ABSTRACT

GIRANTE, MARIA JOANA SACRAMENTO. Three Essays on the Production Effects of Decoupled Payments: Do Decoupled Payments Matter for Acres and Yields? (Under the direction of Barry K. Goodwin).

Conventional wisdom suggests that if decoupled payments do not distort market incentives, they should not distort production or trade. But the literature has identified several potential "coupling" mechanisms that suggest theory and practice are not in accord. Using both estimation and simulation methods, we analyze the effect of decoupled payments on farmers' decisions in the presence of one such mechanism, credit constraints. Intuitively, as payments enhance the liquidity and/or the collateral of credit constrained farmers, additional investment in production is allowed to occur. We estimate the marginal effect of decoupled payments on total, owned, and pasture acres, and on acres of corn, sorghum, soybeans, and wheat and observe whether payments matter more for more leveraged farmers. Our ability to observe farms over time allows us to improve on the existing literature by controlling for farm-specific unobserved effects. In an effort to analyze the income stabilization aspect of these payments we further estimate their effect on farm household consumption expenditures. The significant acreage effects and insignificant marginal propensity to consume suggest payments are being not put to the policy makers' intended use. We also extend the existing literature by using simulation methods in an expected utility maximization framework to evaluate the effects of doubling the amount of payments received and of recently proposed tighter payment limits on the typical Kansas wheat farmer's acreage and borrowing decisions. While tighter limits do not appear to matter, the collateral boosting effect of payments allows farmers to put more acres into production. Finally, we estimate the ability of farm characteristics to explain differences in crop yield performance. Our results reveal the potential for decoupled payments to boost relative yields and give an unfair advantage to their recipients. This may become an issue in future WTO discussions over the distortionary effects of decoupled payments.

Three Essays on the Production Effects of Decoupled Payments: Do Decoupled Payments Matter for Acres and Yields?

by
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DEDICATION

À minha mãe, Helena
Que me ensinou a aprender
E tanto mais

(To my mother, Helena
Who taught me how to learn
And so much more)

BIOGRAPHY

Maria Joana S. Girante was born in 1975 in Oliveira de Azeméis, Portugal, about 40 km south of Porto, the country's second biggest city (it literally means "port" and it is where port wine comes from). Combining her pleasure of learning Mathematics and English, and her desire to travel and one day live abroad, in 1993 Joana enrolled as an International Relations – field of Economics and Politics student at the Universidade do Minho, Portugal. There she had the great fortune to meet a few amazing economists – and friends – who kindled her love for Economics and stimulated her to pursue a career in academia. After graduating in 1997, she soon started teaching at the Universidade do Minho and enrolled in the Masters program in International Trade, which she completed in 2001. In 2002 Joana started the Ph.D. program in Economics at North Carolina State University, which she calls her "big adventure".

About six years, a great deal of lost sleep, and a remarkable lack of vacations later, Joana has received her doctorate degree. For the short-term she will be an Assistant Professor at the University of Minho, where she teaches courses in the field of International Trade.

ACKNOWLEDGMENTS

In episode 20, season 16, of the The Simpsons, Bart said “Look at me, I’m a grad student! I’m 30 years old and I made $600 last year!”, to which Marge replied “Bart, don’t make fun of grad students, they just made a terrible life choice.” These few lines made me laugh countless times as I thought of my own decision come to the United States to do my Ph.D. in Economics. And while it was challenging at times (to put it mildly), I never lost sight of the fact that this was my big adventure and always one hell of a ride. This choice is one I am very happy to have made.

Several people contributed to my achieving the light at end of the tunnel, most likely too many to acknowledge. I name but a few, fully aware of several names left out (I could, for example, thank all the Customs and Border Protection officers who let me in to the country, effectively allowing me to be part of the program). In spite of this and my own limitations in expressing gratitude, as the people I mention deserve so much more, I dedicate my next paragraphs to those who either helped me see the light or made it shine even brighter.

I am deeply thankful to the chair of my committee, Barry Goodwin, for directing me to this topic and guiding me through my dissertation. His enthusiasm was contagious and every single one of his “good job’s” meant the world to me. He was especially tolerant of my being unable to give my undivided attention to my dissertation during the semesters I spent teaching at my home university. The opportunity to work with him has been a privilege.

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I am also grateful to my colleagues and friends at the Universidade of Minho, in Portugal, Cristina Amado, Luís Aguiar-Conraria, Pedro Camões, Fernando Tavares, and Ana Paula Veiga, who advised me to do my Ph.D. in the U.S., guided me through the application procedures, and cheered me on. I also truly appreciated their willingness to help with midterm proctoring and grading when I was away.

A very special thank you goes to my grandparents, Avô Álvaro Tavares and Avó Emília do Sacramento, Avô Manuel Girante and Avó Otília Figueiredo, for their unwavering understanding of my infrequent visits. I also took pleasure in (or suffered through) their many time-zone mix-ups, which made them call me at odd hours to ask what I was having for lunch and whether I was resting enough (ah, the irony!). The truth is I always felt warm and fuzzy after each of these calls, knowing they simply missed me too much and could not wait to talk to me.

My fantastic aunts, Clara Antão and Rosa Pereira, get the best cheerleaders award. They wrote down my big dates on their calendar and never forgot to call after each of them. The same goes for my adoptive aunt, Judite Fernandes, whose tender smile, warm hug, and absolute kindness serves as an inspiration to me.

I also thank my best friend Cátia Rebelo, whom I've known since we were two years

old, and Sónia Nogueira, for welcoming me back every single time as if I had never left. Their laughs followed me and brightened up my days.

I am also very grateful to Manuel Leite, whose friendship and support for my family allowed me to be away for so long.

I am particularly grateful to my mother, Helena Tavares, for all the sacrifice she made for me and abiding encouragement. She shared my successes and suffered through my troubles. I especially appreciate how she, knowing I very much wanted to come and study in the U.S., never, for one second, let me think twice about moving across the ocean. It is because of her I know Math, it is because of her I know English, and it is because of her I know I can follow my dreams. I could not have hoped for a better friend.

