their capital constraints.[41] Thus,

[40] Peckham and Kropp introduce a function $h(\cdot)$ that allows a farmer's subjective probability of updating base acres to influence production decisions in the current period. This is based on the 2008 and 2002 farm bills that allowed farmers to update their acres, but it is not a specification considered here for simplicity.
[41] Goodwin and Mishra also mention that farmers face capacity constraints as well as capital constraints, but do not formalize these constraints in their model.

decoupled payments effect the farmer's marginal decision to acquire assets in the current period. The first order conditions for the expected profit maximization model are shown below. Equation (4.2) shows the input decision and equation (4.3) outlines the farmer's asset allocation decision, which is a function of decoupled payments.

$$\{X_{ijt}\}:\ \ \delta^{t}\left[P_{it}\frac{\partial F(X_{it}, A_{it}, \varepsilon_{it})}{\partial X_{ijt}} - w_{ijt}\right] = 0 \tag{4.2}$$

$$\{L_{it}\}:\left[\ \delta^{t}\left(P_{it}\frac{\partial F(X_{it}, A_{it}, \varepsilon_{it})}{\partial A_{it}} - r_{it}\right) - \ \delta^{t+1}\frac{\partial C(A_{it})}{\partial A_{it}}\right]\frac{\partial A_{it}}{\partial L_{it}\left(DP, w_{ijt}, P_{it}, W_{t-1}\right)} = 0 \tag{4.3}$$

The debt-to-asset ratio measures solvency, which is one element of financial stability. Decoupled payments affect the debt-to-asset ratio through their effect on the decision to acquire assets in the current period (L_{it}), shown in equation (4.3). If decoupled payments have a positive effect on assets acquired in the current period, then an increase in decoupled payments will cause a decrease debt-to-asset ratio, holding debt constant. Similarly, if there is a negative relationship between decoupled payments and the decision to acquire assets then an increase in decoupled payments will cause an increase in the debt-to-asset ratio, holding debt constant.

If the assumption that debt is held constant is relaxed, then the effect of decoupled payments on a farm's solvency depends on the percentage change in debt relative to the percentage change in assets. If the percentage change in debt is larger than the percentage change in assets then the debt-to-asset ratio will increase. However, if the percentage change in assets is larger, then the debt-to-asset ratio will decrease. It is also possible that a famer chooses to pay down his debt balance instead of purchasing additional assets. In which case, the debt-to-asset ratio would decrease but this decrease would not be modeled through the asset response function.

The theoretical model for expected profit maximization also provides insight into the other elements of a farmer's business that affect the debt-to-asset ratio in general. These elements include the market price for the crop, input costs, off farm income and assets, farm size and the opportunity costs of investing in the farm. The higher the output price for a crop the more revenue a farmer receives from producing the crop, increasing profits holding costs constant. As input costs increase, profits decrease for a given output level. The farmer's response to changes in profits determines the effect on the debt-to-asset ratio. Therefore, operator characteristics are an important factor in a farm's debt-to-asset ratio. If a farmer uses an increase in profits to increase assets or pay down debt then an increase in output price or decrease in input costs will lower the debt-to-asset ratio. A farmer could also lower their debt-to-asset ratio when profits decrease by paying down debt balances to lower variable costs. In this case, a decrease in output price or an increase in input costs could cause a decrease in the debt-to-asset ratio as well.

The opportunity cost of investing in the farm is represented in this model by r_{it}. An increase in the opportunity costs of on farm investment will cause the farmer to divert more of his resources to off-farm assets in the current period, thus decreasing profits and increasing the debt-to-asset ratio, holding debt constant. Off farm assets and income in one period enter the model through the asset response function in the next period, directly affecting the farmer's decision to increase or decrease assets. The more wealth available to a farm business through off farm income and assets, the more capital the famer can use to increase farm assets. Thus, holding all else constant, an increase in off farm assets in the previous period could increase a farm's assets in the current period. The effect of this increase, holding debt constant, is a decrease in the debt-to-asset ratio.

Although the comparative statics results from equation (4.3) yield an ambiguous hypothesis about the direction of the effect of decoupled payments on the debt-to-asset ratio, the theoretical model provides a framework in which to think about how farmers make business decisions. Through the asset response function, decoupled payments affect a farmer's decision to acquire assets in the current period and thus affect the debt-to-asset ratio. Other important variables are the market price for the crop, input costs, off farm income, farm size, operator characteristics and the opportunity costs of investing in the farm. The theoretical profit maximization model outlined in equation (4.1) identifies the factors effecting a farmer's production and allocation decisions, which motivate the empirical modeling strategy. This thesis seeks to identify the direction and magnitude of the relationship between decoupled payments and farm debt-to-asset ratio through empirical estimation.

CHAPTER 5

DATA ANALYSIS AND DISCUSSION

This research uses data from the Agricultural Resource Management Survey (ARMS), the Farm Service Agency (FSA) and the Risk Management Agency (RMA). The ARMS is a nationally-representative survey conducted annually that provides farm-level data about operator characteristics, farm business financial ratios, income and expense records, financial assets, and crop production information. The FSA collects the amount of agricultural payments made by the federal government to counties in the United States for programs operated through the FSA. The RMA collects data related to crop insurance programs, including farm premium and indemnity payments used in this research to proxy for production risks.

This study focuses on the four major field crops produced in the United States: corn, wheat, cotton and soybeans. In 2011, these crops made up 64.9 percent of the $212 billion total crop production in the United States.[42] Our analysis focuses on farm businesses located in the top five states producing each crop. This reduces the heterogeneity between farmers by reducing the variability in farm production. If other states are included, decoupled payments may inappropriately explain variation in farmers' financial stability actually caused by differences in the underlying production capacity between farms. Table 5.1 shows the mean production in each state based on the 1997, 2002 and 2007 U.S. Agricultural Censuses.

[42] The USDA National Agricultural Statistical Service (NASS) Quick Stat service provided wheat, cotton, corn, soybean and total crop production measured in dollars for the year 2011 used to calculate this percentage.

Table 5.1 Top States Mean Production from Area Harvested by Crop (in thousands)

Cotton	Bales	Corn	Bu	Soybeans	Bu	Wheat	Bu
TX	759	IA	194,897	IA	44,069	KS	38,126
CA	248	IL	178,350	IL	40,956	ND	32,887
AR	245	NE	130,479	MN	26,395	MT	20,501
MS	230	MN	105,472	IN	24,527	WA	18,102
GA	195	IN	79,339	OH	19,716	OK	14,348

SOURCE: The National Agricultural Statistical Service (NASS) state production from acres harvested by crop data as reported in the U.S. Agricultural Census conducted during 1997, 2002, and 2007.

Sixteen different states are included in this analysis, four of which are top producing states for both corn and soybeans.[43] Farmers in Iowa, Illinois, Minnesota and Indiana are considered both corn and soybean farmers, while farmers in the other twelve states are classified as single crop farmers because they are assumed to produce only cotton, corn, wheat or soybeans in rotation with minor crops that are not analyzed in this study. These data include over twenty nine thousand single crop farmers and over thirty-three thousand corn and soybean farmers spanning sixteen years, for over sixty-two thousand total observations.

Farm-Level Financial Information

Since 1996, the National Agricultural Statistical Service and the Economic Research Service have conducted the Agricultural Resource Management Survey (ARMS) annually to evaluate farms' financial condition. This survey is the only national farm-level survey and is conducted in three phases. In the first phase, potential candidates are screened to participate in the survey. When selecting the sample population, a dual sampling frame approach provides complete coverage of the target population (Kuethe

[43] Farmers in Iowa, Illinois, Minnesota and Indiana are assumed to be corn and soybean farmers. Farmers in Ohio are soybean-only farmers, and farmers in Nebraska are considered corn-only farmers.

and Morehart 2012). During the second phase, production practices and cost reports are collected. The final phase occurs in the following year, and is used to collect information about the farms' costs and returns (Kuethe and Morehart 2012). Some farms may have a higher probability than others of being selected for the survey. Thus, the ARMS dataset provides weights to correct for sample selection bias that are based on the probability of being selected from the total population of farm businesses.

The ARMS data represent the USDA's primary source of information about U.S. agricultural production conditions, market practices, resource use, and the economic well-being of farmers (Goodwin and Mishra 2006). However, the ARMS data are an independently pooled cross section, meaning the survey does not repeatedly sample the same farms. Because the sample is randomly selected in each year, it is impossible to observe the same farm over multiple years. For example, though it is possible to observe a farmer's debt-to-asset ratio in a year, it is not possible to examine how those values compare to the previous years. Thus, these data do not allow for conditioning on observed events in preceding years, or on fixed farm events and so there is an important reliance on cross sectional variability (Goodwin and Mishra, 2006).

This study uses farm business financial ratios, operator characteristics, farm business income, expenses, financial assets, and crop production information from the ARMS. The ARMS collects farm business financial ratios that measure financial stability, including the current ratio, debt to asset ratio, return on assets, asset turnover ratio and term debt-coverage ratio respectively (Ahrendsen and Katchova 2012). Of particular emphasis in this study is farm solvency, as measured by the debt-to-asset ratio.

Table 5.2 shows a list of the financial ratios in the ARMS data set, and the formulas to calculate those ratios from the farm business' financial statements.

Table 5.2 Financial Ratios in ARMS Measuring Elements of Financial Stability

Financial Ratio	Measures	Calculation
Asset Turnover Ratio	Efficiency	Revenue/ Total Assets
Current Ratio	Liquidity	Current Farm Assets/ Current Farm Liabilities
Term Debt Coverage Ratio	Repayment Capacity	Net Farm Income + Depreciation + Interest/ Principal + Interest
Operating Profit Margin	Profitability	Net Income/ Gross Revenue
Rate of Return on Assets	Profitability	Net Income/ Average Assets
Farm Business Debt-to-Asset Ratio	Solvency	Total Debt/Total Assets

SOURCE: The Agricultural Resource Management annual survey of farm businesses provides the list of financial ratios used as dependent variables in this study. Katchova (2010) identifies the relationship between the financial ratios and the measures of financial stability. Calculations for current ratio, operating profit margin, rate of return on assets, and farm business debt-to-asset ratio come from Katchova (2010) and term debt coverage ratio calculation comes from Kropp and Katchova (2011).

NOTE: Net Income is equal to net farm income from operations plus interest expense less family living withdrawals (Katchova, 2010). Term Debt coverage ratio denominator refers to principal and interest on term debt (Kropp and Katchova, 2011).

In order to explain variation in the financial ratios across farms, data on operator-specific characteristics and farm business characteristics such as income, expenses, assets and production practices are collected from the ARMS. Operator characteristics include age, experience, education and gender. Operator experience is the difference between the current year and the year the primary operator began operating as in Katchova (2010). The ARMS survey defines four different classes of education: (1) less than a High School diploma, (2) a High School diploma, (3) some college including an associate's degree, and (4) at least a four-year college degree.[44]

[44] Prior to 2005, the ARMS data set defined five different education classes, distinguishing between a college and a graduate degree as the fourth and fifth classes respectively. To remain consistent through the data set, from 1996 to 2004 the fourth class is equal the sum of the fourth and fifth classes originally defined by the ARMS data set.

In addition to operator characteristics, farm business financial characteristics also help explain variation in farm financial stability. Farm financial characteristics include farm financial assets, expenses, income and production practices. The value of land and building real estate as recorded in the ARMS measures a farm's financial assets in this study. Operated acres provides insight into how the effect of decoupled government payments on farm financial stability may vary with farm size. This study uses total fixed expenses per acre ($FEXP_{it}$) and total variable expenses per acre ($VEXP_{it}$) to capture the effect of farm business expenses on financial stability. These variables are equal to total fixed expenses ($EFTOT_{it}$) and total variables expenses ($EVTOT_{it}$) relative to total acres operated (A_{it}) in year t for farmer i as shown by equations (5.1) and (5.2).

$$FEXP_{it} = \frac{EFTOT_{it}}{A_{it}} \tag{5.1}$$

$$VEXP_{it} = \frac{EVTOT_{it}}{A_{it}} \tag{5.2}$$

In addition to farm assets and expenses, income and varying crop production practices cause differences in a farm business' financial stability. To capture these effects, crop specific ARMS data on harvested acres and total production, along with crop specific state-level price received data from the National Agricultural Statistical Service (NASS) generates revenue per acre for each farmer. The ratio of total production to harvested acres creates yield per harvested acre for corn, cotton, wheat and soybeans. For single-crop farmers, multiplying price received by yield per harvested acre generates the revenue per acre for each farmer from their primary crop. Equation (5.3) shows the function used to calculate the revenue per acre (REV_{ict}) for farmer i and crop c in time t.

$$REV_{ict} = Price_{ct} \times \left(\frac{Total\ Production_{ict}}{Harvested\ Acres_{ict}}\right) \quad (5.3)$$

Farmers living in a top corn and soybean producing state that reported only corn or soybeans production in the survey year have a value for revenue per acre equal to the product of price received and yield per acre for the primary crop produced in that year. The farmers that reported producing both corn and soybeans in the survey year have a value for revenue per acre that is the simple average of corn revenue per acre and soybean revenue per acre.[45] Equation (5.4) shows the expression used to calculate revenue per acre for corn and soybean farmers i who planted both soybeans and corn in time t.

$$REV_{it} = \frac{REV_{it}^{soybean} + REV_{it}^{corn}}{2} \quad (5.4)$$

The final farm characteristics collected from the ARMS data include farm financial assets, expenses, income and production practices. These are measured by the value of land and building real estate, acres operated per farm, fixed expenses per acres and variable expenses per acre and revenue per acre. Operator characteristics include operator age and education. These variables are combined with decoupled payments data

[45] The implicit assumption is that for corn and soybean farmers who planted both crops in the survey year, half of the harvested acres are from corn acres and the other half is from soybean acres.

from the Farm Service Agency (FSA) and expected loss ratio data calculated from premium and indemnity payments collected by the Risk Management Agency (RMA).

Decoupled Payments Data

The Farm Service Agency (FSA) provides county-level government payment records by program type from 1996 to 2011. A number of government programs provided farmers with decoupled payments between 1996 and 2011. From the years 1996 to 2002, farmers received decoupled Production Flexibility Contract (PFC) payments. Farmers enrolled in the PFC program received annual contract payments based upon a predetermined total dollar amount for each year. Between 1998 and 2002, farmers also received Market Loss Assistance (MLA) payments as a form of emergency disaster relief. Price levels triggered MLA payments, providing another form of decoupled payments to farmers. MLA payments are combined with PFC payments for corn, wheat, cotton and soybeans to generate the decoupled payment amount received by each county in the top five states producing these crops from 1996 to 2002.

After 2002, the Direct and Counter Cyclical Payment (DCP) program replaced both Production Flexibility payments and Market Loss Assistance payments. For the years 2002 to 2008, decoupled payments are equal to DCP payments received by counties in the top five states producing corn, wheat, cotton and soybeans. In 2008, the Food, Conservation and Energy Act continued the DCP program and established Average Crop Revenue Election (ACRE) payments. Enrollment in the ACRE program reduced the direct payment rate by twenty percent and farmers were no longer eligible for CCP payments. Although ACRE payments are not decoupled, from 2008 to 2011 the FSA recorded the sum of DCP payments and ACRE payments.

The FSA recorded all payments made to counties in the United States from 1996 to 2008 through the Producer Payment Reporting System (PPRS) Payment Files. From 1996 to 2008, this study includes decoupled payments made based on corn, cotton, soybean and wheat base acres. After 2008, the Direct Attribution (DA) database replaced the PPRS payment files. From 2009 to 2011, the Direct Attribution database did not classify decoupled payments by crop. The decoupled payments data from the PPRS and DA databases cannot be compared directly because the first measures payments from crop specific base acres and the second measures payments from all base acres. Comparing the two measures directly assumes farmers received all of their decoupled payments from corn, soybean, wheat and cotton base acres from 2009 to 2011.

To correct for this problem, the DA data is weighted by the average percent of the total decoupled payments coming from corn, cotton, wheat and soybean base acres from 1996 to 2008 in the PPRS database. Equation (5.5) shows the formula for calculating the weight for county i, where $\sum_{c=1}^{4} DP_{ict}$ is the sum of decoupled payments received from corn, soybean, cotton and wheat base acres in year t, and $\sum_{c=1}^{n} DP_{ict}$ is the sum of decoupled payments from all n crops base acres in the same year.

$$Weight_i = \frac{1}{13} \sum_{t=1996}^{2008} \left(\frac{\sum_{c=1}^{4} DP_{ict}}{\sum_{c=1}^{n} DP_{ict}} \right) \tag{5.5}$$

Figure 5.1 shows the mean county-level average ratio of crop specific payments to total decoupled payments from 1996 to 2008 used to weight total decoupled payments from 2009 to 2011. On average, from 1996 to 2008 farms received at least eighty-five percent of their decoupled payments from corn, cotton, wheat and soybean base acres, except for cotton counties that received approximately sixty-five percent.

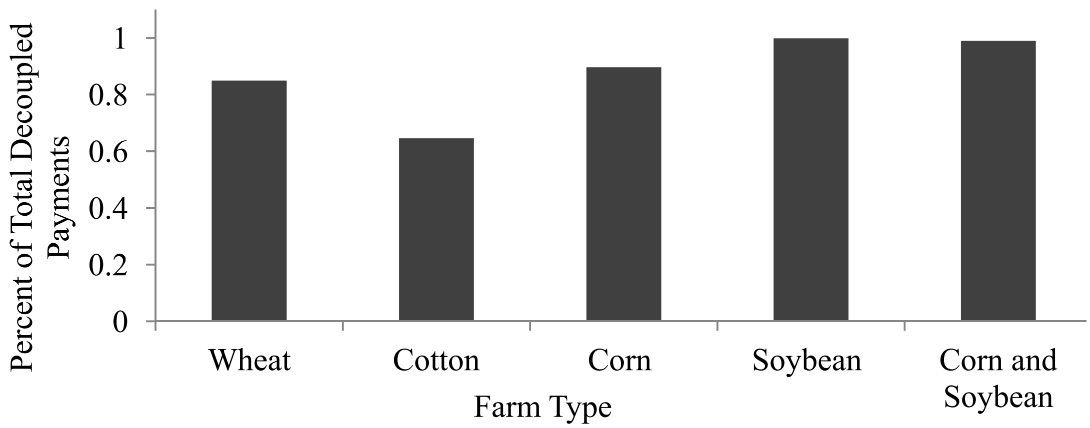

Figure 5.1 Mean Percent of Total Decoupled Payments from 1996 to 2008

SOURCE: The Farm Service Agency (FSA) provided data from 1996 through 2008 under the Producer Payment Reporting System (PPRS) Payment Files.

NOTES: Decoupled payments consist of Production Flexibility payments, Market Loss Assistance payments, and Direct and Counter Cyclical payments. The values shown are the percentage of total decoupled payments a farmer received from wheat, cotton, corn and soybean base acres on average from 1996 to 2011.

The county-level average ratios of crop specific payments over total decoupled payments from 1996 to 2011 are multiplied by the total decoupled payments values from 2009 to 2011 in the DA database. This gives an estimate for the decoupled payment from wheat, cotton, corn and soybean base acres in the years 2009 to 2011.[46] The weighted

[46] Counties not included in these data did not receive decoupled payments during the year.

values from the DA database are combined with the PPRS data to generate decoupled payments per county from 1996 to 2011 from corn, cotton, wheat and soybean base acres.