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Introduction

According to the U.S. General Accounting Office, during the first four fiscal years of the Farm Security and Rural Investment Act of 2002, farmers received approximately $60 billion in federal program payments from the U.S. Department of Agriculture (USDA). Due to unexpectedly weak commodity prices the bill, which was originally expected to cost about $170 billion over the following 10 years, pushed the total price tag to $190 billion. The Food, Conservation and Energy Act of 2008, which extends farm income support programs for major commodities and increases funding for export promotion and rural development, is estimated to cost $286 billion between 2008 through 2012. These rising costs have significant effects at the national and international levels.

At the national level, higher costs increase budgetary pressure. This effect is magnified by increases in production induced by payments. That is, if support payments stimulate production, prices decrease, requiring an even greater level of support in order to maintain the desired level of farm income. A second issue is that heterogeneity within the farm sector results in an unbalanced distribution of payments, so that most of the transfers do not reach small farms. In 2004, the largest 7.5 percent of farms in terms of gross receipts received 56 percent of all government payments (USDA). Hence, the improvement in family farm income, the stated goal of these policies, is not met, creating additional discontent with the policy. A commonly-cited perverse outcome is that recipients of Farm Bill payments include, among others, TV host David Letterman and former NBA star Scottie Pippen,

neither of whom need the additional income, presumably.[1]

At the international level, increased spending on agricultural support payments does not seem compatible with the multilateral commitments made under the World Trade Organization (WTO) to limit trade-distorting agricultural support. This has been highlighted by recent trade disputes in the WTO. For example, in September of 2002, at a meeting of the Dispute Settlement Body of the WTO, Brazil claimed that U.S. cotton subsidies were depressing world prices and injuring Brazilian growers. A similar claim was made about the European Union's sugar subsidies. Two years later the WTO panel decided in favor of Brazil, deeming U.S. support to cotton producers to be trade-distorting. A similar decision was reached for sugar.

These rising budgetary pressures, concentration of support in large farms, and commitments to limit trade-distorting subsidies, along with the potential for negative environmental consequences, all justify the importance of scrutinizing the distortionary nature of decoupled payments. Several studies have attempted to measure the distortionary effects of decoupled payments on production variables such as acreage levels or labor choices, and the consensus suggests that while coupling of decoupled payments is pervasive, its effects when measurable are small, with the exception of the impact on land values (Bhaskar and Beghin 2007). Some of these studies, in particular those that use farm-level data to study the acreage effects of decoupled payments, rely heavily on survey data that come mainly from USDA's Agricultural Resource Management Survey (ARMS) and do not contain observations on individual farms over time. This complicates the identification of causal effects of policy variables.

The goal of this dissertation is to investigate the production effects of decoupled payments and, in particular, to investigate whether the magnitude of these effects depends on the degree to which farmers are constrained by credit. Our use of farm-level records from the Kansas Farm Management Association (KFMA) allows us to overcome the limitation of

[1] According to the Environmental Working Group database of farm payments beneficiaries, subsidy benefits for Scottie Pippen and David Letterman totaled $78,945 and $8,023 respectively for 2003-2005 Program Years (http://farm.ewg.org/).

cross-section data. These micro data are supplemented with more highly-aggregated data from a variety of sources. The KFMA farms are full-time commercial operations, which are mainly farms with gross sales exceeding $100,000. Of the 61,593 farms counted in the 1997 Agricultural Census, 13,436 farms had gross sales exceeding that number (21.81 percent). The KFMA farms represent, according to Albright (2001), the various farming areas and farm types in Kansas.

The dissertation is organized into four main chapters. The next chapter considers the role of decoupled payments in American agricultural policy and reviews the empirical literature on their production effects. Because a substantial amount of attention is given to the role credit constraints may play in bringing these effects about, this chapter also discusses the theoretical foundations of credit constraints and offers evidence of their presence in agriculture. Studies of production effects of decoupled payments in the presence of credit constraints are also reviewed.

The third chapter estimates the marginal effect of decoupled payments on total, owned, and pasture acres, and on acres of corn, sorghum, soybeans, and wheat, and observes whether they matter more for more leveraged farmers. In principle, farmers who exhibit greater credit-worthiness should have a less costly access to outside funds to realize their investment plans and to react more flexibly to short-term price shocks. Therefore, government payments should play a greater role in their investment decisions.

In an effort to analyze the income stabilization aspect of these payments we further estimate their effect on farm household consumption expenditures by estimating the marginal propensity to consume different sources of income, including net farm income, non-farm income, and decoupled payments. If, as intended by policy makers, decoupled payments are used to support farm household income and do not affect production, we should find an insignificant effect of decoupled payments on acreage decisions and a significant marginal propensity to consume these payments. The use of KFMA data allows us to address omitted variable bias by using taking into account the presence of unobserved effects that may cause ordinary least squares to be biased and inconsistent.

The fourth chapter uses simulation methods in an expected utility maximization

framework to analyze the typical Kansas wheat farmer's acreage and borrowing decisions in the presence of credit constraints. The farmer's ability to reach the optimal number of planted acres is constrained by her current liquidity and capacity to borrow. Decoupled payments enhance wealth and thus improve the farmer's collateral, allowing additional borrowing to take place. This framework is then used to evaluate the results of two policy measures. The first measure involves doubling the amount of decoupled payments received by the farmer. The second measure involves tightening the limits of payments as proposed in the Rural American Preservation Act (S. 385) by Senators Charles Grassley and Byron Dorgan in the 109th Congress. This would, among other measures, tighten limits on commodity payments to a total of $250 thousand.