To control for variations in the number of farms within a county, decoupled payments per county is divided by the number of farms in a county to generate the average decoupled payment received per farm within a county. Decoupled payments per farm (DP_{it}) for county i in year t is equal to the total decoupled payments received by county i in year t ($DPCounty_{it}$) divided by the number of farms in county i ($Farms_{it}$), as shown in equation (5.6).

$$DP_{it} = \frac{DPCounty_{it}}{Farms_{it}} \tag{5.6}$$

From 1996 to 2001, counties have a value for number of farms equal to the number of farms recorded per county in the 1997 U.S. Agricultural Census. For the years 2002 to 2006, the number of farm in a county is equal to the number recorded in the 2002 Census. From 2007 to 2011, the number of farms in a county equals the amount recorded in the 2007 Census. The final decoupled payments variable represents the average decoupled payments received per farm within a county each year from 1996 to 2011, where decoupled payments is equal to the sum of PFC, MLA and DCP payments from corn, cotton, wheat and soybean base acres. [47]

[47] From 2009 to 2011, decoupled payments are equal to the sum of both DCP and ACRE payments. However, according to the EWG from 2009 to 2011 only 2.5 billion in total ACRE payments were made to farmers compared to the 75 billion in DCP payments over the same time. Thus, variation ACRE payments will not likely drive the parameter estimate for decoupled payments.

Crop Insurance Data

The Risk Management Agency (RMA) provides data to calculate the expected loss ratio for farm businesses. Given the current legal requirement that the loss ratio be equal to 0.88, an expected loss ratio higher than that will identify the effect of temporary production shocks on a farmer's debt-to-asset ratio.[48] Production areas with higher loss ratios tend to correlate with higher production risk areas (Goodwin and Rejesus, 2008). The loss ratio is calculated from crop specific county-level premiums and indemnity payments provided by the RMA's Summary of Business data from 1990 to 2011. This study includes counties that made premium payments on "buy up" coverage in the top five states producing corn, wheat, cotton and soybeans. After aggregating indemnities and premiums to the county, year and crop specific level, the ratio of indemnity payments over premium payments in each year generates a crop c specific loss ratio (LR_{itc}) for each county i in year t, as follows.[49]

$$LR_{itc} = \frac{Indemnity_{itc}}{Premium_{itc}} \tag{5.7}$$

The county crop specific loss ratios in each year are used to calculate the expected loss ratio. The expected loss ratio is a six-year rolling average of a county's historical loss ratios (LR_{itc}). Equation (5.8) shows the expression for the expected loss ratio in county i, crop c and time t as the average of the past six years loss ratios.

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[48] The requirement is less than one to adjust for the probability of a catastrophic event occurring according to the Federal Crop Insurance Reform Act of 1994.
[49] The premium payment reported by the RMA includes subsidies provided by the federal government, thus the actual cost of insurance to farmers is lower that reported by the RMA.

$$E(LR_{itc}) = \frac{LR_{ic,t-1} + LR_{ic,t-2} + LR_{ic,t-3} + LR_{ic,t-4} + LR_{ic,t-5} + LR_{ic,t-6}}{6} \quad (5.8)$$

Of the 1,586 county-crop specific loss ratios (LR_{itc}), 248 are missing one year and 200 have more than two missing years.[50] Observations without missing years report higher mean total acres in the Summary of Business data than the average for all the data, while observations with missing years have significantly lower acres reported. This suggests counties with missing loss ratios contain a relatively high degree of small farms. Including these counties may bias the effect of decoupled payments on the debt-to-asset ratio if variation in farm size is correlated with fluctuations in decoupled payments. Table 5.3 provides a comparison of mean acres reported in the RMA data between observations with and without missing years.

Table 5.3 Net Reported Total Acres Comparison of Means

	All	None Missing	Missing any year	Missing more than 2yrs
Net Reported Total Acres	50,151	55,556	1,598	1,507
Total Observations	32,713	29,436	3,277	2,288

SOURCE: Summary of Business data from the Risk Management Agency from 1996 to 2011

To determine whether these counties accurately represent the population of farmers in top producing states, production levels between counties with and without missing years are compared. A production comparison of means by crop, shown in Figure 5.2, reveals that observations with missing years have lower production levels relative to the average. Counties with missing years consistently produce less than five percent of the average for corn, wheat, and soybeans, and less than thirty percent of the

[50] Only counties that made premium payments are considered in this study, thus missing years are generated from missing indemnity values.

average for cotton. Production levels decrease as the number of missing years in a county increases.

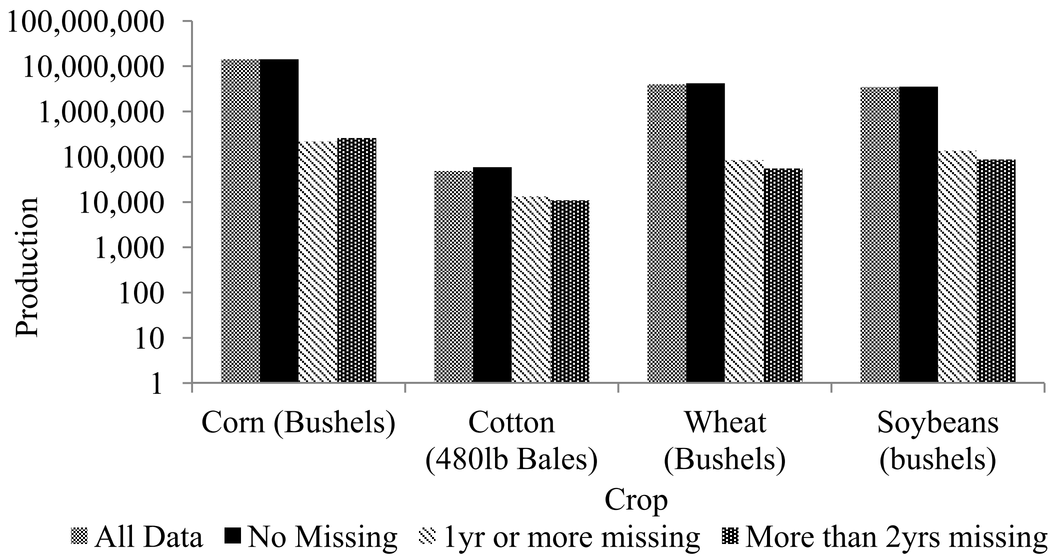

Figure 5.2 Production Comparison of Means by Primary Crop

SOURCE: The National Agricultural Statistical Service (NASS) Quick Stat service provided county level production data in the annual survey from 1996 to 2011.

NOTES: Production data for cotton, corn and soybeans are available through NASS at the county level from 1990 to 2011. Production data for wheat is only available at the county level from 1990 to 2008.

Data from production levels and acres indicate the 248 counties with missing observations are counties with small farms that produce little compared to the average across all farms in the data set. Even though counties with missing years do not appear to be representative of the population of farmers in top producing states, dropping these observations may still be problematic if all of the observations are located in a particular region of the United States. This would suggest that there may be systematic differences in that U.S. region causing smaller farms to exist there. Figure 5.3 shows a map of the spatial distribution of the counties with one or two missing years. The spatial distribution of these counties is not highly concentrated, which suggests the counties with missing years are not geographically clustered. Thus, the 248 cross sectional observations are excluded from the final data set.

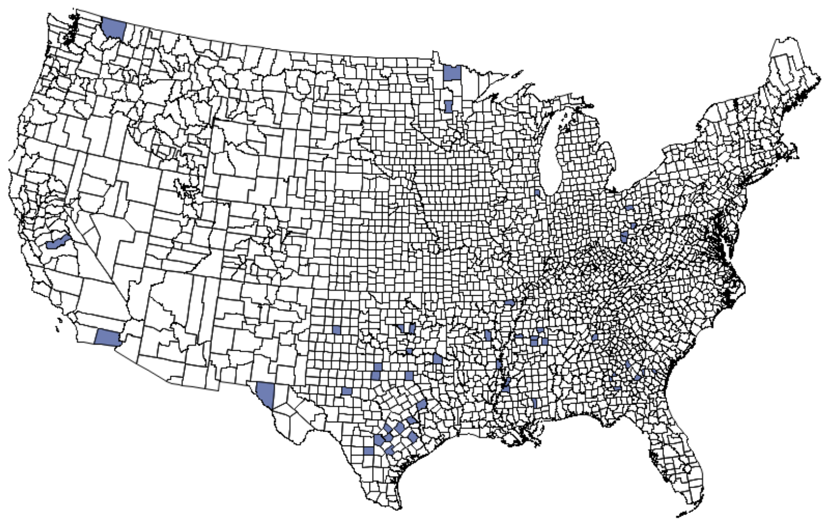

Figure 5.3 Map of Counties Missing One or Two Years of Loss Ratios (48 Counties)

SOURCE: The Risk Management Agency (RMA) Summary of Business provides data from 1990 to 2011 on premiums and indemnity payments to counties in the United States

NOTES: The loss ratio is the ratio of indemnity payments over premiums for each county in the top five states producing corn, cotton, wheat and soybeans. The counties shown in are missing at one or two loss ratios between 1990 and 2011.

The final expected loss ratio data include 230 wheat counties, 200 cotton counties, 466 corn counties and 442 soybean counties from 1996 to 2011. Of the corn and soybean counties, 367 counties produce both corn and soybeans, leaving 99 counties producing only corn and 75 producing only soybeans. For counties producing only one crop, the expected loss ratio is the six-year historical rolling average of the loss ratios for their primary crop. For counties producing corn and soybeans, the expected loss ratio is the weighted average of soybean and corn expected loss ratios, where the weights consist of the proportion of planted acres historically attributed to corn and soybeans. Equation (5.9) shows the expression used to generate the corn soybean county expected loss ratio.

$$E(LR_{it}) = E(LR_{it}^{corn}) \times W_{corn} + E(LR_{it}^{soybean}) \times W_{soybean} \tag{5.9}$$

The corn weight (W_{corn}) and soybean weight ($W_{soybean}$) are based on historical corn and soybean planted acreage data from the National Agricultural Statistical Service (NASS). The soybean weight is the ratio of soybean planted acres over the sum of soybean and corn planted acres. Similarly, the corn weight is the ratio of corn planted acres over the sum of soybean and corn planted acres. Depending on the data availability of county-level planted acre data, some counties have an expected loss ratio weighted using state-level planted acre data from the NASS.[51] The final expected loss ratio data set has one expected loss ratio per county for each year from 1996 to 2011.

The final data set consists of farm-level financial and production variables, and county-level expected loss ratios and decoupled payments from 1996 to 2011. A summary of these variables is outlined in Table 5.4. In addition, variables for 2002 and 2008 indicate years farm bills passed. Categorical variables indicate five types of farmers: wheat farmers, cotton farmers, corn farmers, soybean farmers and corn soybean farmers. The final data set includes 12,891 wheat farmers, 6,933 cotton farmers, 6,525 corn farmers, 2,951 soybean farmers and 33,166 corn soybean farmers over sixteen years, making 62,466 total observations. [52]

[51] Approximately 99 percent corn soy farmers use county weights, the rest use state level planted acres.
[52] The final data set does not include three observations because of extreme values for farm income to household, three for variable expenses per acre, one for fixed expenses per acre and one for acres operated. It also excludes observations with a debt-to-asset ratio above the 99th percentile.

Table 5.4 Summary of Variable Definitions

Variable Name	Units	Definition
Debt-to-Asset Ratio	Dollars of debt per dollar of assets	Total Farm Debt/ Total Farm Assets
Decoupled Payments per Farm	Million Dollars per Farm	Sum of Direct and Counter Cyclical Payments (DCP), Market Loss Assistance (MLA) Payments and Production Flexibility Contract (PFC) Payments to a county/ Number of Farms in that county
Operator Age	Years	Age of Primary Operator
Operator Education	Four Classifications	(1) Less than a High School diploma, (2) a High School diploma, (3) some college including an associate's degree, and (4) at least a four-year college degree
Revenue per Acre	Thousand Dollars	Ratio of total farm production to farm harvested acres multiplied by the state crop specific price
Expected Loss Ratio	Dollars of Indemnities received per dollar paid in Premiums	Six-year historical rolling average county loss ratio. Loss ratio= indemnity/premium payments, where premium payments are the sum of farmer paid premiums and subsidies.
Variable Expense per Acre	Thousand Dollars	Total Variable Expense/ Acres Operated
Fixed Expense per Acre	Thousand Dollars	Total Fixed Expense/ Acres Operated
Value of Real Estate	Million Dollars	The reported sum of the market value of land and buildings
Acres Operated per Farm	Thousand Acres	The reported sum of owned acres and acres rented or leased from others, less the acres rented to others.

SOURCES: The Agricultural Resource Management Survey (ARMS) records the debt-to-asset ratio, operator age, education, revenue per acre, variable expenses per acre, fixed expenses per acre, value of real estate, and acres operated per farm. The Risk Management Agency (RMA) provides county indemnity and premium payments used to calculate the expected loss ratio. The Farm Service Agency (FSA) records DCP payments, MLA payments, and PFC payments and the U.S. Agricultural Census collects the number of farm per county used to calculate decoupled payments per farm.

NOTES: In the Agricultural Resource Management Survey (ARMS) farmers report the total farm debt and total farm assets and the debt-to-asset ratio is calculated by ARMS based on the reported values. The ARMS reports total production levels for a crop, total harvested acres for a crop and the National Agricultural Statistical Service (NASS) reports state prices received. These three elements are used to calculate revenue per acre for a particular crop.

CHAPTER 6

EMPIRICAL METHODOLOGY AND PRELIMINARY INSIGHTS

This research empirically estimates the effect of farm and operator characteristics on farm financial solvency. Of particular interest is the relationship between decoupled payments and farm solvency. Equation (6.1) characterizes the linear regression relationship of the effects of farm acres, assets, income, crop production, production risk, decoupled payments per farm, expenses and operator characteristics on farm solvency as measured by the debt-to-asset ratio (DA_{it}) for farmer i in year t. This model weights observations based on the probability of being selected from the total population of farmers for the Agricultural Resource Management Survey (ARMS).[53]

$$\begin{aligned} DA_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 RE_{it} + \beta_3 REV_{it} + \beta_4 ELR_{it} + \beta_5 ELR0106_{it} + \beta_6 DP_{it} + \beta_7 FEXP_{it} \\ + \beta_8 VEXP_{it} + \beta_9 Age_{it} + \beta_{10} EDU_{it} + \beta_{11} Yr02_{it} + \beta_{12} Yr08_{it} + \beta_{13} Yr0106_{it} \\ + \sum_{j=1}^{4} \beta_{13+j} FT_j + \sum_{j=1}^{n-1} \beta_{17+j} ST_j + \epsilon_{it} \end{aligned} \tag{6.1}$$

The explanatory variables are acres operated per farm (A_{it}), value of real estate (RE_{it}), revenue per acre (REV_{it}), expected loss ratio (ELR_{it}), decoupled payments per farm (DP_{it}), fixed expenses per acre ($FEXP_{it}$), variables expenses per acre ($VEXP_{it}$), operator age (Age_{it}) and operator education (EDU_{it}).[54] In order to control for the

[53] The weighting occurs after the farm-level financial data are merged with the county-level decoupled payments and expected loss ratio data. This controls for sample selection bias that occurs because some farmers have a higher probability of being selected for the survey than other farms.
[54] Decoupled payments per farm (DP_{it}) is defined according to the county average, and does not vary across individual farms within a county.

unobserved effects the Farm Bills may have had on a farmer's debt-to-asset ratio, indicator variables for the years 2002 ($Yr02_{it}$) and 2008 ($Yr08_{it}$) are included in the model. The model also controls for the effect of the increase in crop insurance premium subsidies from the 2000 Agricultural Risk Protection Act on farmer's expected loss ratios by interacting an indicator variable for years 2001 through 2006 ($Yr0106_{it}$) with the expected loss ratio variable ($ELR0106_{it}$).[55]

Farm crop-type indicator variables classify farmers as corn, soybean, wheat, cotton or corn soybean farmers. Classifications are based on state mean production levels from harvested area reported in the 1997, 2002, and 2007 U.S. Agricultural Census. These indicator variables capture the effect of differences in unobserved crop specific characteristics on the farm business debt-to-asset ratio, including differences in crop production practices, or resource uses that cause farmers of different crops to finance different percentages of their assets with debt. Four of the five farm type indicators are included in this model as represented by the term $\sum_{j=1}^{4} \beta_{13+j} FT_j$.

The linear regression model also includes state fixed effects, which captures the effects of state characteristics that are not directly controlled for but that may affect a farmer's debt-to-asset ratio.[56] The inclusion of state fixed effects eliminates variation between states, so that the variation in the explanatory variables used to identify the parameter estimates is variation between farmers within a state over time. State indicator

[55] Since the expected loss ratio is a six-year historical rolling average, an increase in premium subsidies in 2000 would affect a farmer's expected loss ratio until the year 2006.
[56] County-level fixed effects were also considered in lieu of state fixed effects, however because decoupled payments are collected at the county-level and because most of the variation in decoupled payments occurs between counties, county level fixed effects may be collinear with decoupled payments.

variables are represented by $\sum_{j=1}^{n-1}\beta_{17+j}ST_j$ in equation (6.1), where n is the number of states included in this study.

The remaining unobservable characteristics influencing a farmer's debt-to-asset ratio are represented by the error term, ϵ_{it}. The empirical model includes county-clustered standard errors to control for potential serial correlation of farmers within a county. Serial correlation between farmers within a county occurs when the covariance of the residuals of two farmers is greater than zero. Clustering the standard errors at the county-level allows for the residuals of observations with a county to be correlated because of unobserved characteristics, but does not model within county correlation directly. It allows for an arbitrary correlation with counties and the form of the correlation to vary between counties (Wooldridge, 2009). If this correlation exists and is not controlled for then the model specification will underestimate the standard errors and inflate the statistical significance of the explanatory variables (Wooldridge, 2009). Controlling for potential correlation between farmers within a county reduces the probability of falsely concluding explanatory variables have a statistically significant impact on farm solvency. Thus, county-clustered standard errors are used in the linear regression model.

Two-Stage Least Squares Model

One concern with the linear regression model outlined in equation (6.1) is that acres operated are potentially endogenous to the debt-to-asset ratio, implying that acres influence a farmer's level of debt financing and the debt-to-asset ratio could influence acres operated decisions. As acres operated (A_{it}) changes so do assets and the debt-to-asset ratio. However, a farmer's debt-to-asset ratio may also influence their decision to purchase or sell assets. For example, if a farmer has exhausted their access to credit, then they may be unable to rent additional acres because their debt balance has reached a certain level. Thus, the acreage and leverage decisions may be simultaneously determined.