In addition to affecting acres, decoupled payments have the potential to distort production through their impact on the farmers' ability to invest in better production methods that increase productivity and enhance yields. And despite the fact the analysis in the previous chapter recognizes the fact that yields vary from farm to farm (and even from field to field within a farm), no attempt is made to study the elements that may cause this difference. Indeed, the farm-level determinants of yield performance have been largely ignored by the economics literature. The fifth chapter helps fill in this gap by evaluating the determinants of relative yield performance across the farms in our sample. We estimate the effects of several farm characteristics on relative crop yields of eight crop/practice combinations of corn, sorghum, soybeans, and wheat, and observe whether the financial characteristics of the farms may help explain differing yield performances. Moreover, we investigate whether decoupled payments may be used to enhance yields at the farm level. The hypothesis underlying our application is that these payments may be used to implement additional investment in better farming methods, for example new technologies. As in the second chapter, the use of KFMA data allows us to use panel data methods that address the issue of time-constant omitted variables.

In general, we find that decoupled payments matter for production decisions, distorting both acres and yields. Furthermore, for the credit-constrained farmer, decoupled payments have an indirect collateral enhancing effect that allows additional borrowing to

take place and so let further investment in production occur.

Chapter 2

Decoupled payments, an overview

2.1. Introduction

The goal of this section is to introduce the concept of decoupled payments and motivate their potential for distorting production. Special attention is given to the role of credit constraints as they, individually and by interacting with other potential *coupling* mechanisms, can enhance this potential. This section is organized as follows. The second section defines what makes a government payment "decoupled" and the third section presents a historical overview of these payments in American agricultural policy. We discuss the creation of decoupled payments by the 1996 Farm Bill and their continuation in the following 2002 and 2008 Farm Bills. This is followed by a review of the literature on the potential coupling mechanisms and other avenues through which payments may be non production-neutral in the fourth section. One such mechanism is the presence of imperfect capital markets, or credit constraints. These are discussed in greater detail in the fifth section. We begin by describing their theoretical foundation and motivating their presence in agriculture and then move on to reviewing empirical work on the effects of decoupled payments in the presence of credit constraints. The sixth section concludes.

2.2. Definitions of decoupled payments

The past ten years have seen a great deal of scrutiny from the economics profession on the appropriateness of the adjective "decoupled" to describe government payments. The answer depends crucially on the exact nature of the program through which support is provided, the incentives it creates, and the behavior of producers in response to those incentives (Abler and Blandford 2006). Two important definitions of "decoupled" payments are based on the WTO's Uruguay Round Agreement on Agriculture (URAA) and on that of the Organization for Economic Cooperation and Development (OECD).

Decoupled payments are mentioned in Annex 2 of the URAA under the title "Domestic Support: The Basis for Exemption from the Reduction Commitments".[2] Previously in the text, in Part IV, Article 6, Part 5, the URAA asserts that direct payments under production-limiting programs shall not be subject to the commitment to reduce domestic support

> *"(a) if such payments are based on fixed area and yields;*
> *(b) if such payments are made on 85 percent or less of the base level of production."*[3]

In Annex 2 it is further declared that these payments shall meet the "fundamental requirement that they have no or at most minimal, trade-distorting effects or effects on production". In addition, the support in question shall be provided through a publicly-funded program not involving transfers from consumers, and shall not have the effect of providing price support to producers. The reference to decoupling appears in Article 6, on Decoupled Income Support, which states

> *"(a) eligibility for such payments shall be determined by clearly-defined criteria such as income, status as a producer or landowner, factor use or*

[2] http://www.wto.org/english/docs_e/legal_e/14-ag.pdf.
[3] In addition, (c) if livestock payments are made on a fixed number of head.

production level in a defined and fixed base period;
(b) the amount of such payments in any given year shall not be related to, or based on, the type or volume of production (including livestock units) undertaken by the producer in any year after the base period;
(c) the amount of such payments in any given year shall not be related to, or based on, the prices, domestic or international, applying to any production undertaken in any year after the base period;
(d) the amount of such payments in any given year shall not be related to, or based on, the factors of production employed in any year after the base period, and
(e) no production shall be required in order to receive such payments."

Thus, the critical requirements for payments to be deemed "decoupled" are that they are not tied to current production, prices, or factors of production. Further note that, by (e), farmers do not have to actually produce in order to receive these payments.[4]

The OECD's definition of "decoupling" is inspired by the general criterion set forth by Annex 2 of the URAA (OECD 2001), and it includes the two formal concepts used by Cahill (1997), who described policies in terms of "full decoupling" and "effective full decoupling". Effective full decoupling is the less restrictive definition, applying to a policy if it results in a level of production and trade equal to what would have occurred had the policy not been in place. This concept is focused on the equilibrium quantities, and it allows the shape of the demand and supply curves to change by an effectively fully decoupled policy, even if the equilibrium production and consumption do not. Full decoupling applies to a policy if it "does not influence production decisions of farmers receiving payments, and if it permits free market determination of prices". In addition to requiring the same equilibrium values, this concept also focuses on the adjustment process. It is more restrictive since it requires absolutely no change in the way economic agents make decisions.

The key difference between the two definitions of decoupling is that the OECD's definition highlights policy effects, whereas the URAA's definition calls attention to policy design (OECD 2001). Definitional issues aside, what is most relevant is to determine whether decoupled payments do more than simply transfer money to farmers.

[4] The potential lack of fairness in the distribution of subsidies to farmers who do not produce has turned this clause into one politically difficult to justify (http://www.choicesmagazine.org/2004-4/grabbag/2004-4-11.htm).

2.3. Historical overview of decoupled payments in American agricultural policy

On April 4 of 1996, after the longest farm bill debate in history, the Federal Agriculture Improvement and Reform (FAIR) Act of 1996, also known as the "Freedom to Farm" Act, became law, putting an end to the United States' agricultural policy orientation established during the "New Deal" era. Prior to the FAIR Act, or 1996 Farm Bill, agricultural policy sought to raise farm prices by limiting production. Farmers participating in commodity programs were entitled to receive deficiency payments that guaranteed a price similar to what prices should be during favorable years. Through commodity and marketing loans, in years of excess production, when prices fell below the preset target, the government agreed to buy the excess and pay farmers the difference between the target and the market price. While continuing the previous system of price support through commodity and marketing loans, the FAIR Act eliminated production adjustment ("set aside") provisions and most of the restrictions on what crops could be grown on land enrolled in commodity programs, suspended the distribution of deficiency payments, and created predetermined annual payments for the duration of the legislation (1996-2002).

A major change in commodity programs was included in the Act's Title I, known as the Agricultural Market Transition Act (AMTA). Its main stated purposes were "to authorize the use of binding production flexibility contracts between the United States and agricultural producers to support farming certainty and flexibility while ensuring continued compliance with farm conservation and wetland protection requirements" and "to make nonrecourse marketing assistance loans and loan deficiency payments available for certain crops". AMTA payments were administered through the creation of Production Flexibility Contracts (PFC) for wheat, corn, sorghum, barley, oats, cotton and rice, the "contract commodities", to eligible landowners or producers with eligible cropland. Land eligible for enrollment was land which had previously been eligible for deficiency payments and had a "payment base", or land enrolled in the Conservation Reserve Program (CRP), which previously had a

payment base and whose CRP contract would expire at some point during the FAIR Act. These payments were originally scheduled to be phased-out over a seven year period, when the 2002 Farm Bill would come into law.

The Act specified a maximum amount that could be made available for contract payments and the allocation to each contract commodity. Starting with $5.570 billion in fiscal year 1996, the total amount decreased slightly for fiscal year 1997, increased to $5.800 billion in the following fiscal year, and then declined gradually to $4.008 billion by fiscal year 2002. Payment levels were allocated among contract commodities according to percentages specified in the Act, generally derived from each commodity's share of projected deficiency payments for fiscal years 1996-2002 in the Congressional Budget Office's February 1995 budget baseline.

Payment recipients collected a series of annual contract payments based on a predetermined dollar amount for each year, calculated as follows. The annual contract payment was defined as the product of the contract payment quantity and the national annual payment rate. The payment quantity was the product of 85 percent of the farm's contract acreage and the farm program payment yield. The contract acreage for the commodity was the crop acreage base that would have been in effect for the 1996 crop under Title V of the Agricultural Act of 1949 had it not been suspended by the FAIR Act. The farm's program yield was the payment yield established for the 1995 crop of a contract commodity. Finally, the annual payment rate for each commodity was equal to the total amount made available for the year divided by the annual payment quantity, obtained by summing all contract payment quantities for all farms in that year.

In order to receive payments, participants agreed to observe a few requirements. While contract acreage did not have to be planted to a contract commodity, or even any commodity, it could not be used for nonagricultural commercial or industrial use. And any crop could be planted on PFC acres except for fruits and vegetables.[5] This is not a trivial

[5] Fruit and vegetable production was not allowed on contract acreage unless: the farm was in a region with a history of double cropping with fruits or vegetables; the farm was not in a double-crop region, but it had a history of planting fruits and vegetables on contract acreage; or a producer, as determined by the Secretary, had

restriction: in March 2005, due to a dispute settlement case for cotton, the WTO established that decoupled payments (for cotton and by extension all other program commodities) could not be considered non-distorting (green-box) because farmers were not free to plant fruits or vegetables on acres previously used for program crops.[6] Finally, those who operated highly erodible land or whose properties contained wetland had to agree to manage that land under approved conservation practices as required by the "sodbuster" and "swampbuster" provisions of the Farm Bill. No acreage reduction programs were in effect.

Authorized by emergency legislation in 1998-2001, *ad hoc* Market Loss Assistance (MLA) payments were made to recipients of PFC payments to compensate them for the loss of markets.[7] These payments were set at $2.857 billion for 1998 crops, nearly doubled to $5.5 billion for 1999 crops, decreased slightly to $5.465 billion for 2000 crops, and decreased even more to $4.6 billion for 2001 crops. MLA payments effectively doubled the amount of payments given to landowners or producers for the years 1998-1999, and were labeled as "double AMTA" by Goodwin and Mishra (2006).

The 1996 Farm Bill imposed effective limits of $40,000 on PFC payments and $75,000 on marketing loan gains. But through the "three-entity rule", under which an individual can receive a full payment directly and up to a half payment from two additional entities, a farmer could receive up to $80,000 and $150,000 in PFC and marketing loan payments, respectively. Yet these limits too were weakened by subsequent legislation. The emergency legislation that created MLA payments effectively doubled AMTA payments and it created generic certificates for marketing goals that were not subject to that limitation.

The Farm Security and Rural Investment Act of 2002, or 2002 Farm Bill, continued the decoupling idea underlying the creation of PFC payments by the previous bill. It replaced

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a history of planting a specific fruit or vegetable. Lentils, mung beans, and dry peas were not included in the list of fruits and vegetables and could be planted for harvest without limitation on contract acreage.

[6] In WTO terminology, subsidies in general are identified by "boxes" which are given the colors of traffic lights: green (permitted), amber (to be reduced), red (forbidden); the Agriculture Agreement has no red box, although domestic support exceeding the reduction commitment levels in the amber box is prohibited. The green box is defined in Annex 2 of the Agriculture Agreement. In order to qualify, green box subsidies must not distort trade, or at most cause minimal distortion, they have to be government-funded, and must not involve price support.

[7] Similar payments were authorized for oilseed and dairy producers for selected years.

PFC payments by annual fixed Direct Payments (DP), calculated using the same method of multiplying the payment rate of the applicable crop by the base acres and base yield of the farm. But contrary to the PFC payment rate, which changed from year to year, the payment rate per bushel was now fixed over the life of the Farm Bill.[8] The bill also represented a more systematic approach to assisting farmers in times of extremely low prices other than the *ad hoc* MLA payments given in the years 1998 through 2001 by creating created Counter-Cyclical Payments (CCP) for program commodities. These became available when market prices went below the target levels defined in the legislation. These payments were similar to the deficiency payments eliminated by the 1996 Farm Bill. Like DP and their predecessor MLA payments, CCP were calculated on historical base acres and yields.