If the debt-to-asset ratio, which measures a farmer's decision to leverage their equity with debt, influences the number of acres a farmer chooses to operate, then acres operated (A_{it}) would be correlated with the error term (ϵ_{it}) in equation (6.1) due to reverse causality. This is problematic in a linear regression context because it violates the assumption of a zero conditional mean of the error term ϵ_{it} and generates biased parameter estimates (Wooldridge, 2009). This bias is stated formally in equation (6.2), where $plim\ \hat{\beta}_{A_{it}OLS}$ is the probability limit of the parameter estimate for acres operated generated from the equation (6.1), $\beta_{A_{it}}$ is the true population parameter, and $\sigma_{\epsilon_{it}}$ and $\sigma_{A_{it}}$ represent the standard deviations of the error term and acres operated in the population, respectively.

$$plim\ \hat{\beta}_{A_{it}OLS} = \beta_{A_{it}} + Corr(A_{it}, \epsilon_{it}) \cdot \frac{\sigma_{\epsilon_{it}}}{\sigma_{A_{it}}} \tag{6.2}$$

A critical assumption for the ordinary least squares (OLS) model to be an unbiased and consistent estimator is that the correlation between acres operated and the error term is zero, $Corr(A_{it}, \epsilon_{it}) = 0$. However, if the debt-to-asset ratio influences acres operated then the correlation may not be zero and a two-stage least squares model (TSLS) may be more appropriate than OLS. The concept behind a two-stage least squares model is to isolate the variation in acres operated (A_{it}) that is uncorrelated with the error term (ϵ_{it}) in the debt-to-asset ratio equation, and use that part of the variation to consistently estimate the effect of acres operated on the debt-to-asset ratio. This is done through a third variable, used as an instrument to identify the variation in acres operated.

To obtain consistent estimators when acres and the error term are correlated, the instrumental variable must satisfy two properties. The first is that the instrument is exogenous, meaning it is uncorrelated with the error term ϵ_{it}. The second requirement is that the instrument is relevant, meaning the correlation between acres operated and the instrument is not zero. If these two properties hold, then the parameter estimate from the TSLS model will be unbiased. This is demonstrated in equation (6.3), which shows the probability limit of the TSLS parameter estimate for acres operated ($\hat{\beta}_{A_{it},TSLS}$), where z_{it} is the instrumental variable, $\beta_{A_{it}}$ is the true population parameter, and $\sigma_{\epsilon_{it}}$ and $\sigma_{A_{it}}$ represent the standard deviations of the error term and acres operated in the population, respectively.

$$plim\ \hat{\beta}_{A_{it},TSLS} = \beta_{A_{it}} + \frac{Corr(z_{it}, \epsilon_{it})}{Corr(z_{it}, A_{it})} \cdot \frac{\sigma_{\epsilon_{it}}}{\sigma_{A_{it}}} \qquad (6.3)$$

The exogeneity condition is formally expressed as $Corr(z_{it}, \epsilon_{it}) = 0$, and the relevance condition is stated as $Corr(z_{it}, A_{it}) \neq 0$. If these two conditions hold and acres operated is endogenous, $Corr(A_{it}, \epsilon_{it}) \neq 0$, then a TSLS model is preferred over the linear regression model in equation (6.1) because it is unbiased. Equation (6.4) outlines the first stage regression in the TSLS model, where acres operated is regressed on the instrumental variables and all other exogenous variables in equation (6.1).

$$
\begin{aligned}
A_{it} = \beta_0 + \beta_1 PFM_{it} + \beta_2 PMO_{it\text{-}1} + \beta_3 TFM_{it} + \beta_4 TMO_{it\text{-}1} + \beta_5 RE_{it} + \beta_6 REV_{it} \\
+ \beta_{10} FEXP_{it} + \beta_8 DP_{it} + \beta_7 ELR_{it} + \beta_9 ELR0106_{it} + \beta_{12} Age_{it} \\
+ \beta_{13} EDU_{it} + \beta_{11} VEXP_{it} + \beta_{14} Yr02_{it} + \beta_{15} Yr08_{it} + \beta_{16} Yr0106_{it} \\
+ \sum_{j=1}^{4} \beta_{16+j} FT_j + \sum_{j=1}^{n\text{-}1} \beta_{21+j} ST_j + v_{it} \qquad (6.4)
\end{aligned}
$$

State-level climatic variables are used as instruments for acres operated in this study. Specifically, the instruments are total precipitation from February to May of the current year (PFM_{it}), total precipitation from March to October of the previous year ($PMO_{it\text{-}1}$), average temperatures from February to May of the current year (TFM_{it}), and average temperatures from March to October of the previous year ($TMO_{it\text{-}1}$).[57] Unlike acres operated, farmers have little control over weather conditions they experience from year to year. Therefore, farmers are unable to simultaneously determine precipitation or temperature and leverage. In general, the instrument exogeneity condition cannot be tested empirically, but theoretical reasoning suggests temperature and precipitation do not have a partial effect on the debt-to-asset ratio after controlling for acres operated. Although weather conditions may have an impact on the year-to-year operations, they are unlikely to influence the long run debt or assets and thus are considered exogenous.

It is also likely that temperature and precipitation are relevant, meaning they influence a farmer's operated acres. Temperature and precipitation between February and

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[57] These data are collected from 1995-2011 from the National Climatic Data Center of the National Oceanic and Atmospheric Association (NOAA) at the state-level. Monthly precipitation and temperature data are reported in inches and Fahrenheit, respectively.

May of the current year measure pre seeding weather conditions. Temperature and rainfall from March to October of the previous year are used to measure weather conditions from the prior year. Both pre seeding and the prior year's weather conditions may influences the acres operated decision in the current year. For example, if a famer expects low yields on particular acreage because extreme weather conditions damaged the soil, then they may decide not to operate on that acreage in the current year. To empirically test the relevance of the climatic variables a test for joint significance can be conducted from the first stage results shown in equation (6.4). If β_1 through β_4 are jointly statistically significant, then at least one of the instruments can be considered relevant.

Assuming the climatic instruments are relevant and exogenous, the predicted values of acres operated ($\hat{A}_{it}$) from the first stage isolate the variation in acres operated that is uncorrelated with the error term from the structural model ϵ_{it}. These values are included in the second stage regression to generate an unbiased parameter estimate for acres operated. Equation (6.5) shows the second stage TSLS regression of the debt-to-asset ratio (DA_{it}) on predicted acres operated ($\hat{A}_{it}$) and all other exogenous explanatory variables included in the structural model outlined in equation (6.1).

$$DA_{it} = \beta_0 + \beta_1 \hat{A}_{it} + \beta_2 RE_{it} + \beta_3 REV_{it} + \beta_4 ELR_{it} + \beta_5 ELR0106_{it} + \beta_6 DP_{it} + \beta_7 FEXP_{it} + \beta_8 VEXP_{it} + \beta_9 Age_{it} + \beta_{10} EDU_{it} + \beta_{11} Yr02_{it} + \beta_{12} Yr08_{it} + \beta_{13} Yr0106_{it} + \sum_{j=1}^{4} \beta_{13+j} FT_j + \sum_{j=1}^{n-1} \beta_{17+j} ST_j + \epsilon_{it} \quad (6.5)$$

The advantage to the TSLS model is that it generates unbiased parameter estimates when acres operated is endogenous to the debt-to-asset ratio, if exogenous and relevant instruments are obtained. However, a consequence of TSLS estimator is an increase in the asymptotic variance relative to the OLS estimator (Wooldridge, 2009). If acres operated is uncorrelated with the error term (ϵ_{it}) then the OLS model will generate unbiased parameter estimates and is preferred over TSLS because it is a more efficient estimator. In order to determine which model is appropriate, the Hausman-Wu test for endogeneity can be performed which uses the predicted residuals ($\hat{v}_{it}$) from the first stage as an additional regressor in the second stage, instead of the predicted values for acres operated ($\hat{A}_{it}$). If the coefficient on $\hat{v}_{it}$ is statistically significant then this provides evidence that acres operated is endogenous, and TSLS is the preferred model (Wooldridge, 2009).

The reliability of the Hausman-Wu test and the consistency of the TSLS estimator rely on the exogeneity and relevance of the instrumental variables. If the climatic instruments and acres operated are only moderately correlated, then the TSLS estimator can have large standard errors and can also generate an asymptotic bias, as shown in equation (6.3), making it a biased and less efficient estimator than OLS (Wooldridge, 2009). Thus, both models are compared in this study.

Debt-to-Asset Ratio

Financial stability can be broken down into five elements and each of the elements can be measured by a separate financial ratio. This thesis focuses on the farm debt-to-asset ratio, which is used as a measure of farm solvency. The debt-to-asset ratio is defined as the ratio of total farm debt to total farm assets (Park et al., 2011). Thus, it measures a farm's decision to leverage their equity to take on debt. In general solvency refers to a farm's capacity to meet its long-term financial obligations, and the debt-to-asset ratio measures those commitments as a percentage of total assets. Low levels of debt relative to assets may indicate that the farm is better insulated from the risks associated with commodity production, changing macroeconomic conditions, and fluctuations in farm asset values (Morehart, 2013). An investigation of the relationship between decoupled payments and the debt-to-asset ratio provides insight into decoupled payments' effect on farm solvency through its effect on the decision to leverage equity to take on debt.

Although the ARMS provides multiple ratios to measure the elements of financial stability such as the current ratio, term-debt coverage ratio and operating profit margin, the debt-to-asset ratio is the only one without missing observations.[58] All of the farmers in the top five states producing corn, cotton, wheat and soybeans sampled in the ARMS reported their debt-to-asset ratio. However, the distribution of the reported ratios suggests the presence of outliers. Specifically, the observations in the top one percent of the distribution vary substantially from the mean of the data. A comparison of means and standard deviations between the top one percent of the distribution and the remaining observations is shown in Table 6.1. The mean debt-to-asset ratio for the top one percent is 5.19 while the mean for the remainder of the data is 0.17. In other words, observation in the 99th percentile have 5.19 times more total debt than total assets compared to the rest of the sample that has debt balance of seventeen percent of total assets.

[58] There two measure of debt-to-asset ratio in the ARMS data set, the one used in this study is called the farm business debt-to-asset ratio.

Table 6.1 Comparison of Means and Standard Deviation for the Ninety-Ninth Percentile

	Top 1%		Lower 99%	
	Mean	STDV	Mean	STDV
Debt-to-Asset Ratio	5.19	17.91	0.17	0.19
Decoupled Payments per County (in millions)	7.79	6.65	6.19	4.85
Operator Age	48.02	11.87	53.27	12.18
Revenue per Acre (in thousands)	0.37	0.23	0.38	0.23
Expected Loss Ratio	0.97	0.63	0.78	0.51
Variable Expenses per Acre (in thousands)	0.48	1.94	0.29	1.17
Fixed Expenses per Acre (in thousands)	0.16	0.29	0.08	0.11
Value of Real Estate (in millions)	0.19	0.72	1.22	2.87
Acres Operated (in thousands)	2.39	3.40	1.50	2.28
Number of Observations	632		62466	

SOURCES: The Agricultural Resource Management Survey recorded the debt-to-asset ratio, revenue per acre, operator age, acres operated, value of real estate, and fixed and variable expenses per acre. The Farm Service Agency provided decoupled payments data, and The Risk Management Agency provided crop insurance premium and indemnity payments used to calculate the expected loss ratio.

NOTES: Decoupled payments per county are the sum of Direct and Counter Cyclical Payments, Market Loss Assistance payments, and Production Flexibility Contract payments made to a county from 1996 to 2011 from corn, cotton, wheat and soybean base acres. The data reported consider farmers in the top five states producing corn, cotton, wheat and soybeans in the United States from 1996- 2011.

These observations are problematic because the linear regression model used in this analysis minimizes the sum of squared residuals, thus observations with large residuals receive more weight in the least squares estimation problem than observations around the mean (Wooldridge, 2009). Outlier observations can occur for two primary reasons. The first reason is human error. In the ARMS data, outliers can occur because of a misrepresentation of the debt-to-asset ratio by farmers, or a mistake entering the data. Secondly, outliers can occur because members of the sample population are very different in some relevant aspect from the rest of the population (Wooldridge, 2009). However, a comparison of means does not reveal a substantial difference in the outlying observations for the primary variable of interest. Based on this information, observations with a value for debt-to-asset ratio in the 99th percentile are removed from the data set.[59] Figure 6.1 shows the trend in the mean debt-to-asset ratio from 1996 to 2011 for farmers in the top five states producing corn, wheat, cotton and soybeans excluding observations in the 99th percentile.

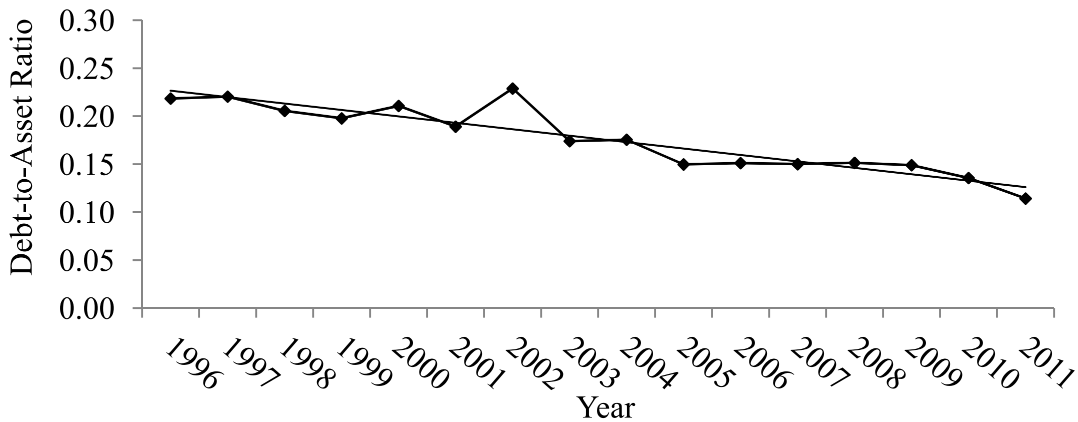

Figure 6.1 Trend in the Debt-to-Asset Ratio from 1996 to 2011

SOURCE: The Agricultural Resource Management Survey (ARMS) provide individual farmer debt-to-asset ratios from 1996 to 2011 for farmers in the top five states producing corn, wheat, cotton and soybeans according to the U.S. Agricultural Census in 1997, 2002 and 2007.

NOTES: The value for each year is the mean debt-to-asset ratio for all farmers in the top five states producing corn, cotton, wheat and soybeans in the United States. The fitted linear trend overtime is also shown. The highest one percent of reported debt-to-asset ratios are excluded from this trend.

The trend in the debt-to-asset ratio is downward sloping from 1996 to 2011. Potential explanations for this trend could be changes in land values, technology adoption, or economies of scale stemming from the growth in large farms. Over this time, farmers in the top five states producing corn, wheat, cotton and soybeans maintained an average debt-to-asset ratio of less than 0.23, meaning that for every hundred dollars of assets, a farm has less than twenty-three dollars in debt. By 2011, farmers only financed

[59] Dropping the largest one percent of debt-to-asset ratios is consistent with the work of Kropp and Katchova (2011) who only considered observations above the 5th percentile and below the 95th.

11.4 percent of their assets with debt on average, which is the lowest amount over the period of interest. Figure 6.2 shows the average debt-to-asset over time broken up by primary crop designation.

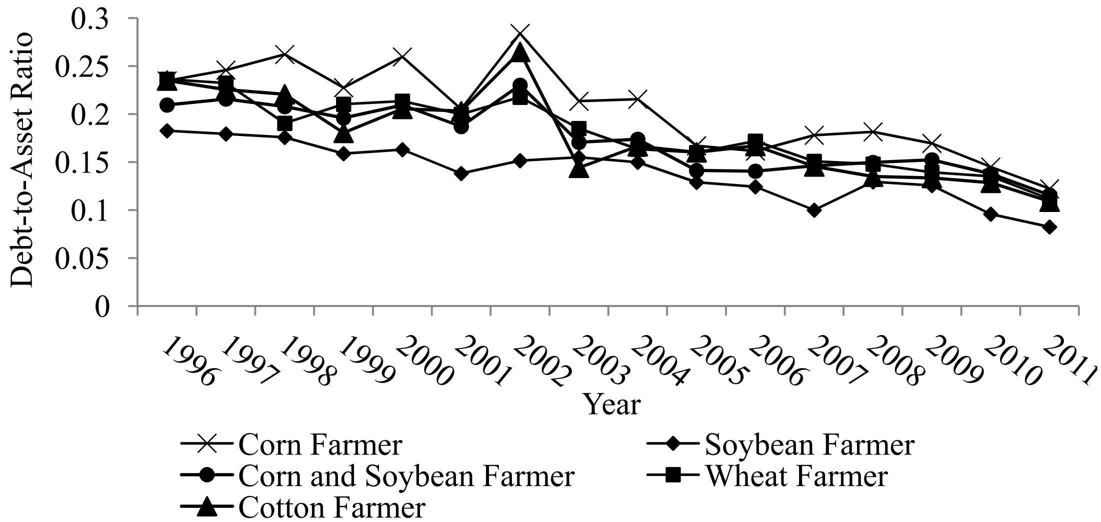

Figure 6.2 Trend in the Debt-to-Asset Ratio by Primary Crop from 1996 to 2011

SOURCE: The Agricultural Resource Management Survey (ARMS) provide individual farmer debt-to-asset ratios from 1996 to 2011 for farmers in the top five states producing corn, wheat, cotton and soybeans according to the U.S. Agricultural Census in 1997, 2002 and 2007.

NOTES: The value for each year is the mean debt-to-asset ratio for farmers in the top five states producing corn, cotton, wheat and soybeans in the United States in that year. Four of the top five states producing corn and soybeans overlap, thus farmers in these four states are classified as corn and soybean farmers. The farmers in the remaining top producing corn state are considered corn farmers, and farmers in the remaining top producing soybean state are considered soybean farmers.

Figure 6.2 shows corn farmers have the highest debt-to-asset ratios over the period of interest. Nebraska corn farmers represent the corn-only farmer trend because Nebraska is the only top five state producing corn that is not also a top soybean producing state. Cotton farmers also have a higher debt-to-asset ratio over the period of interest relative to the other farm types. The most variation in the average debt-to-asset ratio for cotton farmers occurs from 2001 to 2003. From 2003 to 2006, the debt-to-asset ratio rose. After reaching 0.16 in 2006, it began to decline. By 2011, the debt-to-asset ratio reached a low of 0.11 for cotton farmers. Soybean farmers consistently have the lowest debt-to-asset ratios, with the exception of cotton farmers in 2003. The soybean trend represents the trend in the debt-to-asset ratio for Ohio soybean farmers, which is the only top soybean producing state that is not also a top state producing corn.[60]

Despite the differences in the debt-to-asset ratio across farm types, on average farmers have been decreasing their debt-to-asset ratio from 1996 to 2011. In 1996, the debt-to-asset ratio by farm primary crop ranged from 0.18 to 0.24. By 2011, farm debt-to-asset ratios ranged from 0.08 to 0.12 on average. This suggests that farmers are becoming more solvent over time. This study seeks to investigate the cause of this decrease over time and to identify whether decoupled payments have influenced farmer's solvency.

Explanatory Variables

Potential explanations for changes in farmer debt-to-asset ratio over time and variation across farmers are differences in farm acres, assets, income, crop production, production risk, decoupled payments, expenses, and operator characteristics. The variable acres operated per farm (A_{it}) captures the effect of scale.[61] The value of real estate (RE_{it}) measures the effect of changes in land values that directly impact a farmer's debt-to-asset ratio. Revenue per acre (REV_{it}) captures the effects of a farm business's crop production practices. The expected loss ratio (ELR_{it}) controls for differences in recent production

[60] Because both corn farmers and soybean farmers are represented by a single state, the trends overtime are not as representative of the total population of corn farmers and soybean farmers as the other primary crop designations represented by a larger sample of farmers.

[61] Other acre variables include acres harvested, rented, and owned. However, acres operated per farm is the most consistently collected and best represents the total size of a farm.

risks. Variable expenses per acre ($VEXP_{it}$) capture the effect of input costs on a farm's financial stability. Fixed expenses per acre ($FEXP_{it}$) represent fixed costs such as land and equipment that affect a farmer's solvency. Farm operator age (Age_{it}) and education (EDU_{it}) are operator characteristics that may affect a farmer's management style and farm's financial stability.[62] Summary statistics for these variables and decoupled payments per farm are below.

Table 6.2 Summary Statistics for Explanatory Variables

	N	Level	Mean	Median	STDV
Decoupled Payments per Farm	62466	County	$8,051.00	$6,284.00	$7,280.00
Operator Age	62466	Individual	53.27	53.00	12.18
Operator Education	62466	Individual	2.68	3.00	0.88
Revenue per Acre	62466	Individual	$383.14	$323.20	$231.00
Expected Loss Ratio	62466	County	0.78	0.65	0.51
Variable Costs per Acre	62466	Individual	$291.44	$162.87	$1,171.13
Fixed Cost per Acre	62466	Individual	$82.06	$58.12	$111.54
Value of Real Estate (in millions)	62466	Individual	$1.22	$0.60	$2.82
Acres Operated per Farm	62466	Individual	1,502.13	890	2,275.03

SOURCE: Decoupled payments per farm come from the Farm Service Agency PPRS and DA databases from 1996 to 2011. The expected loss ratio is from the Risk Management Agency Summary of Business data from 1990 to 2011. Price received data from the National Agricultural Statistical Service and Agricultural Resource Management Survey yield per harvested acre data from 1996 to 2011 generate the revenue per acre variable. All other variables come from the ARMS annual data from 1996 to 2011.

NOTE: Data includes only farmers in the top five states producing corn, wheat, cotton and soybeans according to the 1997, 2002 and 2007 U.S. Agricultural Census. Expected loss ratio is a six-year rolling historical average of crop specific loss ratios. Decoupled payments represent Production Flexibility Contract, Market Loss Assistance, and Direct and Counter Cyclical payments from 1996 to 2011.

Farm financial assets, expenses and income are all farm-level characteristics. It is possible that as farm size increases, farm income and expenses rise as well. If economies of scale are present in agriculture then as farm size increases, fixed and variable expenses

[62] Katchova (2010) found that older farmers are less likely to experience financial stress. Antoni, Mishra and Chintawar (2009) determined a farmer's age, size of operation, years of operation, and farm type are significant determinants of financial stress.

per acre may decrease. Because decoupled payments are a function of production acres, farm size and decoupled payments are likely to be positively related. This relationship may persist when comparing a farm's size with average county-level decoupled payments per farm. Thus, it is important to investigate the correlation between variable and fixed expenses per acre, the value of real estate, revenue per acre, decoupled payments per farm, expected loss ratio and acres operated per farm. A correlation matrix between these key variables is shown in Table 6.3 to help determine if multicolinearity is a concern with these data. Multicolinearity is problematic because it inflates the variance and standard errors of the estimated parameters and causes imprecise results (Wooldridge, 2009).

Table 6.3 Correlation Matrix for Farm Characteristic Explanatory Variables

	DP	REV	ELR	FEXP	VEXP	Acres
Decoupled Payments per Farm	1	--	--	--	--	--
Revenue per Acre	-0.00	1	--	--	--	--
Expected Loss Ratio	0.01	-0.26	1	--	--	--
Fixed Expenses Per Acre	-0.02	0.27	-0.13	1	--	--
Variable Expenses per Acre	-0.01	0.11	-0.04	0.45	1	--
Acres Operated per Farm	0.12	-0.06	0.12	-0.10	-0.04	1
Value of Real Estate	-0.04	0.20	-0.05	0.06	0.05	0.36

SOURCE: Total variable expenses, total farm financial assets and acres operated per farm are collected from the Agricultural Management Survey (ARMS) annual data from 1996 to 2011. Decoupled payments per farm are generated at the county-level from the Farm Service Agency PPRS data file and DA database from 1996 to 2011 and from the U.S. Agricultural Census reports of number of farms in a county. The expected loss ratio is calculated from the Risk Management Agency Summary of Business data from 1990 to 2011. Price received data from the National Agricultural Statistical Service is used in conjunction with ARMS yield per harvested acre data from 1996 to 2011 to generate revenue per acre.

NOTE: All data considers only farmers in the top five states producing corn, wheat, cotton and soybeans according to the U.S. Agricultural Census in 1997, 2002 and 2007. Expected Loss Ratio is a six-year rolling historical average of county specific loss ratios. Decoupled payments per farm represents the average county-level Production Flexibility Contract, Market Loss Assistance, and Decoupled and Counter Cyclical payments made to farms from 1996 to 2011.

The correlations between the variables shown in Table 6.2 are relatively low, with no correlation above 0.5. The highest correlation of 0.45 exists between variable expenses per acre and fixed expenses per acre. Acres operated per farm and the value of real estate has a correlation of 0.36. This suggests as a farm grows the value of their land and buildings increase as well. The next two highest correlations are between revenue per acre and expected loss ratio and fixed expense at -0.26 and 0.27 respectively. The remaining correlations are less than or equal to 0.20. Thus, multicolinearity does not appear to be problematic with these data.

Expected Loss Ratio

The expected loss ratio is calculated as a six-year rolling historical average of county crop-specific loss ratios.[63] The expected loss ratio could capture two different effects of subsidized crop insurance. The first is the income effect. Because crop insurance premiums are subsidized, higher loss ratios may provide an incentive for farmers to purchase crop insurance because it will increase their long run expected income.[64] The loss ratio may also capture the effect of crop insurance on farmer's production risk. Crop insurance helps reduce yield or revenue risk depending on the product purchased. The primary purpose of including the expected loss ratio is to measure temporary production shocks on the debt-to-asset ratio, as a proxy for production risk. Production areas with higher loss ratios tend to correlate with higher production risk areas (Goodwin and Rejesus, 2008). Figure 6.3 shows the trend in the mean crop-specific expected loss ratio across counties for all farm types from 1996-2011.

[63] By considering only the loss ratios over the last six years, implicitly it is assumed that farmers base their expectations about losses in the current period on recent events. To the extent that some farmers may generate expectations about losses in the current period based on losses from more than six years ago, this proxy will not be exact.
[64] Premium payments used to calculate the expected loss ratio include farmer payments and government subsidies. The income effect occurs over the long term and this study considers only the last six years loss ratios. Thus, the effect of crop insurance on farmer's expected income is not full captured in this study.

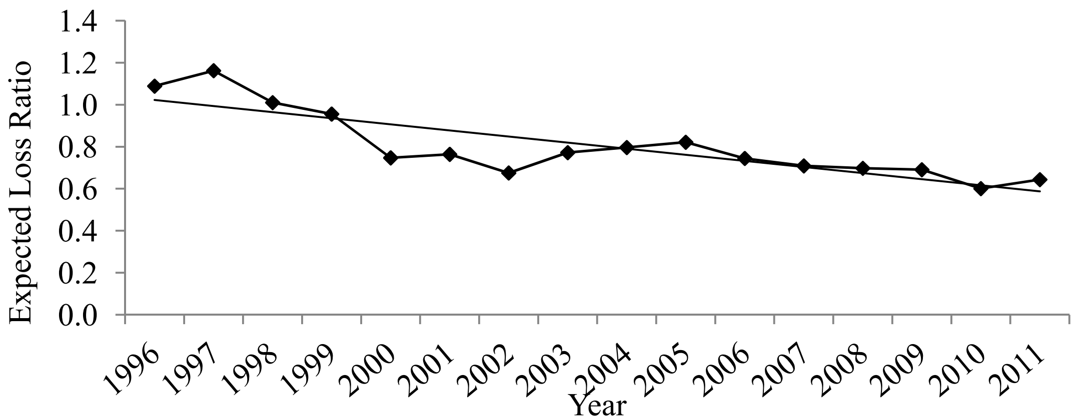

Figure 6.3 Trend in Expected Loss Ratio from 1996 to 2011

SOURCE: The Risk Management Agency (RMA) Summary of Business provides data from 1990 to 2011 on premiums and indemnity payments to counties in the United States

NOTES: The value for each year is the mean expected loss ratio for all counties located in one of the top five states producing corn, wheat, cotton and soybeans according to the US Agricultural Census in 1997, 2002 and 2007. The expected loss ratio is equal to six-year rolling historical average of a county's loss ratio based on premiums and indemnity payments, including premium subsidies.

The expected loss ratio trends downward from 1996 to 2011 for counties in the top five states producing corn, wheat, cotton and soybeans. This suggests expected indemnity payments have been decreasing relative to premium payments, indicating a decrease in production losses over the period of interest. From 1996 to 2011, the highest expected loss ratio of 1.16 occurred in 1997. This means that for every $1.00 of premium payments from subsidies and producers, a farmer expected to receive $1.16 in indemnity payments from crop insurance on average. An expected loss ratio greater than one suggests a farmer expects to receive more in indemnity payments than is paid in premium. The average expected loss ratio was above one in the years 1996 through 1998 and less than one for the remaining years. Figure 6.4 shows the change in the expected loss ratio by farm type from 1996 to 2011.

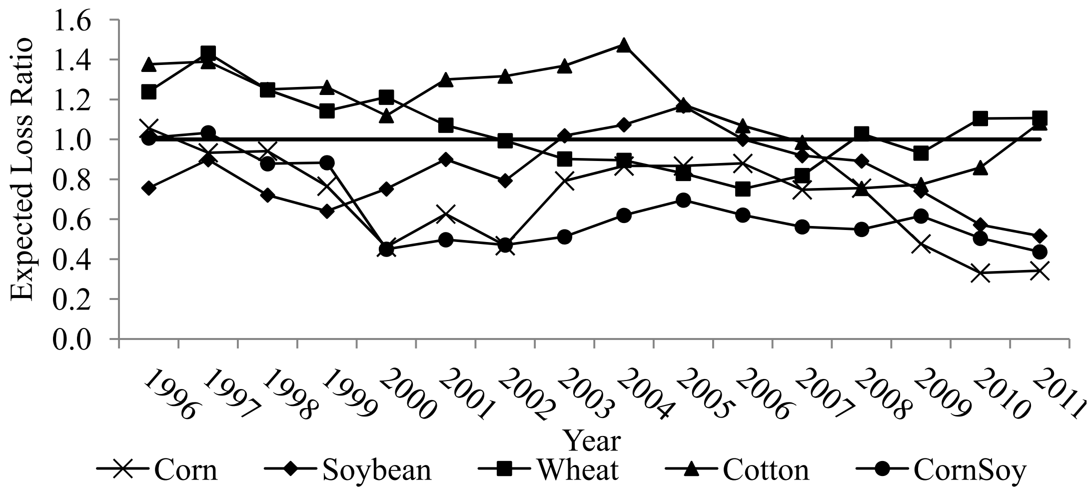

Figure 6.4 Change in Expected Loss Ratio by Primary Crop from 1996 to 2011

SOURCE: The Risk Management Agency (RMA) Summary of Business provides data from 1990 to 2011 on premiums and indemnity payments to counties in the United States

NOTES: The value for each year is the mean expected loss ratio for all counties located in one of the top five states producing corn, wheat, cotton and soybeans according to the US Agricultural Census in 1997, 2002 and 2007. The expected loss ratio is equal to six-year rolling historical average of a county's loss ratio based on premiums and indemnity payments, including premium subsidies.

Figure 6.4 highlights the variation in expected loss ratios between crops, capturing temporary production shocks by crop over the period of interest. In 1996, soybeans were the only crop with an expected loss ratio less than one. Since then, there has been a decrease in the disparity between crop expected loss ratios. The expected loss ratio for all crops has lowered over the period of interest. This decrease occurs over a period in which subsidization of crop insurance premiums increased.[65] By 2011, only wheat and cotton have an expected loss ratio greater than one.

[65] The 1980 Federal Crop Insurance Act established thirty percent premium subsidies for crop insurance to encourage participation. In 1994, the subsidies increased to forty percent under the Crop Insurance Reform Act. The Agricultural Risk Protection Act of 2002 increased the premium subsidy rate to sixty percent and in 2008 the subsidy rate increase to ninety percent through the Food Conservation Energy Act (Glauber, 2013; Smith and Glauber, 2012).

The summary statistics provided in Table 6.4 support the findings from Figure 6.4. Wheat and cotton farmers have higher expected loss ratios than corn and soybean farmers, indicating they had higher production losses from 1990 to 2005. However, both the coefficient of variation and the standard deviation suggest corn farmers and corn soybean farmers experience more variation in the expected loss ratio from year to year. The standard deviation and coefficient of variation for soybean farmers suggest they experience the least amount of variability in losses.

Table 6.4 Summary Statistics for Expected Loss Ratio by Primary Crop

Farm Type	Mean	Median	Standard Deviation	Coefficient of Variation
Wheat	1.03	0.93	0.57	55.91
Corn	0.69	0.60	0.44	63.97
Cotton	1.16	1.07	0.60	51.35
Soybean	0.82	0.77	0.38	45.84
Corn Soybean	0.62	0.52	0.39	62.24

SOURCE: The Risk Management Agency (RMA) Summary of Business data from 1990 to 2011 on county-level premiums and indemnity payments

Corn soybean farmers have an average expected loss ratio of less than one, suggesting they expect to receive less indemnity payments than were paid in premiums on average. Premium payments used to calculate the expected loss ratio include government subsidies and farmer payments. The expected loss ratio for a farmer would be larger, holding indemnities constant, if government subsidies were not included in premium payments. Wheat and cotton farmers have an average expected loss ratio greater than one meaning they expect to receive more in indemnities than were paid in premiums. Thus, assuming risk neutrality, these data suggest wheat and cotton farmers are expected to have a higher demand for crop insurance than corn and soybean farmers (Goodwin, 1993; Smith and Goodwin, 1996; Bekkerman, Smith and Watts, 2012). To ensure that a particular region of the United States does not drive the inferences made from the summary statistics in Table 6.4, Figure 6.5 shows a spatial representation of the distribution of the expected loss ratio across counties from 1996 to 2011. The map shows wheat-producing states, and cotton-producing states in the central plains have higher average expected loss ratios than corn and soybean producing states Iowa, Illinois, Nebraska and Indiana.

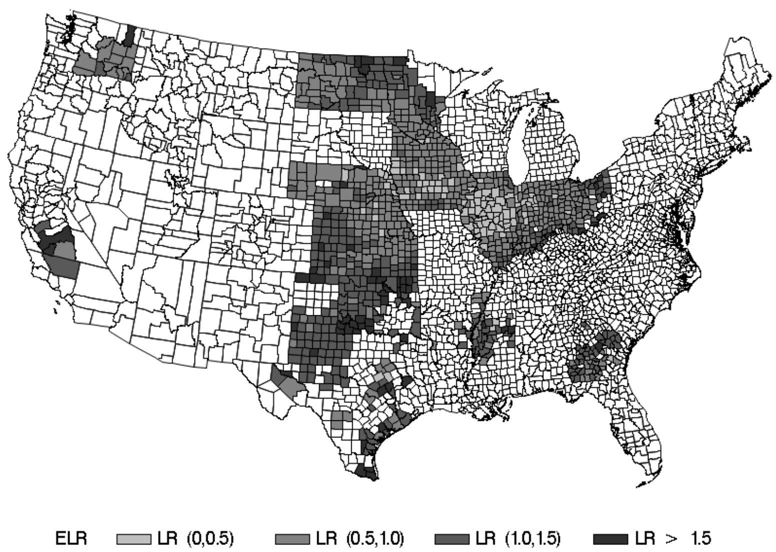

Figure 6.5 Mean Expected Loss Ratio from 1996-2011 by County

SOURCE: Risk Management Agency (RMA) Summary of Business data from 1990 to 2011

NOTES: The value for each county is the mean expected loss ratio (ELR) from 1996 to 2011. The ELR for each county is the average of the past six-year's loss ratios. The loss ratio for each year is the ratio of indemnity payments over premiums in a county for that year as reported by the RMA.

The findings from Figure 6.5 are consistent with those from Figure 6.4 and Table 6.4 that suggest cotton and wheat counties have higher production losses on average, and thus farmers there are more likely to purchase crop insurance. The variation in expected loss ratios across crops and over time allows inferences to be made about the effect of temporary production shocks on the financial solvency of farms from 1996 to 2011.

Decoupled Payments

Although decoupled payments are often considered constant over time, a graph of the mean decoupled payments per farm from 1996 to 2011 reveals the variability in decoupled payments. Figure 6.6 shows the mean county decoupled payments per farm from 1996 to 2011, for all counties receiving payments in the top five states producing corn, wheat, cotton and soybeans.

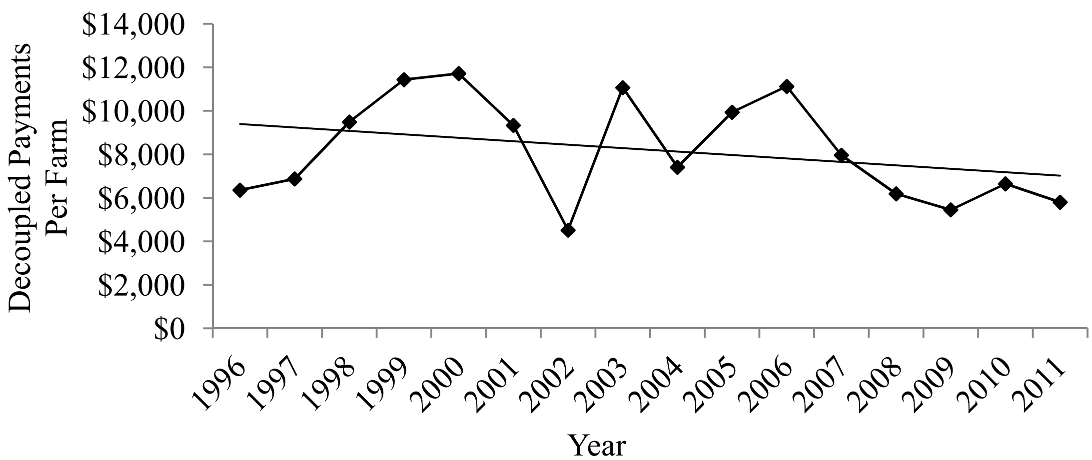

Figure 6.6 Mean County Decoupled Payments per Farm from 1996-2011

SOURCE: The Farm Service Agency (FSA) provided data from 1996 through 2008 under the Producer Payment Reporting System (PPRS) Payment Files. From 2009 to 2011, the FSA recorded decoupled payments made to counties in the Direct Attribution (DA) database, payments entitled DCP/ACRE.

NOTES: Decoupled payments consist of Production Flexibility payments, Market Loss Assistance payments, and Direct and Counter Cyclical payments. Each data point represented in the graph is equal to the sum of decoupled payments for all counties receiving payments in the top five states producing corn, wheat, cotton and soybeans divided by the number of farms.