Along with improving the instruments to compensate farmers in periods of low prices, other innovations of the 2002 Farm Bill included the introduction of oilseed base acreage and the possibility of updating base acres and, under certain conditions, yields. If chosen, the base acres update would permit a better reflection of recent planting history. From the five possible options to update base acres, only the fourth gave farmers the opportunity to update base yields for the purposes of CCP.[9] This option let farmers set base acres equal to the average acreage planted and prevented from planting in 1998-2001. The bill also revised national and county loan rates used to calculate Loan Deficiency Payments (LDP) and marketing loans, whose provisions remained similar for a greater number of products.

Under the provisions of the 2002 Farm Bill, government payments included payments for commodity programs, such as fixed DP, paid on the basis of a landowner's or farmer's holding of base acreage; CCP, also made on base acreage and triggered when market prices fell beneath a predefined target price, and LDP, which paid benefits on current production whenever prices fell beneath a predetermined loan rate. Under payment limit guidelines, DP

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[8] Although DP rates were higher than PFC payment rates for 2001 and 2002, DP rates were lower than the average PFC rates under the previous bill (Westcott and Young 2002).

[9] The options to update yields included the following: (1) use previously established program yields; (2) update yield by adding to current program yields 70 percent of the difference between current program yields and the farm's average yields per planted acre for the period 1998-2001, and (3) update yield to 93.5 percent of 1998-2001 average yields per planted acre.

were limited to $40,000, CCP were limited to $65,000, and LDP were limited to $150,000. Under the "three-entity rule", however the overall limit on these payments was $360,000 per person. In addition, payments based on commodity certificates or forfeiture settlements of marketing loans were unlimited.[10]

Instituted to "provide for the continuation of agricultural and other programs of the Department of Agriculture through fiscal year 2012", The Food, Conservation, and Energy Act of 2008, or 2008 Farm Bill, was enacted into law in June 2008.[11] While continuing several provisions for covered commodities (for example, the bill continued the provision on planting restrictions for fruits and vegetables) and adjusting payment levels and eligibility (for example, the bill reduced payment acres for DP to 83.3 percent of base acres for the 2009 through 2011 crop years), the bill launched an elective revenue-based counter-cyclical program, the Average Crop Revenue Election (ACRE) program, as an alternative to receiving CCP (price-based). For participating farmers, the program generates payments on a crop-specific basis whenever average per-acre revenue at the state level falls below the per-acre state guarantee.[12] These payments come at the cost of a 20 percent reduction in DP and a 30 percent reduction in marketing loan rates (and CCP). In principle, by moving farmers away from government set target price-based income support towards support based on variable market conditions, the ACRE program should result in less production distortions. Also, in order for payments to be collected, along with a statewide average loss, participating farmers are required to show they have suffered a loss at the farm level.

Finally, other highlights of the 2008 Farm Bill include the elimination of the "three-entity rule" (though it keeps the "spouse rule" that effectively doubles payments for married farmers) and the amendment to provisions designed to limit benefit payments to farmers. The bill contains an income eligibility requirement that denies commodity payments to persons if their non-farm income portion of average adjusted gross income is $500,000 or greater. And

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[10] In 2003, Senator Charles Grassley proposed Senate Bill 385, aimed at restricting FDP to $20,000 per person, CCP to $30,000, and the combination of loan deficiency payments, marketing loan gains, commodity certificates, and forfeiture of loans to $87,500 per person per year. Had it been approved by the Senate, the Grassley-Dorgan amendment would have limited total annual farm subsidy payments to $250,000.

[11] http://www.usda.gov/documents/Bill_6124.pdf.

[12] Once producers elect to participate in ACRE, they must remain in the program until the next bill.

for those receiving DP, net farm income cannot exceed $750,000.[13]

While the FAIR Act decoupled government payments, the extent to which it actually changed U.S. farm policy continues to be debated. This debate is fostered by the amount of *ad hoc* support and continuation of AMTA payments in the 2002 Farm Bill, as well as the base and yield updates it allowed. The next section discusses the mechanisms through which decoupled payments may have an effect on production.

2.4. Potential *coupling* effects of decoupled payments

While in theory decoupled payments should not distort production, empirical studies have found this not to be the case. For example, Adams *et al.* (2001) used state-level data for the years 1998 through 2001 to test whether PFC and MLA payments affected field crops' planted area and whether these payments had a different impact on total area than returns from market sales or marketing loans. They found PFC and MLA payments had a significant positive effect on planted area and that the magnitude of this effect was greater than that from the other sources of income. Using wealth effects elasticities for U.S. corn and U.S. soybeans acreage, Young and Westcott (2000) estimated that an increase in wealth by the full value of PFC payments would have an aggregate acreage impact of 180,000 to 570,000 acres annually. While neither of these studies investigated the channels through which decoupled payments affected production, they nonetheless found significant effects. The remainder of this section explores the channels through which decoupled payments may distort production. Distortions can occur through wealth effects and their impact on investment, risk aversion, and labor choices, through credit constraints, land markets, farmer expectations, farm survival, and sector consolidation.[14] We turn to each channel next.[15]

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[13] The bill does not impose this condition for CCP or LDP.

[14] The OECD (2001) classifies coupling mechanisms according to their effects as static, dynamic, or under uncertainty. Static effects occur when policies affect the incentive prices of agricultural inputs or outputs. An example of static effects includes wealth effects. Dynamic effects occur because investment decisions taken in one period affect production in subsequent years or because farmers form expectations about future payments that influence their decisions. Expectations about future rebasing fall in this category. Finally, effects under

Although decoupled payments are fixed income transfers which do not depend on the farmers' production choices or market conditions in general, they still raise the overall income of farm households, so that general wealth effects may indirectly bring about production effects. For example, because additional wealth allows for greater savings, decoupled payments may be used to increase the supply of investment capital to the farm business. Assuming away effects of payments on the rental price of land, if a farmer's production function is characterized by increasing returns to scale, she would have the incentive to use at least part of the payments to finance increasing the scale of the farm and expand output. The additional income may also be used to cover short run fixed and variable costs of production that would not be profitable at prevailing market prices, or to make longer term investments. Payments may also help farmers who have a preference for the farming lifestyle, slowing down structural change in the sector.

This liquidity effect may be particularly important for the credit constrained farmer, for whom decoupled payments may replace or complement own funds and allow investment in production to occur. Additionally, decoupled payments may improve the farmers' collateral and so enhance their credit-worthiness. This grants an easier access to formal credit, or lower loan costs. Another collateral enhancing mechanism appears through the increase in land values brought about by decoupled payments, a mechanism we review last. We defer a more extensive explanation of the connection between government payments and credit constraints to the next section.

An extensive literature shows that in the presence of uncertainty, decoupled payments increase farmers' wealth, potentially reducing risk aversion and the degree of risk (see, for example, Sandmo 1971, Young and Westcott 2000, and Serra *et al.* 2006, 2005). If farmers' preferences are characterized by decreasing absolute risk aversion (DARA), an increase in wealth implies a reduction in the coefficient of absolute risk aversion, causing them to undertake riskier projects, such as planting riskier crops or expanding production by planting

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uncertainty occur when farmers are risk averse and any measure that reduces risk or increases income will have production and consequently trade effects

[15] For thorough reviews of coupling mechanisms and evidence see Bhaskar and Beghin (2007) and Abler and Blandford (2007, 2005).

crops on land that would otherwise be viewed as too risky. This effect can be magnified if payments vary inversely with market prices, thereby reducing income variability. Hennessy (1998) classified these effects as wealth and insurance effects of decoupled payments; while the latter effect would not be expected to apply to PFC payments, they could apply to MLA payments, which explicitly provided assistance in offsetting the effects of market loss. Hennessy's Monte Carlo simulation results suggested that the wealth effects of decoupled programs were likely to be small when compared to the insurance effects of coupled programs. To ensure decoupled payments would not have insurance effects, he suggested payments should not vary with the source of randomness, and preferences would have to be constant absolute aversion for the wealth effect to be absent. Assuming wealth elasticities between 0.087 and 0.270 (taken from Chavas and Holt 1990), Young and Westcott (2000) found that PFC payments increased aggregate acreage for program crops by 0.18 to .57 million acres annually, a maximum increase in acreage of 2 percent over the period of the FAIR Act. The fundamental question, however, involves the extent to which payments actually shift the wealth of farmers. What could be considered as a large payment may not be so substantial when compared against a farmer's overall wealth, which tends to be quite large for the average U.S. farmer (Goodwin and Mishra 2006, Just 2006). For example, Goodwin and Mishra (2006) reported that AMTA payments over the 1998-2001 period averaged 1.8 percent of the typical farm's overall net worth. In general, because the necessary amounts of transfers to bring about significant production changes in the presence of risk aversion is quite large, this body of literature is met with skepticism.

Labor choices are also potentially affected by decoupled payments because of the wealth effects they bring about, which takes them away from production and into more leisurely activities, and because of their influence on the on- and off-farm labor supply decisions. The latter effect could be critical to the financial well-being of the farm household given the importance of off-farm income in total income (in 1998, off-farm income was six times that of cash farm income) and given that the majority of workers on U.S. farms are the operators and their families, who contribute at least two-thirds of the labor hours worked (Ahearn *et al.* 2006). Using farm household data for the years 1996-99, these authors found

that PFC, MLA, and loan deficiency payments, individually and in aggregate, reduced the farmers' likelihood to work off the farm. Empirical studies overall report a less than 5 percent impact of decoupled payments on off-farm work (Abler and Blandford 2007, 2005).

Another source of coupling effects comes through expectations about future revisions to the policy, namely expectations about rebasing. To the extent that farmers expect current production to determine future program benefits, their decisions may be altered by the policy, even when such policy is bestowed via decoupled payments. Consider, for example, the extension of AMTA payments for another six years provided by the 2002 Farm Bill and the opportunity it gave farmers to update base acreages and yields and include historical soybean acreage in this base.[16] This extension in payments led to issues of time consistency and credibility of agricultural policies as described by Kydland and Prescott, with farmers anticipating future base revisions and increasing current acreage so as to take advantage of this expected revision, however unexpected by current policy stance. Young *et al.* (2005) found that farmers exploited the opportunity to update base acres and payment yields. Their results indicated that farmland owners with high-payment base acres, such as rice and cotton, held on to these base acres and expanded them whenever possible, while farmland owners with low-payment commodity base acres, such as oats and barley, switched to higher payment commodities whenever possible. But since some farmers may have been unable to respond immediately due to credit constraints, their results may actually have underestimated the credibility problem. Goodwin and Mishra (2006) also observed that farmers may have anticipated the opportunity to update program parameters such as yield and base, and may not have wanted to move to nontraditional crops or to idling land because they would not want to lose the opportunity to secure an updated base. Finally, note how as market conditions changed, the government's discretion to change the criteria and payments made

[16] The 2002 Farm Bill gave farmers one of two options for base acres for all covered commodities enrolled for the farm, including oilseeds. The first option was to update base acres to reflect the four-year average of planted acres plus "prevented from planting" (land on which a farmer intended to plant a program crop or insurable crop but was unable to do so because of drought, flood, or other natural disaster) for the commodity during 1998-2001. The second option was to use the 2002 PFC contract acres as the new base for wheat, feed grains, cotton, and rice and add oilseed bases using four-year average of planted acreage plus "prevented from planting" for individual oilseeds during 1998-2001. In general, oilseed base acres could not exceed the difference between total acreage for covered crops for the crop year and sum of 2002 contract acreage.

them unable to make a binding commitment over time (Baffes and De Gorter 2003). For example, by 1998 AMTA payments had nearly doubled because of emergency assistance payments, sending farmers mixed signals about the extent of decoupling.