Decoupled payments per farm peaked in 1998 and 1999, which were the first years Market Loss Assistance payments were introduced to farmers. Payments fell from

1999 until 2002. After the implementation of the Direct and Counter Cyclical payment program in the 2002 Farm Bill, decoupled payments per farm rose to $11.1 thousand in 2003 and since then have fallen to $5.8 thousand in 2011. The variation in payments shown in Figure 6.6 exists despite the constant trend in the number of counties receiving payments. This suggests that within county variation drives the overall variability in decoupled payments, not changes in the number of counties. Within county variation includes variation in decoupled payments driven by policy changes in county base acres and payment rates, or in the number of farms per county.[66] Despite the variation in decoupled payments per farm, the linear trend shown in Figure 6.6 indicates they have been decreasing over time. This study seeks to determine if this decrease in decoupled payments has influenced changes in the debt-to-asset ratio over the same period.

To identify where the decrease in decoupled payments is originating, Figure 6.7 shows mean county decoupled payments per farm by primary crop from 1996 to 2011 for those counties who received payments. Figure 6.7 suggests for most years over this period cotton farms received the most decoupled payments per farm on average, with a peak in 2003 of $26.3 thousand. Soybean farmers consistently received the least decoupled payments per farm on average over the period of interest. Although there are differences in payment levels between primary crop designations, they followed a similar trend. All primary crop types saw an increase in payments because of MLA payments, and then a reduction in those payments in 2002. After the implementation of the DCP program farmers returned to previous levels of support across all farm types.

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[66] Number of farms per county does not likely drive variation in decoupled payments per farm over time because the number of farms per county only changes over time in three years due to data availability.

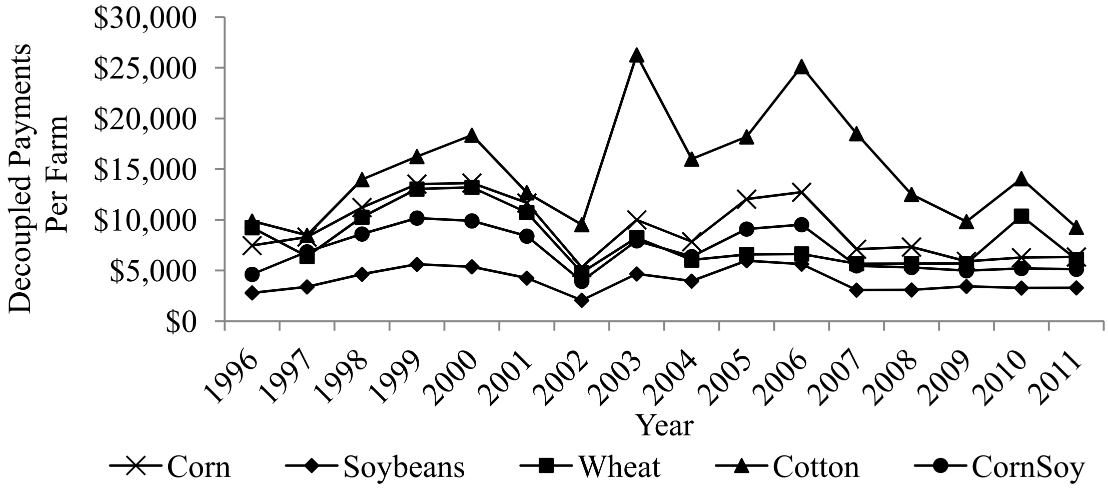

Figure 6.7 Mean County Decoupled Payments per Farm by Primary Crop 1996-2011

SOURCE: The Farm Service Agency (FSA) provided data from 1996 through 2008 under the Producer Payment Reporting System (PPRS) Payment Files. From 2009 to 2011, the FSA recorded decoupled payments made to counties in the Direct Attribution (DA) database, payments entitled DCP/ACRE.

NOTES: Decoupled payments consist of Production Flexibility payments, Market Loss Assistance payments, and Direct and Counter Cyclical payments. Each data point represented in the graph is equal to the sum of decoupled payments for all counties receiving payments in the top five states producing corn, wheat, cotton and soybeans divided by the number of farms.

The debt-to-asset ratio, decoupled payments and the expected loss ratio have all trended downward from 1996 to 2011. The preliminary insights gained from dissecting these variables suggest there may be a relationship between decoupled payments and a farm's financial solvency. The direction and magnitude of the relationship is left to empirical estimation. To estimate the relationship a linear regression model is used that controls for farm acres, assets, income, crop production, production risk, decoupled payments, expenses, operator characteristics and is weighted based on the probability of being selected for ARMS from the total population of farmers.

CHAPTER 7

EMIPIRICAL RESULTS AND IMPLICATIONS

The results in Table 7.1 show the estimated effects of decoupled payments per farm, operator age, education, the expected loss ratio, fixed and variable expenses per acre, farm size, and the value of real estate on the farm debt-to-asset ratio, while controlling for state, year and farm primary crop fixed effects as shown in equation (6.1). Additionally, these results include county-clustered standard errors to control for potential serial correlation of farmers within a county. Results are obtained across all farms in the top five states producing corn, cotton, wheat and soybeans from 1996 to 2011. The results in Table 7.1 suggests that decoupled payments, operator age, revenue per acre, expected loss ratio, fixed expenses per acre, value of real estate and acres operated per farm all have statistically significant impacts on the debt-to-asset ratio.

Increases in decoupled payments, the expected loss ratio, farm acres, and fixed expenses per acre are estimated to increase the debt-to-asset ratio, suggesting a reduction in farm solvency. Increases in operator age, revenue per acre and value of real estate are estimated to decrease the debt-to-asset ratio. The debt-to-asset ratio appears to be most responsive to changes in fixed expenses per acre, followed by operator age, acres operated per farm, the value of real estate, decoupled payments, revenue per acre, and the expected loss ratio. The magnitude of the estimated effects are compared in Table 7.2 as percentage changes in the debt-to-asset ratio resulting from a standard deviation change in the mean of the explanatory variable.

Table 7.1 Impacts on the Debt-to-Asset Ratio across All Farms

Decoupled Payments per Farm (in millions)	2.143***
	(6.03)
Operator Age	-0.004***
	(-16.10)
Operator Education	0.004
	(1.62)
Revenue per Acre (in thousands)	-0.047***
	(-3.18)
Expected Loss Ratio	0.009**
	(2.35)
Expected Loss Ratio 2001-2006	0.001
	(0.00)
Variable Expenses per Acre (in thousands)	-0.005
	(-0.76)
Fixed Expenses per Acre (in thousands)	0.468***
	(3.40)
Value of Real Estate-land and building (in millions)	-0.012***
	(-10.66)
Acres Operated per Farm (in thousands)	0.020***
	(10.93)
Year 2001- 2006	-0.013
	(-1.02)
Year 2002	0.032***
	(3.37)
Year 2008	-0.017***
	(-3.51)
Corn Farmer	0.040***
	(4.15)
Soybean Farmer	-0.025**
	(-2.27)
Corn and Soybean Farmer	0.067***
	(4.15)
Wheat Farmer	-0.038***
	(-2.78)
Fixed Effects	State
Cluster	County
N	62,466
Adjusted R-Squared	0.190

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

Table 7.2 Debt-to-Asset Ratio Response from one Standard Deviation Change

	Mean	STD	Change in Debt-to-Asset Ratio
Decoupled Payments per Farm	$8,051.00	$7,280.00	9.18%
Revenue per Acre	$383.14	$231.00	-6.39%
Expected Loss Ratio	0.78	0.51	2.68%
Operator Age	53.27	12.18	-28.65%
Acres Operated (in thousands)	1.50	2.28	26.76%
Value of Real Estate (in millions)	$1.22	$2.87	-20.27%
Fixed Expenses per Acre	$82.06	$111.54	30.56%

NOTES: The values represent the percent change in the average debt-to-asset ratio estimated to occur from one standard deviation increase in the explanatory variable evaluated at the mean. All explanatory variables listed in this table are significant at the ten percent level.

The effect of decoupled payments on farm solvency is of primary interest in this thesis. The results in Table 7.1 suggest that holding land values and other included variables constant, there is a positive relationship between decoupled payments and the farm business debt-to-asset ratio across all farm types. This result does not support the hypothesis that farmers use decoupled payments to pay down debt balances and increase the share of equity financing. Rather, it suggests that increases in decoupled payments are correlated with increases in the debt-to-asset ratio. In level terms, a thousand dollar increase in the average decoupled payments received per farmer in a county is estimated to increase in the debt-to-asset ratio by 0.241 percentage points, or approximately twenty-four dollars for every hundred dollars of assets for farmers located in that county. [67] This could indicate decoupled payments induce farmers to reduce assets in the current period, or it could imply a positive relationship between decoupled payments and the acquisition

[67] The results in Table 7.1 include ACRE payments from 2009-2011. When the model is estimated excluding those years the parameter estimate for decoupled payments is the same in magnitude, sign and significance. Thus, ACRE payments do not appear to drive the parameter estimate for decoupled payments.

of assets, where the percentage increase in total debt is greater than the percentage increase in assets.

Although the impact of decoupled payments on farm business debt-to-asset ratio is statistically significant it is important to recognize the magnitude of the estimated effect is relatively small. From 1996 to 2011, farmers in counties in the top five states producing corn, cotton, wheat and soybeans received an average of $8.05 thousand in decoupled payments in each year and had an average debt-to-asset ratio of 0.17. A $1 thousand increase in decoupled payments received constitutes approximately a 12.5 percent increase relative to the average. At the mean, this increase is estimated to increase the debt-to-asset ratio by 0.002, which is only 1.5 percent. As shown in Table 7.2, the magnitude of this effect is smaller than those estimated for operator age, acres operated, value of real estate, and fixed expenses, but larger than the estimated coefficient of the expected loss ratio and revenue per acre.

Even though the effect of decoupled payments on the debt-to-asset ratio is relatively small in magnitude, with the potential elimination of direct payments in the upcoming Farm Bill it is important to consider what this parameter estimate suggests about the financial implications for farmers of eliminating decoupled payments (Paulson, Woodard and Babcock, 2013). The elimination of decoupled payments would represent a loss of over eight thousand dollars to corn, soybean, wheat and cotton producing farmers on average in the United States. According to the results presented in Table 7.1, this drop in payments is correlated with a 10.15 percent drop in the debt-to-asset ratio on average. If decoupled payments are eliminated in the upcoming Farm Bill the results in Table 7.1

suggest it would results in a more substantial decrease in farm debt-to-asset ratios than the marginal effect may initially suggest.

A decrease in the debt-to-asset ratio is generally interpreted as an indication of increased solvency, which is often considered a signal of increase financial stability (Morehart, 2013). However, decreases in the debt-to-asset ratio do not necessarily indicate improved financial conditions. Kropp and Katchova (2011) suggest that decoupled payments appear to influence a farmer's access to credit. To the extent that decoupled payments increase a farmer's liquidity and improve their repayment capacity by providing an addition source of income, the positive effect of decoupled payment on the debt-to-asset ratio could be driven by increased access to credit allowing farmers to more profitably leverage their assets. If this were the case, the elimination of decoupled payments would remove that income source, leading farmers to use a less profitable percentage of debt financing. Thus, although a reduction in the debt-to-asset ratio can indicate a lower percentage of debt financing and increased solvency, it cannot always be considered an improvement in a farm's financial condition.

Operator age is found to have a significant effect on a farm's debt-to-asset ratio. In level terms, the results suggest an increase in operator age by a year decreases the farm debt-to-asset ratio by 0.4 percentage points. Meaning, for every year a farmer ages they decrease debt financing by 40 cents for every hundred dollars of assets. A negative relationship between decoupled payments and farmer age is consistent with the results from Antoni, Mishra and Chintawar (2009). This relationship could suggest that as farmers' age they have had more time to pay down debt balances. It could also suggest that as farmers' age they acquire more assets, holding debt constant. While increases in age suggest increased farm solvency, the results do not find a significant impact of operator education on farm solvency at the traditional ten percent level. The t-statistic of the operator education coefficient is 1.62 making the coefficient significant at the 10.7 percent level, just outside the conventional criteria.

The results also suggest that increases in revenue lead to increased farm solvency, while increases in fixed costs reduce solvency, as measured by the debt-to-asset ratio. In addition, the debt-to-asset ratio appears to be more responsive to changes in fixed costs than to changes in revenue. An increase of a thousand dollars in revenue per acre is estimated to decrease in the debt-to-asset ratio by 4.72 percentage points. At the mean, one standard deviation increase in revenue per acre leads to approximately a 6.4 percent decrease in the debt-to-asset ratio. Although this effect is small in magnitude, it suggests that as revenue per acre increases farms use a lower percentage of debt financing. A thousand dollar increase in fixed expenses per acre is estimated to increase the debt-to-asset ratio by 46.8 percentage points. At the mean, this result suggests one standard deviation increase in fixed expenses, which is one hundred ten dollars per acre, leads to approximately a 30.6 percent increase in the debt-to-asset ratio. The debt-to-asset ratio appears to be the most responsive to changes in fixed expenses relative to all other explanatory variables. This suggests that farmers are likely to use debt financing to purchase assets like land and equipment.

For the value of real estate, a million dollar increase in the value of a farm's land and buildings is estimated to decrease the debt-to-asset ratio by 1.22 percentage points.

As the value of real estate increases total farm assets increase, decreasing the ratio of total debt over total assets. After controlling for the impacts of land values on the debt-to-asset ratio, the results suggest as farm size grows farmers increase their debt-to-asset ratio. This result is consistent with the work of Katchova (2010) who finds that larger farms are more likely to take on larger amounts of debt. At the mean, one standard deviation increase in acres is estimated to increase the debt-to-asset ratio by 26.8 percent. Similarly, one standard deviation increase in the value of real estate at the mean is only estimated to decrease the debt-to-asset ratio by 20.3 percent. Thus, the debt-to-asset ratio appears to be more responsive to changes in acres than to changes in the value of real estate.

The results in Table 7.1 suggest for the expected loss ratio that an increase in expected indemnity payments by one dollar relative to a dollar of premium payments leads to a 90-cent increase in debt for every hundred dollars of assets. However, these results do not suggest the change in farmer's expectations about loss ratios between 2001 and 2006 because of the Agricultural Risk Protection Act of 2000, had a significant effect on their debt-to-asset ratio. The coefficient estimate for the expect loss ratio indicates the change in solvency resulting from temporary production shocks. When farmers experience temporary negative shocks to production these results indicate that farmers may increase the percentage of debt financing to cover crop losses. Although the expected loss ratio parameter is statistically significant, it is important to note that according to Table 7.2, the magnitude of the estimate is smaller than the estimated effect of all the explanatory variables in the model.

In order to control for the unobserved effects the Farm Bills may have had on a farmer's debt-to-asset ratio, indicator variables for the years 2002 and 2008 are included in the model. The parameter estimate for year 2002 suggests the Farm Security and Rural Investment Act of 2002 had a significant immediate positive impact on farmer's average debt-to-asset ratio. Specifically, the parameter estimate suggests farmers increased their debt-to-asset ratio by 3.2 percentage points on average in 2002. The parameter estimate for the year 2008 is also statistically significant, but suggests the Food, Conservation and Energy Act had a negative impact on the average farm debt-to-asset ratio in that year. In level terms, it suggests farmers decreased their debt-to-asset ratio by approximately 1.7 percentage points on average in 2008. These results suggest the Farms Bills had differing impacts on farm solvency, and it appears the average debt-to-asset ratio was more responsive to the FSRI Act of 2002 than the Food, Conservation and Energy Act of 2008.

Based on parameter estimates for primary crop indicator variables shown in Table 7.1, the average debt-to-asset ratios of corn farmers and corn soybean farmers are higher than average debt-to-asset ratios for cotton farmers from 1996 to 2011.[68] In level terms, corn farmers use an additional $4 in debt financing and corn soybean farmers use approximately $6.70 more debt financing on average than cotton farmers for every one hundred dollar of assets. These results suggest the production practices of corn and corn soybean farmers allow for a greater use of debt financing as a percent of total assets than cotton production practices. Alternatively, wheat and soybean farmers had lower average debt-to-asset ratios than cotton farmers from 1996 to 2011. The parameter estimates

[68] Because the model excludes the indicator variable for cotton farmers, the coefficient estimates for the included farm types are interpreted relative to cotton farmers.

suggest soybean farmers used $2.50 less debt financing than cotton farmers and wheat farmers used $3.80 less debt financing than cotton farmers. Based on these results, wheat farmers have the lowest debt-to-asset ratios over the period of interest, followed by soybean farmers, cotton farmers, corn farmers and finally corn soybean farmers.

The linear regression model presented in Table 7.1 excludes observations above the 99^{th} percentile for the debt-to-asset ratio to mitigate the influence of outliers on the parameter estimates. However, alternative model specifications are considered in Appendix A to tests the robustness of the results to outlier assumptions and censoring in the debt-to-asset ratio. Comparing the estimation techniques suggests the importance of controlling for outliers in the debt-to-asset ratio because they appear to create an attenuation bias. The different approaches to addressing the outliers do not vary substantially in sign and significance, and after controlling for outliers in the 99^{th} percentile, the results appear robust to different model specifications.

Farm Analysis by Primary Crop Produced

Building upon the debt-to-asset ratio analysis in Table 7.1, the results discussed in this section investigate the impacts of decoupled payments per farm and other explanatory variables on the debt-to-asset ratio of farms by primary crop produced. There are five regression results shown in Table 7.3 where each column corresponds to one of the five farm primary crop designations: wheat farmers, cotton farmers, corn farmers, soybean farmers, and famers that produce corn and soybeans. Farmers are classified according to their state of location. Each of the sixteen states included in these data are top five states producing corn, wheat, soybean or cotton. Four of the top five states for corn and soybean overlap, farmers in these states are considered both corn and soybean farmers. Farmers in the other twelve states are classified as single crop farmers because they are assumed to produce cotton, corn, wheat or soybeans in rotation with minor crops that are not analyzed in this study.

Consistent with the main results in Table 7.1 operator age, fixed expenses per acre, value of real estate and acres operated appear to influence a farmer's debt-to-asset ratio across all farm types. The directions of the estimated relationships are consistent with the general results as well. Particular subsets of farmers appear to be driving the general results for the expected loss ratio, decoupled payments per farm, revenue per acre, operator education and variable expenses per acre. The results suggest only corn soybean farmers, corn farmers and wheat farmers' debt-to-asset ratios appear to be significantly responsive to changes in decoupled payments, implying they would be the farmers primarily impacted by the elimination of decoupled payments. Similarly, cotton farmers are the only farmers whose debt-to-asset ratio appears to be responsive to changes in the expected loss ratio. Revenue per acre is estimated to negatively influence a farmer's debt-to-asset ratio for all primary crop designations except for corn soybean farmers. A statistically significant effect of operator education is only estimated for the debt-to-asset ratio of soybean farmers. Finally, corn farmers, soybean farmers and cotton farmers' debt-to-asset ratios appear to be negatively correlated with fluctuations in variable expenses per acre.