Decoupled payments also have the potential to distort markets by affecting farm business survival. Farms receiving high payments per acre could bid up prices of fixed resources, like land, causing low payment per-acre farms to shrink or exit. Payments could effectively raise a farm's net worth, thereby making it less costly to obtain financing when liquidity constraints caused the cost of capital to depend on net worth. If large farms were liquidity constrained and small farms were not, an increase in payment per acre could cause large farms to expand and increase in number, bidding up land prices and causing small farms to shrink and decline in number. Finally, greater payments could make agriculture more profitable relative to other occupations, reducing the incentive to exit farming. Controlling for farm sales, farm type, age, race, gender, and primary occupation of the operator, and the organizational structure of the farm business, Key and Roberts (2006) compared the estimated life of a farm business for different levels of government payments. They found that a 50 percent reduction in payments shortened the life span of farms, and more so for large farms (by 5.4 percent, from 14.25 to 13.48 years, compared to the 1.71 percent reduction from 8.83 to 8.68 years for small farms). While this positive relation between scale and effect was expected, since farm income represents a larger share of total farm household income for larger farms, their conclusion was that past agricultural support payments have contributed disproportionately to the survival of large operations. A similar result was reported by Ahearn *et al.* (2005), who found that government payments had a significant positive impact on the share of farms with more than 1,000 acres. This result supported the authors' hypothesis that farmers may use payments to buy the land of a small neighbor and increase in scale.

By influencing farm business survival, decoupled payments can also affect farm consolidation, *i.e.*, the number of small or family farms relative to large, commercial farms. There is some disagreement in the literature about the direction of this effect. Westcott and Young (2002) suggested two hypotheses regarding the way decoupled payments may affect

farm consolidation. The first hypothesis said decoupled payments inhibit sector consolidation if the payments allow small and less efficient firms to remain in production, as government transfers cover short run variable costs associated with the normal decisions to produce. Second, decoupled payments can help these firms by providing a low cost source of funds, or by relieving them of credit constraints they are usually subject to, as they are not able to provide many guarantees in the form of collateral. In contrast, Ahearn *et al.* (2005) and Key and Roberts (2006) suggested that decoupled payments may accelerate sector consolidation because larger firms may use the government transfers to buy out smaller firms, or to rent more land. According to Burfisher and Hopkins (2004), the effects of decoupled payments are expected to only slightly affect consolidation, subject to trends already under way.

Finally, empirical work suggests decoupled payments have their greatest impact on land values and rental rates (Bhaskar and Beghin 2007, Abler and Blandford 2007, 2005). Because they are based on historical (base) acres, decoupled payments are capitalized into the value of land and passed-through to landowners via higher land rents and land values, many of whom not the actual operators of the land. For example, the 2003 Report of the Commission on the Application of Payment Limitations for Agriculture asserted that total government payments in recent years increased U.S. farmland values by 15 to 25 percent. The report also indicated that about 41 percent of all farmland was rented out by landowners who did not operate the farms themselves, even though they might share the risk of production through crop share rental agreements. Goodwin *et al.* (2004) showed that substantial benefits from agricultural policy were captured by landowners through higher land values and higher lease rates, at the expense of tenants, whom in principle the policies are aimed at helping. Moreover, they found that programs with strong insurance objectives, such as price support payments, significantly affected the gap between cash and share lease rates, with the share rate premium decreasing with programs that lowered the risk associated with uncertain farm earnings. Roe *et al.* (2002) and Burfisher and Hopkins (2003) reported similar conclusions. In general, the magnitude of the impact varies across studies, with the increase in cash rents per dollar of decoupled payments ranging from 0.34 to 0.85 dollars (Abler and Blandford 2007, 2005). Further note that the increase in land values provides

additional incentives to retain land in agriculture. Finally, for farmers who own land, this increase in land values represents an improvement on their collateral, and so on their credit worthiness. This effect should be particularly important for the credit constrained farmers.

The preceding section reveals the difficulty in disentangling the relative importance of different distortionary effects of decoupled payments. The presence of credit constraints was mentioned in some of these mechanisms. We now proceed to review the effects of decoupled payments in the presence of credit constraints in more depth.

2.5. Credit constraints and decoupled payments

2.5.1. Credit constraints in agriculture

The theoretical foundations of credit constraints are mainly found in contemporary contract theory, where informational asymmetries between borrowers and lenders lead to unresolved problems of adverse selection, moral hazard, or costly state verification. Incentive compatibility problems arise, which in turn create capital market imperfections that make external financing more costly than internal financing.

Stiglitz and Weiss (1981) defined credit rationing[17] as those circumstances in which either among observationally identical loan applicants some receive a loan and others do not, and the rejected applicants would not receive a loan even if they offered to pay a higher interest rate, or there are identifiable groups of individuals in the population who, with a given supply of credit, are unable to obtain loans at any interest rate, but would at a greater supply of credit. More broadly, credit rationing appears when agents demonstrate an excess demand for credit so that they face a binding supply constraint. The probability of the constraint being binding decreases with the increasing availability of signaling and/or screening devices to overcome the above mentioned information asymmetries, such as

[17] We use the terms “credit constraint” and “credit rationing” interchangeably.

availability of collateral, individual characteristics and skills of the borrower, and a positive credit history, along with the expected performance and risk exposure of the credit-funded project.

Farms are especially vulnerable to credit constraints because (a) there is a substantial lag between the purchase of inputs and the sale of outputs; (b) farms are highly capital intensive relative to their levels of sales and cash flow; (c) farmers' assets are undiversified and inflexible – held almost exclusively in farm-specific capital, especially land; (d) the direct link between private wealth and farm capital limits the possibilities for providing collateral; (e) debt is important as a source of investment funds to a lack of well developed equity markets, and (f) most farms are relatively small (Blancard *et al.* 2006 and Bierlen *et al.* 1998).

The conventional form of credit constraints, and the most cited in the literature, is through "quantity rationing", when farmers are denied access to credit. Other forms include "transaction cost rationing", when farmers may have access to credit but do not apply because of high transaction costs associated with loan application, and "risk rationing", when lenders require farmers to bear some contractual risk and so provide some form of collateral (Guirkinger and Boucher 2006). In the latter case, some risk averse individuals may be reluctant to assume the risk in spite of the increase in expected income the loan may provide. All these forms of credit constraints break the separability between endowments and resource allocation, and imply that agents facing a binding constraint will under-invest relative to those unconstrained in the credit market.