Table 7.3 Impacts on the Debt-to-Asset Ratio by Primary Crop Designation

	Corn Soy	Corn	Soybean	Wheat	Cotton
Decoupled Payments per Farm (in millions)	3.100***	2.330**	-0.361	1.592***	0.322
	(4.57)	(2.30)	(-0.19)	(2.43)	(0.66)
Operator Age	-0.003***	-0.004***	-0.002***	-0.004***	-0.003***
	(-10.13)	(-8.46)	(-4.23)	(-13,50)	(-8.53)
Operator Education	0.001	0.009	0.015***	-0.001	-0.001
	(0.33)	(1.62)	(3.30)	(-0.29)	(0.12)
Revenue per Acre (in thousands)	-0.028	-0.059**	-0.010***	-0.192***	-0.089***
	(-1.53)	(-2.45)	(-3.08)	(-3.81)	(-4.10)
Expected Loss Ratio	0.009	0.022	0.012	0.011	-0.019**
	(1.60)	(1.38)	(1.07)	(1.52)	(-2.00)
Expected Loss Ratio 2001-2006	-0.008	-0.008	0.07	-0.032*	0.076**
	(-0.42)	(-0.27)	(0.78)	(-1.85)	(2.14)
Variable Expenses per Acre (in thousands)	-0.003	-0.008*	-0.007***	-0.008	-0.021***
	(-0.35)	(-1.76)	(-2.27)	(-0.36)	(-4.12)
Fixed Expenses per Acre (in thousands)	0.405***	0.815***	0.782***	0.897***	0.993***
	(2.82)	(6.14)	(5.62)	(2.34)	(6.78)
Value of Real Estate-land and building (in millions)	-0.020***	-0.022***	-0.016***	-0.017***	-0.005***
	(-11.31)	(-6.15)	(-5.73)	(-4.35)	(-4.82)
Acres Operated per Farm (in thousands)	0.056***	0.016***	0.064***	0.017***	0.008***
	(18.49)	(4.34)	(9.54)	(8.15)	(3.34)

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

Table 7.3 Impacts on the Debt-to-Asset Ratio by Primary Crop Designation (Cont.)

	Corn Soy	Corn	Soybean	Wheat	Cotton
Year 2001- 2006	-0.016	-0.020	-0.089	0.037**	-0.091***
	(-1.14)	(-0.61)	(-1.05)	(2.08)	(-2.60)
Year 2002	0.032**	0.094***	0.001	0.016	0.044
	(2.43)	(4.00)	(0.06)	(1.35)	(1.34)
Year 2008	-0.013*	-0.007	-0.032***	-0.014	-0.06***
	(-1.84)	(0.77)	(-3.33)	(-1.22)	(-3.49)
Fixed Effects	State	State	State	State	State
Clustered Standard Errors	County	County	County	County	County
N	33,166	6,525	2,951	12,891	6,933
Adjusted R-Squared	0.190	0.209	0.198	0.265	0.183

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

The results in Table 7.3 indicate the effect of decoupled payments, operator education, expected loss ratio, revenue per acre, variable expenses per acre and the year indicator variables on the farm debt-to-asset ratio are primary crop specific. The positive relationship between decoupled payments and a farm's debt-to-asset ratio estimated in Table 7.1 appears to be primarily driven by the effect of decoupled payments on corn soybean, corn, and wheat farm solvency. Furthermore, corn soybean farmer's debt-to-asset ratios are estimated to be the most responsive to changes in decoupled payments per farmer, followed by corn farmers and then wheat farmers.[69] This is shown in Table 7.4 comparing the change in the debt-to-asset ratio estimated to occur from a one standard deviation change in decoupled payments.

Table 7.4 Debt-to-Asset Ratio Response to Changes in Decoupled Payments

	Mean	STD	STD Change in DP	Elimination of DP
Corn and Soybean Farmers	$6,733.10	$3,885.40	7.31%	12.67%
Corn Farmers	$8,664.40	$5,527.20	6.75%	10.59%
Wheat Farmers	$7,658.00	$5,847.90	5.39%	7.05%

NOTES: The values represent the percent change in the average debt-to-asset ratio estimated to occur from one standard deviation increase in decoupled payments (DP) evaluated at the mean, in the fourth column. The fifth column shows the change in the debt-to-asset ratio estimated to occur if decoupled payments (DP) dropped by the mean amount. The effect of decoupled payments on the debt-to-asset ratio of all primary crop designations listed have is estimated to be significant at the five percent level.

According to the results in Table 7.3, soybean farmers and cotton farmers' debt-to-asset ratios are not significantly responsive to changes in decoupled payments. This finding further illuminates the potential implications of removing the decoupled payments program in the upcoming Farm Bill. It suggests that farmers producing corn

[69] When the results are broken down to the top two states producing corn and soybeans, Iowa and Illinois, they are consistent with the results from the corn soybean regression in Table 7.3. This is also true for the top two wheat-producing states, Kansas and North Dakota.

and soybeans, corn and wheat will be most affected by the elimination of decoupled payments, relative to soybean and cotton farmers. As shown in Table 7.4, if decoupled payments are eliminated this will represent between a $6.7 and $8.6 thousand drop in the mean decoupled payments received per farmer in a county on average for corn soybean, corn and wheat farmers. According to the parameter estimates of decoupled payments per farm for corn soybean, corn and wheat farmers, this reduction is estimated to reduce their debt-to-asset ratios by 12.7, 10.6 and 7.1 percent respectively. Although a reduction in the debt-to-asset ratio is often interpreted as an improvement in solvency, this does not necessarily suggest these farmers would see an improvement in their financial condition if decoupled payments were eliminated. If they use decoupled payments to more profitably leverage their assets through increased access to credit, then the elimination of decoupled payments may result in a less optimal percent of debt financing.

Given the results in Table 7.3, the effects of the expected loss ratio on the solvency of cotton farmers appear to be driving the general results shown in Table 7.1. An increase in the expected loss ratio for cotton farmers is estimated to decrease their debt-to-asset ratio. This suggests as cotton farmers expect to receive more indemnity payments relative to premium payments, the level of debt financing decreases, holding assets constant. Furthermore, the results indicate the effect of the expected loss ratio on the farm debt-to-asset ratio decreased in magnitude for wheat and cotton farmers from 2001 to 2006 because of the Agricultural Risk Protection Act as indicated by the significance of the interaction term between the expected loss ratio and years 2001 to 2006. However, these results are not found with any other primary crop designation.

Revenue per acre appears to be negatively correlated the debt-to-asset ratio of all primary crop designations except for corn soybean farmers. The debt-to-asset ratio of corn soybean farmers does not appear to be influenced by fluctuations in revenue per acre. Of the primary crop designations estimated to have a significant relationship between decoupled payments and the debt-to-asset ratio, the debt-to-asset ratio of wheat farmers appears to be the most responsive to fluctuations in revenue per acre. A one standard deviation change in revenue per acre is estimated to reduce the debt-to-asset ratio of wheat farmers by 15.3 percent. The next largest decrease of 13.9 percent is estimated for cotton farmers, then 10.1 percent for soybean farmers, and lastly 8.1 percent for corn farmers.

As soybean farmers become more educated, the debt-to-asset ratio is estimated to increase. However, this relationship is not found for wheat, corn, cotton or corn and soybean farmers. In level terms, an increase of one education class for soybeans farmers leads to an increase in the debt-to-asset ratio by 1.5 percentage points respectively. This result suggests the more educated soybean farmers are the less solvent their farms will be. However, this could indicate that as farmers receive more education they have a better understanding of financial tools and are able to use debt financing to increase the profitability of their farms, thus increasing the farm debt-to-asset ratio.

Although the main results do not indicate that farmer's debt-to-asset ratios are responsive to changes in variables expenses per acre, the results by primary crop designation estimate a significant effect of variable expenses per acre on the debt-to-asset ratio for corn farmers, cotton farmers and soybean farmers. Across all three primary crop types, an increase in variable expenses per acre is estimated to have a negative impact on a farmer's debt-to-asset ratio. This suggests that for corn, soybean and wheat farmers variable expenses per acre have the opposite impact on their debt-to-asset ratio than fixed expenses per acre. An increase in variable expenses per acre does not appear to increase the percent of debt financing used for these farmers, suggesting they primarily use equity financing to cover increases in variables expenses.

The results indicate the debt-to-asset ratio is significantly responsive to fluctuation in operator age, fixed expenses per acre, value of real estate and acres operated across all primary crop designations. The magnitude of the estimated effects of between farm primary crop types are compared in Table 7.5, which compares the estimated effect on the debt-to-asset at the mean resulting from one standard deviation increase in the explanatory variable. Considering the results from Table 7.3 in this way allows for a comparison of the magnitude of the estimated effects across farm primary crop categories and across explanatory variables.

Table 7.5 Debt-to-Asset Ratio Response Comparisons by Farm Primary Crop

	Corn Soy	Corn	Soybean	Wheat	Cotton
Operator Age	-21.65%	-25.87%	-16.64%	-29.62%	-21.40%
Fixed Expenses per Acre	32.64%	36.13%	46.70%	30.16%	42.93%
Value of Real Estate	-30.78%	-21.94%	-21.19%	-25.64%	-14.20%
Acres Operated	38.20%	23.74%	48.66%	30.21%	15.27%

NOTES: The values represent the percent change in the average debt-to-asset ratio estimated to occur from one standard deviation increase in the explanatory variable evaluated at the mean.

As farm operators age the percentage of debt financing used on the farm decreases across all primary crop designations. For every year a farmer ages, they decrease debt financing between 20 and 40 cents for every hundred dollars of assets, depending on the primary crop type. Wheat farmers are estimated to decrease debt financing the most per year. The next largest parameter estimate is corn farmers, followed by corn soybean farmers, then cotton farmers and lastly soybean farmers. This relationship could suggest that as farmers' age they have had more time to pay down debt balances, holding assets constant. It could also suggest that as farmers' age they acquire more assets, holding debt constant.

At the mean one standard deviation decrease in fixed expenses leads to the greatest decrease in the debt-to-asset ratio for soybean farmers, compared to other farm types. The next largest decrease occurs with cotton farmers, then corn farmers, then corn and soybean farmers and lastly wheat farmers. It is also important to note that changes in fixed expenses at the mean are estimated to have the largest impact on corn and cotton farmer's debt-to-asset ratios compared to operator age, value of real estate and acres operated. An increase in the value of real estate appears to have the largest influence on corn and soybean farmer's debt-to-asset ratio compared to the other farm types. Specifically, one standard deviation increase in the mean value of corn soybean farmer's real estate leads to approximately a 30.8 percent decrease in their debt-to-asset ratio. Cotton farmer's debt-to-asset ratios appear to be the least responsive to changes in the value of real estate. According to Table 7.5, one standard deviation increase in the value of real estate results in a 14.2 percent decrease in the debt-to-asset ratio.

Table 7.5 suggests the debt-to-asset ratio of corn soybean, soybean and wheat farmers are most responsive to changes in acreage at the mean than to changes in operator age, value of real estate and acres operated. One standard deviation increase in the average acreage for corn soybean, soybean and wheat farmers results in a 38.2, 48.7 and 30.2 percent increase in their debt-to-asset ratios, respectively. Comparatively, the same percentage increase in acreage for corn, and cotton farmers leads to approximately a 23.7 and 15.3 percent increase in their debt-to-asset ratios.

The purpose of breaking down the results by primary crop produced is to better identify where the variation in the explanatory variables driving the parameter estimates in Table 7.1 is originating. Based on the results presented in this section, the effects of operator age, fixed expenses per acre, the value of real estate and acres operated on the debt-to-asset ratio are consistent in sign and significance across all farm primary crop designations. However, the estimated effects of the expected loss ratio, decoupled payments, operator education, revenue per acre, and variable expenses per acre are primary crop specific. The results presented in this section suggest that the likely elimination of decoupled payment in the upcoming Farm Bill would primarily affect farmers producing corn and soybeans, corn and wheat.

Farm Analysis by Size

To better understand the relationship between decoupled payments and farm solvency this section analyzes how the relationship varies with farm size. If there are systematic differences in the relationship by farm size, that may provide insight into the potential for decoupled payments to contribute to the growth of large farms in the United States. This analysis is conducted in two ways. First, the effect of decoupled payments on farm solvency is considered to vary with farm size by interacting acres operated with decoupled payments. The coefficient on the interaction term estimates the marginal effect of an increase in acreage at the mean on the relationship between decoupled payments and farm solvency. The second approach breaks farms into quartiles based on their size. The farm acre indicator variables are interacted with decoupled payments to determine how the relationship between decoupled payments and farm solvency changes as farm size increases by quartile. The results from these two estimation processes are discussed in turn in the next sub-sections.

Marginal Analysis of Farm Size

The results in Table 7.6 include two regression specifications. The results in column (1) include the interaction term between decoupled payments per farm and acres operated per farm. Column (2) presents the results shown in Table 7.1. Comparing the two results, all explanatory variables that are significant at the ten percent level in the model shown in column (2) are also significant at the ten percent level in column (1). The results in column (1) suggest the debt-to-asset ratio is significantly responsive to fluctuations in decoupled payments per farm, operator age, revenue per acre, expected loss ratio, fixed expenses per acre, value of real estate and acres operated. Including the interaction term does not change the sign of the parameter estimates for the remaining explanatory variables or the overall fit of the model.[70] The results from column (1) indicate that as farm acreage grows the effect of decoupled payments on the debt-to-asset ratio does not change in magnitude.

[70] Because the parameter estimates between column (1) and (2) did not change significantly in magnitude, sign, or significance this suggests that collinearity is not likely introduced with the inclusion of the interaction term between decoupled payments and farm size.

Table 7.6 Interaction Term between Farm Size and Decoupled Payments

	(1)	(2)
Decoupled Payments per Farm (in millions)	2.344***	2.143***
	(5.12)	(6.03)
Decoupled Payments * Acres Operated per Farm	-0.171	--
	(-0.88)	--
Operator Age	-0.004***	-0.004***
	(-16.11)	(-16.10)
Operator Education	0.004	0.004
	(1.61)	(1.62)
Revenue per Acre (in thousands)	-0.047***	-0.047***
	(-3.14)	(-3.18)
Expected Loss Ratio	0.009**	0.009**
	(2.39)	(2.35)
Expected Loss Ratio 2001-2006	0.001	0.001
	(0.08)	(0.00)
Variable Expenses per Acre (in thousands)	-0.004	-0.005
	(0.76)	(-0.76)
Fixed Expenses per Acre (in thousands)	0.467***	0.468***
	(3.40)	(3.40)
Value of Real Estate-land and building (in millions)	-0.012***	-0.012***
	(-10.61)	(-10.66)
Acres Operated per Farm (in thousands)	0.021***	0.020***
	(8.08)	(10.93)
Year 2001- 2006	-0.014	-0.013
	(-1.06)	(-1.02)
Year 2002	0.032***	0.032***
	(3.40)	(3.37)
Year 2008	-0.017***	-0.017***
	(-3.50)	(-3.51)
Corn Farmer	0.040***	0.040***
	(3.93)	(4.15)
Soybean Farmer	-0.024**	-0.025**
	(-2.23)	(-2.27)
Corn and Soybean Farmer	0.066***	0.067***
	(4.13)	(4.15)
Wheat Farmer	-0.037***	-0.038***
	(-2.79)	(-2.78)
Fixed Effects	State	State
Cluster	County	County
N	62,466	62,466
Adjusted R Squared	0.190	0.190

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

The estimated effect of decoupled payments on farm solvency increased in magnitude from column (2) to column (1). Column (1) suggests that at the mean one standard deviation increase in decoupled payments leads to an increase in the debt-to-asset ratio by 10.1 percent compared to the 9.18 percent increase estimated in column (2). The insignificance of the interaction term between decoupled payments and farm size in column (2) indicates this effect does not change as farm size grows. This result could be interpreted to suggest that the effect of decoupled payments on farm solvency is uniform across farm size. However, before any conclusions can be made about the relationship between farm size and decoupled payments' effect on farm solvency, it is important to investigate if this results is consistent across farm size categories.

Quartile Analysis of Farm Size

Farms are grouped into quartiles based on their farm size, which is defined by acres operated. Each quartile contains approximately 15,500 observations over sixteen years. An indicator variable is generated for each quartile defined as small, medium, large, and very large farms. Small farms are defined as farms operating on less than 370 acres. Medium farms range from 370 acres to less than 890 acres. Large farms include farms operating from 890 acres up to 1,870 acres. Very large farms are defined as farms operating on at least 1,870 acres. The farm size indicator variables are interacted with decoupled payments to estimate how the effect of decoupled payments on the debt-to-asset ratio varies by farm size quartile. Included in this regression specification are interaction terms between decoupled payments and small, medium and large farms. State and farm type fixed effects are also included, as well as county-clustered standard errors.

Table 7.7 Interaction Term between Decoupled Payments and Farm Size Quartiles

Decoupled Payments per Farm (in millions)	1.560***
	(3.70)
Decoupled Payments per Farm * Small Farm	0.137
	(0.18)
Decoupled Payments per Farm * Medium Farm	0.571
	(0.98)
Decoupled Payments per Farm * Large Farm	-0.388
	(-0.65)
Operator Age	-0.003***
	(-15.32)
Operator Education	0.002
	(0.78)
Revenue per Acre (in thousands)	-0.056***
	(-3.69)
Expected Loss Ratio	0.008**
	(2.26)
Expected Loss Ratio 2001-2006	-0.002
	(0.12)
Variable Expenses per Acre (in thousands)	-0.004
	(0.61)
Fixed Expenses per Acre (in thousands)	0.476***
	(3.43)
Value of Real Estate-land and building (in millions)	-0.014***
	(-10.35)
Acres Operated per Farm (in thousands)	0.009***
	(6.95)
Small Farm	-0.088***
	(-11.41)
Medium Farm	-0.048***
	(-6.63)
Large Farm	-0.015**
	(-2.27)
Year 2001- 2006	-0.011
	(-0.85)
Year 2002	0.028***
	(3.10)
Year 2008	-0.018***
	(-3.55)

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

Table 7.7 Interaction Term Between Decoupled Payments and Farm Quartiles (Cont.)

Corn Farmer	0.047***
	(4.66)
Soybean Farmer	-0.005
	(-0.43)
Corn and Soybean Farmer	0.081***
	(5.32)
Wheat Farmer	-0.037***
	(-2.65)
Fixed Effects	State
Cluster	County
N	62,466
Adjusted R Squared	0.165

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

The coefficient of decoupled payments in Table 7.7 suggests a positive relationship between decoupled payments and the debt-to-asset ratio, which is consistent with Table 7.6 and Table 7.1. The regression specification in Table 7.7 suggests at the mean, for a standard deviation increase in decoupled payments the debt-to-asset ratio will increase by 6.7 percent. However, the results do not suggest that this effect changes with farm size because the coefficient estimates for the interaction terms between decoupled payments and farm size are not significant at the ten percent level. Consistent with the results presented in Table 7.1, the results in Table 7.7 indicate operator age, revenue per acre, expected loss ratio, decoupled payments per farm, fixed expenses per acre, value of real estate, acres operated and Farm Bill years 2002 and 2008 are significant determinates of a farm business debt-to-asset ratio. The direction of these estimated effects are also consistent with the general results.

The significance of the farm size indicator variables implies that the average debt-to-asset ratio for a farm changes with farm size. The estimated coefficients for all of the farm size indicator variables are negative, indicating small, medium and large farms have lower average debt-to-asset ratios than very large farms. Furthermore, the magnitude of the coefficient estimate for small farms is the greatest, then medium farms and then large farms. This suggests that small farms have the lowest average debt-to-asset ratio, and that as farm size increases the average debt-to-asset ratio rises. This result is consistent with Katchova (2010) indicating larger farms are more likely to use a higher percentage of debt financing.

Although the results in Table 7.7 suggest differences in average debt-to-asset ratios across farm size, they do not suggest the differences are driven by fluctuations in decoupled payments. This result supports the hypothesis that the effects of decoupled payments on farm solvency are uniform across farm size. Thus, according to the findings in this study decoupled payments do not appear to grant larger farms a financial advantage in relation to solvency, which is consistent with the intended decoupled nature of the program. The findings presented in this section could reasonably be interpreted to provide support for the categorization of decoupled payments as “green box” policies by the WTO, in relation to their effect on farm solvency across farm size.

Two-Stage Least Squares Results

In order to determine if an ordinary least squares model is the most appropriate estimator, this section investigates the robustness of the OLS results to the exogeneity assumption of acres operated by comparing the main results in Table 7.1 to results generated from a two-stage least squares (TSLS) model. This section is divided into two sub-sections. The first examines the results from the first stage of the TSLS model outlined in equation (6.4). The first stage results empirically test the relevance of the climactic instrumental variables and generate the predicted values of acres operated used in the second stage TSLS regression. The predicted residual values from the first stage are used to test for endogeneity of the acres operated to help determine if the TSLS model is a more appropriate estimator than OLS. In the second section, the results from the second stage TSLS model outlined in equation (6.5) are compared to the results from the OLS model shown in Table 7.1.

First-Stage Regression

The first stage of the two-stage least squares model outlined in equation (6.4) estimates the effect of the exogenous explanatory variables from the structural model, equation (6.1), and the climatic instrumental variables on acres operated. The purpose of the first stage regression is to isolate the variation in acres operated that is uncorrelated with the error term from the structural model, and use this variation to obtain an unbiased estimate of the effect of acres operated on the debt-to-asset ratio. The consistency of the TSLS estimator relies on the exogeneity and relevance climatic instrumental variables. However, if the instruments are relevant and exogenous, the OLS estimator may still be the preferred model if acres operated is exogenous to the debt-to-asset ratio. Therefore, before comparing the TSLS results to the main results presented in Table 7.1 it will be necessary to empirically test the relevance of the instrument variables and test for the endogeneity of acres operated. Table 7.8 shows the results from the first-stage regression of the TSLS model.

Table 7.8 First Stage Regression on Acres Operated per Farm

Average Temperature Feb-May of Current Year	-0.008*** (-2.59)
Average Temperature March-Oct of Previous Year	-0.008 (-1.50)
Total Precipitation Feb-May of Current Year	-0.000 (-0.11)
Total Precipitation March-Oct of Previous Year	-0.006*** (-3.88)
Decoupled Payments per Farm (in millions)	16.841*** (6.44)
Operator Age	-0.007*** (-11.09)
Operator Education	0.090*** (10.50)
Revenue per Acre (in thousands)	-0.127*** (-2.30)
Expected Loss Ratio	0.074*** (3.58)
Expected Loss Ratio 2001-2006	0.252*** (3.99)
Variable Expenses per Thousand Acre (in millions)	-0.061*** (-3.21)
Fixed Expenses per Thousand Acre (in millions)	-0.354*** (-4.03)
Value of Real Estate-land and building (in millions)	0.384*** (14.26)
Year 2001- 2006	-0.189*** (-4.20)
Year 2002	0.079*** (3.28)
Year 2008	0.052* (1.66)

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

Table 7.8 First Stage Regression on Acres Operated per Farm (Cont.)

Corn Farmer	-0.785***
	(-5.27)
Soybean Farmer	-1.243***
	(-9.38)
Corn and Soybean Farmer	-0.915***
	(-5.33)
Wheat Farmer	0.110
	(0.43)
Fixed Effects	State
Cluster	County
N	62,466
Adjusted R Squared	0.2848

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

The significance of the state-level average temperature from February to May and the total precipitation from March to October of the previous year in the first-stage results suggest that they have a significant influence on acres operated. An F-test for joint significance of all four climatic variables formally tests the relevance of the instrumental variables. The null hypothesis is that parameter estimate of all four instrumental variables are equal to zero. The alternative hypothesis is that at least one of the parameter estimates for the instrumental variables is statistically different from zero. The F-test returned at F-statistic of 5.97 and a p-value of less than 0.0001, so the null hypothesis that all four instrumental parameter estimates are zero is rejected at the one percent significance level. This provides evidence that at least one of the instruments, average temperature or total precipitation from February to May of the current year or March to October of the previous year, is a relevant instrument for acres operated.

To test for the endogeneity of acres operated the predicted residuals are generated from the first stage regression. Then, the predicted residuals are added to the structural equation, equation (6.1), which includes acres operated. If the coefficient estimate on the predicted residuals is statistically different from zero then it can be concluded that acres operated is endogenous (Wooldridge, 2009). The results from the regression of the predicted residuals and the explanatory variables in equation (6.1) on the debt-to-asset ratio estimate a significant relationship between the predicted residuals and the debt-to-asset ratio.[71] This provides evidence that acres operated is endogenous to the debt-to-asset ratio and suggests that the OLS model generates biased parameter estimates.

Although some literature has identified a simultaneous relationship between farm size and productivity, the endogeneity of acres operated to the debt-to-asset ratio has not been explicitly determined in current agricultural economics literature (Yee and Ahearn, 2005; Ahern, Yee and Korb, 2005; Hadrich and Olson, 2011). The Hausman-Wu test conducted in this study identifies an endogenous relationship between acres operated and the debt-to-asset ratio however, it is important to note that the reliability of the test is dependent upon the exogeneity and relevance of the climactic instruments. This thesis provides suggestive evidence that endogeneity may exist, and so it will be beneficial to consider the results from the second-stage of the TSLS model to help determine the magnitude and direction of the potential bias generated in the ordinary least squares model outlined in equation (6.1).

Second-Stage Regression

The results in Table 7.9 include two regression specifications. The results in column (1) are from the second stage of the TSLS model, outlined in equation (6.5).

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[71] The parameter estimate for the predicted residuals is -0.268 with a t-statistic of -3.93 making the estimate statistically significant at the one percent level.

Column (2) presents the results shown in Table 7.1. The results in column (1) were generated using the predicted values of acres operated generated from the first stage results regressing acres operated on all exogenous explanatory variables in the structural model, equation (6.1), and the climatic instruments.[72] Although the test for joint significance implied the instruments influence acres operated, the relative strength of the correlation between acres and the climatic variables is still considered weak according to the criteria outlined by Staiger and Stock (1997). They suggest that an instrument is weak if the F statistics falls below ten. With weak instruments, the asymptotic properties of the TSLS estimator cannot necessarily be considered to produce unbiased results (Staiger and Stock, 1997). Therefore, the parameter estimates from the TSLS model shown in column (1) should be interpreted with caution.

Comparing the two estimation techniques, the parameter estimates for decoupled payments and the expected loss ratio from the two-stage least squares model are opposite in sign from the parameter estimates generated by ordinary least squares. In addition, the results from the TSLS model do not suggest there is a significant relationship between revenue per acre and the debt-to-asset ratio. However, the TSLS results do suggest a negative relationship between the debt-to-asset ratio and the expected loss ratio between the years 2001 and 2006. Similarly, a positive relationship is estimated between variable expenses per acre and the debt-to-asset ratio in column (1). The parameter estimates for acres operated, operator age, fixed expenses per acres and value of real estate did not change in sign or significant between the TSLS and the OLS models.

[72] The second stage of the TSLS does not include county-clustered standard errors, which may lead to an underestimate the standard errors and inflate the statistical significance of the explanatory variables.

Table 7.9 Two-Stage Least Squares and Ordinary Least Squares Comparison

	(1)	(2)
Decoupled Payments per Farm (in millions)	-2.174**	2.143***
	(-2.43)	(6.03)
Predicted Acres Operated per Farm (in thousands)	0.287***	0.020***
	(5.53)	(10.93)
Operator Age	-0.002***	-0.004***
	(-5.05)	(-16.10)
Operator Education	-0.020***	0.004
	(-3.99)	(1.62)
Revenue per Acre (in thousands)	-0.007	-0.047***
	(-0.64)	(-3.18)
Expected Loss Ratio	-0.012**	0.009**
	(-2.27)	(2.35)
Expected Loss Ratio 2001-2006	-0.062***	0.001
	(-3.17)	(0.00)
Variable Expenses per Thousand Acre (in millions)	0.012***	-0.005
	(2.79)	(-0.76)
Fixed Expenses per Thousand Acre (in millions)	0.564***	0.468***
	(22.77)	(3.40)
Value of Real Estate-land and building (in millions)	-0.115***	-0.012***
	(-5.76)	(-10.66)
Year 2001- 2006	0.032**	-0.013
	(2.06)	(-1.02)
Year 2002	0.008	0.032***
	(1.05)	(3.37)
Year 2008	-0.032***	-0.017***
	(-4.71)	(-3.51)
Corn Farmer	-0.080	0.040***
	(-1.46)	(4.15)
Soybean Farmer	--	-0.025**
	--	(-2.27)
Corn and Soybean Farmer	-0.021	0.067***
	(-0.88)	(4.15)
Wheat Farmer	-0.428	-0.038***
	(-5.49)	(-2.78)
Fixed Effects	NA	State
Cluster	State	County
Estimation Procedure	TSLS	OLS
N	62,466	62,466
Adjusted R-Squared	0.177	0.190

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01. TSLS stands for two-stage least squares and OLS stands for ordinary least squares.

Although the linear regression model suggests decoupled payments and the expected loss ratio have a significant positive impact on the debt-to-asset ratio, the TSLS model suggests increases in both are correlated with a decrease in a farmer's percentage of debt financing. The parameter estimate from the TSLS model for the expected loss ratio and decoupled payments increase in magnitude and are opposite in in sign from the OLS estimate. Operator age, acres operated, value of real estate, and fixed expenses per acre are consistent in sign between the two models. However, the magnitude of the estimated effect decreased for operator age and increased for fixed expenses per acres, acres operated and the value of real estate with the TSLS model.

Assuming the instrumental variables are exogenous and relevant and the TSLS model generates unbiased parameter estimates, these results suggest the endogeneity of acres operated in the OLS model introduced a positive bias on the parameter estimate for decoupled payments. The TSLS results suggest that a one standard deviation decrease in decoupled payments leads to a decrease in a farmer's debt-to-asset ratio by approximately 9.3 percent, compared to the increase of approximately 9.2 percent estimated in the OLS model. The results from the TSLS model suggest decoupled payments lead farmer's to use a higher percentage of equity financing, which is generally interpreted as an increase in solvency and financial stability.

As decoupled payments increase, the TSLS results suggest farmers either lower their debt balances holding assets constant, or purchase more assets holding debt constant. Relaxing the assumption that debt or assets is held constant, it could imply that farmers decrease assets and debt in the current period, but the percentage decrease in debt is greater than the percentage decrease in assets. For example, if decoupled payments induce farmer's to sell assets and use the proceeds to pay down debt. However, it could also be that farmers increase assets and debt in the current period but the percentage increase in assets is greater than the percentage increase in debt. For example, if a farmer purchases assets that are financed primarily with equity.

If decoupled payments were eliminated in the upcoming Farm Bill the results from the TSLS model suggest farmers would see increases in their debt to asset ratio by approximately 10.3 percent. Although this is generally interpreted as a decrease in farm solvency, it is possible that the elimination of decoupled payments allow farmers to more profitably leverage their assets. Thus, although an increase in the debt-to-asset ratio can indicate a higher percentage of debt financing and decreased solvency, it cannot be concluded that farmer's will be in worse financial condition with the elimination of decoupled payments.

Summary of Results

The purpose of the empirical analysis is to understand the factors that influence a farm business' debt-to-asset ratio, and to determine how decoupled payments impact farm solvency. In the analysis across all farm types operator age, education, revenue per acre, expected loss ratio, decoupled payments, fixed expenses per acre, value of real estate and acres operated per farm are shown to have significant impacts on farmer debt-to-asset ratios, used to measure farm solvency. These impacts are robust to different model specifications that employ alternative approaches to dependent variable outliers and to censoring in the debt-to-asset ratio. Increases in operator age, revenue per acre, and value of real estate are estimated to have a negative relationship with the debt-to-asset ratio. Fixed expenses, the expected loss ratio, and acres operated are found to have a positive relationship with the debt-to-asset ratio. As fixed costs rise, or expected losses rise these results suggest farmers increase debt financing to cover increased costs and crop losses. The results also indicate the average debt-to-asset ratio increases as farm size increases, which is consistent with Katchova (2010).

According to the linear regression model, the overall relationship between decoupled payments and the debt-to-asset ratio is estimated to be positive. Furthermore, the results suggest that the elimination of decoupled payment in the upcoming Farm Bill could lead to a decrease in the debt to asset ratio of approximately 10.15 percent. Even though reductions in the percentage of debt financing often indicate increases in financial solvency, this finding does not necessarily suggest famers will improve their financial condition with the elimination of decoupled payments. For example, the positive relationship between decoupled payments and the debt-to-asset ratio could stem from increased access to credit that allows farms to more profitably leverage their assets. In which case, the elimination of decoupled payments would cause farmers to reduce their debt balance from a more profitable level. However, an analysis of the effects of decoupled payments on farm solvency by primary crop designation suggests only corn soybean farmers, corn farmers, and wheat farmers' debt-to-asset ratios are significantly responsive to changes in decoupled payments, implying they would be the farmers primarily impacted by the elimination of decoupled payments.

Based on the findings from the farm size analysis the effect of decoupled payments on the debt-to-asset ratio does not appear to vary with farm size. The results from this analysis indicate that the average debt-to-asset ratio increases as farm size increases, suggesting as farms grow they use a higher percentage of debt financing. The farm size analysis also supports the overall results suggesting increases in decoupled payments lead to increases in the debt-to-asset ratio. However, it does not indicate the effect of decoupled payments on farm solvency varies with farm size. This finding lends support to the hypothesis that the effect of decoupled payment on farm solvency is uniform across farm size.

This thesis also finds preliminary evidence of an endogenous relationship between acres operated and the debt-to-asset ratio. Using state-level average temperature and total precipitation from February to May of the current year and October to March of the previous year as instrumental variables for acres operated, the results from a two-stage least squares model suggest that decoupled payments and the debt-to-asset ratio have a negative relationship and that the OLS model generates a positively biased parameter estimate. Although further work is needed to test the robustness of the Hausman test and the TSLS results to different instrumental variables, this thesis serves as an important first step in properly modeling the relationship between decoupled payments and the debt-to-asset ratio. If the TSLS parameter estimates are unbiased, this study suggests results from research failing to account for a potential endogenous relationship between acres and the debt-to-asset ratio are likely biased and should be interpreted with caution.

CHAPTER 8

CONCLUSION

Understanding how decoupled payments influence farm solvency is the main objective of this thesis. The growth of the U.S. agricultural market has been characterized by growth in large farms and research suggests this shift in production could be caused in part by government agricultural support programs (Key and Roberts 2006, Yee and Ahearn 2005). This thesis investigates the implications of this shift for farm financial stability by estimating the relationship between decoupled payments the debt-to-asset ratio, used as a measure of farm solvency. Decoupled payments are designed to be independent of farmer's current production and resource allocation decisions, but research suggests they could be influencing farm financial stability (Foltz, Useche and Barham 2012; Olson and Vu 2009; Donnellan and Hennessy 2012; Katchova 2010). With the proposed elimination of decoupled payments in the upcoming Farm Bill, it is important to understand the effects of decoupled payments on farm financial stability in order to make a more informed policy decision (Paulson, Woodard and Babcock, 2013).

Financial stability consists of liquidity, solvency, repayment capacity, profitability and efficiency (Katchova 2010). Studies estimating the effect of decoupled payments on farm solvency focus primarily on the solvency of new and beginning farmers. Katchova (2010) finds that government payments increase the financial stability of farms in all categories, except for solvency. The study also finds larger farms are more likely to take on more debt. Antoni, Mishra and Chintawar (2009) find operator age, experience, farm size, farm type, and farm income affect a farmer's debt-to-asset ratio, but they do not consider decoupled payments. This thesis differs from their studies by including all decoupled payments since their creation in 1996 and all farmer experience levels. An estimation of the broader relationship between decoupled payments and farm solvency is missing from the current literature and this thesis attempts to fill that void by providing evidence that decoupled payments positively influence the debt-to-asset ratio for corn, cotton, wheat and soybean farmers across all farm sizes but with a farm primary crop specific component.

The developed theoretical model of profit maximization provides a framework in which to think about how decoupled payments influence the debt-to-asset ratio. Through the asset response function, decoupled payments affect a farmer's decision to acquire assets in the current period and thus affect the debt-to-asset ratio. The profit maximization model does not yield any definitive predictions, thus empirical estimation is necessary to quantify the effects of decoupled payments on the debt-to-asset ratio.

To empirically estimate the effects of decoupled payments on the debt-to-asset ratio, this thesis uses farm-level financial information from the Agricultural Resource Management Survey, county-level decoupled payments data from the Farm Service Agency and county-level crop insurance indemnity and premium data from the Risk Management Agency from 1996 to 2011. Consistent with the literature, a linear regression model estimates the effects of decoupled payments, farm acres, assets, income, expenses, production risk, operator age, and education on the debt-to-asset ratio, where observations are weighted based on the probability of being selected from the total population of farmers.

The overall results, across all farm sizes and primary crops, suggest operator age, revenue per acre, and the value of real estate have a negative relationship with the debt-to-asset ratio. Fixed expenses per acre, the expected loss ratio, acres operated and decoupled payments are estimated to be positively related to the debt-to-asset ratio. Throughout the empirical analysis, the results suggest that after controlling for the value of the land, as farm size grows farms use a higher percentage of debt financing, a results consistent with Katchova (2010). These impacts are robust to different model specifications that employ alternative approaches to dependent variable outliers and to the censoring in the debt-to-asset ratio.

The results across all farms indicate decoupled payments increase the debt-to-asset ratio. Although the results suggest a significant effect of decoupled payments, the debt-to-asset ratio appears to be more responsive to fluctuations in operator age, revenue per acre, acres operated, value of real estate, and fixed expenses. Even though the estimated positive relationship between decoupled payments and the debt-to-asset ratio is small in magnitude compared to most other explanatory variables, the results imply that the elimination of decoupled payment in the upcoming Farm Bill could lead to decreases in farmers' debt-to-asset ratios by an average of approximately 10.15 percent. A reduction in the debt-to-asset ratio from the elimination for decoupled payment suggests a lower percentage of debt financing and increased solvency, but it cannot always be considered an improvement in a farm's financial condition. It could be the case that farmers are able to more profitably leverage their assets with decoupled payments because of increased access to credit. Thus, the elimination of decoupled payments would cause farmers to reduce their debt balance from a more profitable level.

The results proceed with an analysis of the relationship between decoupled payments and the farm debt-to-asset ratio by primary crop produced. This analysis indicates the effects of fixed expenses per acre, value of real estate, acres operated and operator age on the debt-to-asset ratio are consistent with the overall results in sign and significance across primary crop designations. However, the estimated effects of the expected loss ratio, revenue per acres, variable expenses per acre and decoupled payments are primary crop specific. In addition, the results indicate that corn and soybean farmers, corn farmers and wheat farmers primarily drive the estimated effect of decoupled payments on farm solvency. This analysis suggests that only corn and soybean farmers, corn farmers and wheat farmers' debt-to-asset ratios are significantly responsive to changes in decoupled payments, implying they would be the farmers primarily impacted by the elimination of decoupled payments.

Based on the findings from the farm size analysis the effect of decoupled payments on the debt-to-asset ratio does not appear to vary with farm size. The results from the farm size analysis support the overall results suggesting that as farms size increases farmers use a higher percentage of debt financing on average, and that increases in decoupled payments are correlated with increases in the debt-to-asset ratio. Furthermore, the results suggest the relationship between decoupled payments and the debt-to-asset ratio is uniform across farm size. According to the results in this study, decoupled payments are not found to contribute to a financial advantage for large farms with regard to farm solvency.

In addition to the linear regression results, this thesis also contributes to the current body of literature by providing preliminary evidence of an endogenous relationship between acres operated and the debt-to-asset ratio. Furthermore, the parameter estimates from a two-stage least squares model using state-level average temperature and total precipitation from February to May of the current year and March to October of the previous year as instruments for acres operated, suggests decoupled payments are negatively correlated with the debt-to-asset ratio. According to these results, the elimination of decoupled payments in the upcoming Farm Bill will lead to increases in corn, wheat, cotton, and soybean farmers' debt-to-asset ratios. Estimating the relationship between decoupled payments and the debt-to-asset ratio with an ordinary least squares model appears to introduce a positive bias on the parameter estimate for decoupled payments. Although more work is necessary to identify the acres operated variable, this finding suggests that research that fails to account for the potential endogenous relationship between acres operated and the debt-to-asset ratio will likely generate biased results and should be interpreted with caution.

The primary focus of this research moving forward will be to appropriately identify the acres operated variable using alternative instruments. Potential instruments include county-level climatic variables, and farmer level variables in the Agricultural Resource Management Survey. Obtaining exogenous and relevant instrumental variables is critical in order to accurately test for the endogeneity of acres operated and obtain unbiased two-stage least squares results. Obtaining farm-level decoupled payments data would allow for a more accurate estimation of how fluctuations in decoupled payments influence farm solvency. A more extensive avenue for future research would be to conduct an analysis of how participation in crop insurance influences farm debt-to-asset ratios. This is a particularly relevant topic, as crop insurance becomes an increasingly important source of federal agricultural support for farmers in the United States.

Currently the House of Representatives and Senate are working towards creating a new Farm Bill to replace the Food, Conservation and Energy Act of 2008. Among the proposed changes is the elimination of direct payments and renovation of counter-cyclical payments (Paulson, Woodard and Babcock, 2013). To better understand the implications in the agricultural market from this type of policy change, future research should seek to understand how decoupled payments affect all elements of farm financial stability for all farm types. This thesis serves as an important step in accurately modeling the relationship between decoupled payments and farm solvency. It is prudent for future research to build off these findings to understand how decoupled payments influence the financial condition of farms in order to make an informed policy decision.

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APPENDIX A

ALTERNATIVE MODEL SPECIFICATIONS

Debt-to-Asset Ratio Outlier Analysis

The empirical analysis presented in Chapter 7 excludes observations with a debt-to-asset ratio above the 99th percentile to mitigate the influence of outliers on the parameter estimates. However, it is worth discussing alternative approaches to addressing outliers in order to insure the reported results are robust to outlier assumptions. Six alternative model specifications are estimated for the analysis of farm solvency across all farm types in Table A.1. All regression specifications in Table A.1 include state fixed effects, farm primary crop fixed effects, indicator variables for years 2002 and 2008, and report county-clustered standard errors.

The columns of Table A.1 differ based on the number of observations included and the estimation procedure. Columns (1) and (4) – (6) include all observations regardless of their value for debt-to-asset ratio, while columns (2) and (3) exclude observations above the 99th and 95th percentile respectively.[73] Columns (1) – (4) generate parameter estimates by maximizing the sum of squared residuals. Column (5) uses iteratively reweighted least squares to weight the observations based on deviations from the mean, and column (6) minimizes the sum of the absolute value of the residuals. Column (4) differs from column (1) by including an interaction term between the debt-to-asset ratio and a variable indicating whether the observation is in the 99th percentile. The purpose of including various estimation methods is to gain a better understanding of how outliers are influencing the parameter estimates, and to determine which estimation procedure most appropriately addresses outliers in the debt-to-asset ratio.

[73] The results reported in column (2) of Table 7.3 are the same as those reported in Table 7.1, but are included in Table 7.3 for convenience in comparison.

Table A.1 Impacts on Debt-to-Asset Ratio based on Outlier Treatment

	(1)	(2)	(3)	(4)	(5)	(6)
Decoupled Payments per Farm (in millions)	2.528**	2.143***	1.557***	2.129***	0.571***	0.698***
	(2.40)	(6.03)	(5.58)	(6.10)	(24.63)	(2.85)
Debt-to-Asset Ratio*Outlier	--	--	--	1.000***	--	--
	--	--	--	(6318.17)	--	--
Operator Age	-0.004***	-0.004***	-0.003***	-0.004***	-0.002***	-0.002***
	(-10.40)	(-16.10)	(-13.25)	(-16.34)	(2958.84)	(-21.88)
Operator Education	0.015	0.004	0.003	0.004	0.004***	0.003**
	(1.56)	(1.62)	(1.41)	(1.64)	(47.18)	(2.38)
Revenue per Acre (in thousands)	-0.071	-0.047***	-0.031**	-0.046***	-0.083***	-0.051***
	(-1.17)	(-3.18)	(-2.49)	(-3.21)	(687.69)	(-9.45)
Expected Loss Ratio	0.007	0.009**	0.005	0.009**	0.009***	0.010***
	(0.41)	(2.35)	(1.60)	(2.34)	(62.70)	(3.91)
Expected Loss Ratio 2001-2006	-0.006	0.001	-0.011	0.001	-0.015***	-0.014
	(-0.16)	(0.00)	(-1.36)	(0.05)	(-6.58)	(-1.59)
Variable Expenses per Acre (in thousands)	-0.007	-0.005	-0.003	-0.005	-0.009***	-0.010***
	(-0.83)	(-0.76)	(-0.55)	(-0.89)	(77.57)	(-2.97)
Fixed Expenses per Acre (in thousands)	0.614***	0.468***	0.348***	0.458***	0.992***	1.005***
	(3.33)	(3.40)	(3.07)	(3.46)	(27107.0)	(32.27)
Value of Real Estate-land and building (in millions)	-0.028***	-0.012***	-0.008***	-0.012***	-0.011***	-0.011***
	(-4.01)	(-10.66)	(-8.40)	(-10.65)	(711.69)	(-16.63)
Acres Operated per Farm (in thousands)	0.023***	0.020***	0.017***	0.019***	0.030***	0.034***
	(8.97)	(10.93)	(10.58)	(10.94)	(4484.41)	(21.24)

Estimates are reported with t-statistics in parenthesis, except column (5) reports chi-squared statistics. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

Table A.1 Impacts on Debt-to-Asset Ratio based on Outlier Treatment (Cont.)

	(1)	(2)	(3)	(4)	(5)	(6)
Year 2001- 2006	-0.028	-0.013	-0.003	-0.013	-0.004	0.001
	(-0.92)	(-1.02)	(-0.30)	(-1.01)	(0.77)	(0.20)
Year 2002	0.057**	0.032***	0.014*	0.032***	0.015***	0.012***
	(2.16)	(3.37)	(1.94)	(3.44)	(43.43)	(2.20)
Year 2008	-0.039***	-0.017***	-0.014***	-0.017***	-0.020***	-0.018***
	(-4.33)	(-3.51)	(-3.09)	(-3.49)	(79.04)	(-6.61)
Outlier (top 1%)	--	--	--	-0.231***	--	--
	--	--	--	(-26.65)	--	--
Corn Farmer	0.046	0.040***	0.033***	0.039***	0.028***	0.019**
	(1.63)	(4.15)	(4.55)	(3.92)	(51.72)	(2.32)
Soybean Farmer	-0.050***	-0.025**	-0.006	-0.026***	-0.018***	-0.015*
	(-2.56)	(-2.27)	(-0.72)	(-2.40)	(19.73)	(-1.81)
Corn and Soybean Farmer	0.088**	0.067***	0.042***	0.066***	0.019	0.019
	(2.56)	(4.15)	(3.38)	(4.26)	(1.10)	(0.61)
Wheat Farmer	-0.032	-0.038***	-0.030***	-0.038***	-0.043***	-0.035***
	(-1.00)	(-2.78)	(-4.55)	(-2.87)	(49.45)	(-3.03)
Fixed Effects	State	State	State	State	State	State
Clustered Standard Errors	County	County	County	County	No	No
Estimation Procedure	SSR	SSR	SSR	SSR	IRLS	SAR
N	63,098	62,466	59,248	63,098	63,098	63,098
Percentile	100	99	95	100	100	100
Adjusted R-Squared	0.009	0.190	0.173	0.985	0.169	NA

Estimates are reported with t-statistics in parenthesis, except column (5) reports chi-squared statistics. The estimation procedure SSR stands for maximizing the sum of squared residuals, IRLS stands for iteratively reweighted least squares where the observations are weighted based on deviations from the mean, and SAR stand for minimizing the sum of the absolute value of the residuals. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

It is likely that farmers are not completely accurate in their reporting of the farm business debt-to-asset ratio in the Agricultural Resource Management Survey. Thus, the reported debt-to-asset ratio may vary from the true ratio for at least some subset of the sample, especially for observations with abnormally high debt-to-asset ratios. Measurement error in the debt-to-asset ratio can result in larger variances and deflated t-statistics. Column (1) does not control for the impacts of outliers on the estimated parameters. In this specification only decoupled payments, operator age, fixed expenses per thousand acres, value of real estate and acres operated per farm are estimated to have a significant influence on farm solvency. Indicator variables for year 2002, year 2008, soybean farmer, and corn and soybean farmer are also statistically significant. This finding is consistent with the hypothesis that outliers in the debt-to-asset ratio create an attenuation bias in the parameter estimates caused by measurement error.

The only way to correct attenuation bias is to reduce the measurement error in the debt-to-asset ratio. If the outliers are caused by measurement error, then eliminating those observations from the data set will reduce the bias and generate more efficient and unbiased estimates. Column (2) and (3) eliminate observations with a debt-to-asset ratio in the 99th and 95th percentile. The most significant improvement in the overall fit of the model occurs when eliminating the 99th percentile. The adjusted R^2 increases from 0.009 to 0.190 between columns (2). Moving from column (1) to column (2) additionally, revenue per acre, and expected loss ratio are found to significantly influence a farmer's debt-to-asset ratio.[74] This result may imply that some of the measurement error in the

[74] Corn farmer and wheat farmer indicator variables were are also statistically significant, although the parameter estimates are not shown in Table 7.3.

debt-to-asset ratio has been removed with the exclusion of the 99th percentile. By eliminating the 95th percentile in column (3), the explanatory power of the model reduces to 0.173, as measured by the adjusted R^2, and there is no significant reduction in the variance of the parameter estimates. Thus, in order to maintain the maximum number of observations while reducing measurement error in the debt-to-asset ratio, column (2) is the preferred model.

Like columns (1) – (3), column (4) estimates model parameters by maximizing the sum of squared residuals, however instead of removing a percentage of the observations a variable indicating observations with a debt-to-asset ratio in the 99th percentile is interacted with the debt-to-asset ratio. This interaction variable captures fluctuations in the debt-to-asset ratio attributed to outliers. Controlling for outliers in the debt-to-asset ratio this way greatly improves the overall fit of the model. The adjusted R^2 in column (4) is 0.985 meaning that the model explains 98.5 percent of the variation in the debt-to-asset ratio. The advantages of this model are the improvement in overall fit and the inclusion of all observations. However, it is important to note that parameter estimates and statistical significance of the explanatory variables in columns (2) and (4) are similar. Thus, there are not substantial difference is in estimated effects of the explanatory variables on farm solvency.

Another way to control for the effects of outliers without eliminating observations is to use an estimation technique that places less emphasis on observations with large residuals. Column (5) estimates the parameters of the model by placing smaller weights on observations that have larger deviations from the median. This process is called iteratively reweighted least squares (IRLS).[75] The parameter estimates generated from this process are smaller in magnitude for decoupled payments, operator age, value of real estate, farm bill year 2002 and the primary crop indicator variables than column (2). Larger estimates were generated for revenue per acre, fixed expenses per acre, acres operated and farm bill year 2008. However, the direction effects of the explanatory variables on the debt-to-asset ratio remained the same.

Column (6) generates parameter estimates by minimizing the sum of the absolute values of the residuals. Because this process does not square the residual values, as is the case with ordinary least squares, observations with larger residuals do not receive as much weight. Consistent with the other methods of estimation, the results in column (6) suggest operator age, revenue per acre, expected loss ratio, fixed expenses per acre, value of real estate and acres operated per farm have a significant impact on the debt-to-asset ratio. The directions of the estimated effects are consistent with column (2), although the magnitudes of the effects are smaller for some variables.[76]

Comparing the estimation techniques in Table A.1 suggests the importance of controlling for outliers in the debt-to-asset ratio because they appear to create an attenuation bias. The different approaches to addressing the outliers presented in Table

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[75] The results in column (5) were obtained using the M estimation process. For this process a weighted least squares fit is carried out inside an iteration loop. For each iteration, a set of weights for the observations is used in the least squares fit. The weights are constructed by applying a weight function to the current residuals. Initial weights are based on residuals from an initial fit (SAS 9.2 User's Guide, Second Edition).

[76] The estimated effects of age, education, expected loss ratio, decoupled payments, value of real estate, Farm Bill years 2002 and 2008 and the farm-type indicator variables are smaller in magnitude in column (6) compared to column (2).

A.1 vary in the magnitude of the estimated coefficients, but after controlling for outliers in the 99th percentile the results appear robust to different model specifications. [77]

Tobit Model Comparison

The debt-to-asset ratio is considered a censored variable because it cannot take on a value of less than zero. For some subset of the sample, a farmer's optimal level of debt financing may lead to a corner solution where no debt financing is used. If this occurs for a nontrivial fraction of the sample then a linear regression model may generate biased parameter estimates. In this case, a Tobit model may be more appropriate because they are explicitly designed to model corner solution dependent variables (Wooldridge, 2009).[78] The magnitude of the bias generated in a linear regression model is functionally related to the degree of limit observations. If the number of limit observations is a small percentage of the total observations then a linear regression model may provide a good approximation of impact of decoupled payments on farm solvency (Wooldridge, 2009). To determine if a Tobit model is preferred, Table A.2 shows the estimates generated from a Tobit and linear regression model in columns (1) and (2) respectively.

[77] Both column (5) and column (6) find a statistically significant impact of variable expenses per acres and operator education on the debt-to-asset ratio that is not found in columns (1) – (4). Additionally columns (5) and (6) do not find a significant difference the in average debt-to-asset ratio for corn and soybean farmers compared to cotton farmers.

[78] The Tobit model estimates the expected value of the debt-to-asset ratio conditional on the ratio begin greater than zero. By estimating the model this way, it accounts for the distribution of the debt-to-asset ratio through the inverse Mills ratio, which is omitted from linear regressions potentially generating omitted variable bias if the observations at the corner solution make up a nontrivial percentage of the total sample.

Table A.2 Tobit and Linear Model Analysis of Debt-to-Asset Ratio

	(1)	(2)
Decoupled Payments per Farm (in millions)	2.141***	2.143***
	(14.20)	(6.03)
Operator Age	-0.004***	-0.004***
	(-67.54)	(-16.10)
Operator Education	0.005***	0.004
	(5.54)	(1.62)
Revenue per Acre (in thousands)	-0.049***	-0.047***
	(-11.92)	(-3.18)
Expected Loss Ratio	0.009***	0.009**
	(5.55)	(2.35)
Expected Loss Ratio 2001-2006	-0.000	0.001
	(-0.04)	(0.00)
Variable Expenses per Acre (in thousands)	-0.005***	-0.005
	(-3.71)	(-0.76)
Fixed Expenses per Acre (in thousands)	0.478***	0.468***
	(60.39)	(3.40)
Value of Real Estate-land and building (in millions)	-0.012***	-0.012***
	(-21.70)	(-10.66)
Acres Operated per Farm (in thousands)	0.020***	0.020***
	(33.46)	(10.93)
Year 2001- 2006	-0.012**	-0.013
	(-1.97)	(-1.02)
Year 2002	0.032***	0.032***
	(11.07)	(3.37)
Year 2008	-0.017***	-0.017***
	(-5.68)	(-3.51)
Corn Farmer	-0.026	0.040***
	(-1.10)	(4.15)
Soybean Farmer	-0.034***	-0.025**
	(-12.30)	(-2.27)
Corn and Soybean Farmer	—	0.067***
	—	(4.15)
Wheat Farmer	-0.050***	-0.038***
	(-7.36)	(-2.78)
Fixed Effects	State	State
Cluster	No	County
Estimation Procedure	Tobit	OLS
N	62,466	62,466
Lower Bound	0	NA
N Observations at Lower Bound	589	NA

Estimates are reported with t-statistics in parenthesis. P-values are reported based on a two-tailed test where *p<0.10, **p<0.05 and ***p<0.01.

The Tobit estimates in column (1) do not differ substantially from the linear regression estimates in column (2). This is likely because the marginal effects in the Tobit model are estimated by multiplying the parameter estimate by the percent of non-limit observations and in this case, less than one percent of the observations in the sample have a debt-to-asset ratio equal to zero (Greene, 2012). The magnitude of the estimated coefficients vary by less than 0.01 percentage points, and the direction of the effect is consistent between column (1) and column (2) for all explanatory variables.[79] The Tobit model estimates a statistically significant effect of variable expenses per acre on the debt-to-asset ratio. The coefficient estimate suggests an increase in variable expenses by a thousand acres will lead to a decrease in the farm debt-to-asset ratio by 0.51 percentage points at the mean, conditional on a debt-to-asset ratio greater than zero. In other words at the mean, a thirty percent increase in variable expenses per acre leads to a decrease in the debt-to-asset ratio by 0.26 percent, conditional on a debt-to-asset ratio greater than zero. Variable expense per acre is the only explanatory variable that differs in statistical significance between the two models.[80] Based on the limited number of observations at the lower bound and the similarities between columns (1) and (2), the linear regression model appears to provide a good approximation of the parameter estimates for the determinates of farm solvency.

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[79] The coefficient and standard error for corn and soybean farmers is not estimated in the Tobit model because it identifies the matrix as singular.

[80] The Tobit model does not use county-clustered standard errors so the reported standard errors may be underestimated and the resulting t-statistics could be overstated because the reported standard errors do not allow for the residuals between farmers within a county to be correlated. This would explain why the t-statistics in the Tobit model are higher than those reported in the linear regression model.