2.5.2. Studies of credit constraints in agriculture

This section reviews the empirical evidence on the importance of credit constraints in the farm sector and the effects of decoupled payments in the presence of credit constraints. The remainder of this section synthesizes the results of key papers, organized as follows. Bierlen and Featherstone (1998) and Barry *et al.* (2000) provide evidence of credit constraints in agriculture. Then, Roe *et al.* (2002) and Goodwin and Mishra (2006) study the impact of

decoupled payments in the presence of credit constraints.

Using farm-level data from Kansas for the years 1976 through 1992, Bierlen and Featherstone (1998) tested whether investment in farm machinery was subject to credit constraints. They preferred machinery investment to whole-farm investment because machinery was largely operator owned, and credit constrained farmers who wished to acquire the use of additional land could do so through leasing. The authors divided their sample into three time periods based on the farm business cycle (1976-80 boom, 1981-86 bust, and 1987-92 recovery), and within each time period divided the sample into several classes depending on assets, farm debt-to-asset ratio, and operator age. They expected the following. First, farms with higher asset levels to have better access to credit because larger farms have more collateral to offer potential lenders, and lower per unit monitoring and processing costs are associated with large loans. Second, lenders to be less averse to lend to farms with lower debt to asset ratios because of better collateral and lower risk of default. Third, older operators to have longer standing relations with lenders and better financial variables. Debt level was found to be the strongest determinant of credit constraints, and more so for more in debt farms, while asset size and age were less important: during the bust and recovery periods, among farms with a high debt to asset ratio, an additional dollar of cash flow led to an estimated 0.1 to 0.2 dollars in additional investment, whereas among farms with a low debt to asset ratio, an additional dollar of cash flow led to an estimated 0.04 to 0.05 dollars in additional investment.

Barry *et al.* (2000) used farm-level data from Illinois for 1990 through 1994 to test the applicability of the pecking order theory of firm investment to farm businesses. This theory recognizes that the cost of debt capital may exceed the cost of internal funds because of lenders' efforts to resolve asymmetric information problems and misaligned incentives. When the lenders' cost of screening, monitoring, and other agency costs associated with adverse selection and moral hazard are passed on to borrowers, firms may first prefer to use lower cost internal funds, followed by higher cost external funds. The authors believed the same should apply to farms because they are typically small in size, capital intensive, risky, and make extensive use of debt capital and leasing of farm real estate while utilizing little, if

any, outside equity capital, and they are also subject to periodic episodes of financial stress. Specifically, they tested whether farmers preferred internal funds and the leasing of farm real estate over debt-financed purchases of farm land. They claimed that the liquidity features of leasing land were favorable to farmers, and share leases constituted effective risk management tools. In addition, informational asymmetries and agency problems could be less severe than those between farmers and agricultural lenders. Their results supported the pecking order theory, as strong cash flows led farms to expand through leasing land and other investment expenditures while paying down debts or refraining from borrowing. In their sample of 590 farms, an additional dollar of cash flow led to approximately $0.638 in additional investment. When the authors split their sample according to credit scores, between high credit risk (more credit constrained) and low credit-risk (less credit constrained) farms, they found that an additional dollar of cash flow led to approximately $0.531 in additional investment for low credit risk farms, and to approximately $0.658 for high credit risk farms.

The results from Bierlen and Featherstone (1998) and Barry *et al.* (2000) support the view that credit constraints are pervasive among farm businesses, and are more severe among high credit risk farms. We can now ask ourselves what proportion of farms that receive decoupled payments fall into each credit risk class. Drawing on household ARMS data, Burfisher and Hopkins (2003) reported that, in 2001, of those farms that received PFC payments, about 60 percent of the farms held debt that represented less than 40 percent of their debt repayment capacity, while only about one-fifth carried debt representing 80 percent or more of their capacity. However, because their measure did not include non-farm sources of income or assets, it is likely to be a low estimate of debt capacity.

Roe *et al.* (2002) used an economy-wide approach to assess the effect of decoupled payments on resource allocation and production. This approach was deemed necessary because the market effects of those taxed to provide the transfer might offset the market effects of the recipients, thereby leaving resource allocation and production at the market level unaffected. Their results were based on two versions of an intertemporal three-sector general equilibrium model of the US economy that differed on the assumption regarding

capital markets. The first version assumed capital markets for agriculture and the rest of the economy were perfectly integrated, and any differences in short run rates of return to capital and land were instantly arbitraged to zero. The second version assumed capital markets were segmented, and the arbitrage condition only held in the long run. PFC payments were incorporated into the model as a lump-sum transfer from urban households to the rural households, and were paid in each period of time from 1997 in perpetuity. The benchmark was defined as the situation without PFC payments. With perfectly integrated capital markets, only land values changed, exceeding the benchmark in almost 9 percent in the short run, and about 8.3 percent in the long run. This increase, along with the payments themselves, rose spending on consumption goods, which were about 0.8 percent higher than in the benchmark. The authors also noted that the rise in household asset holdings should increase access to credit, so that PFC payments could not be decoupled after all. When capital markets were segmented, the value of land rose by over 10 percent relative to the benchmark in the short run, exceeding the value of land when markets were perfectly arbitraged by about 1 point in the short run. This was explained by the behavior of the rental rate of capital in agriculture, which declined by about 0.1 percent in the first ten years as compared to the benchmark, and slowly converged to that of the rest of the economy. Decoupled payments caused the rental rate of capital to decline because, in the short run, farmers allocated a relatively larger proportion of their payments to investment in agricultural capital. This caused more labor hours to be allocated to production relative to the base as well, although the capital to labor ratio rose, revealing the increase in the substitution of capital for labor relative to the base. Production increased by about 0.18 percent relative to the benchmark. As additional capital investment led to diminishing returns, farmers saved less and spent a larger share of the payments on final goods. Despite the fact that payments were made into the indefinite future, there were no long run effects on the level of capital stock in agriculture, capital to labor ratio, or production. Land values and rental rates nevertheless increased.

Goodwin and Mishra (2006) used both farm-level data from USDA's ARMS and aggregate county-level data to evaluate the effects of decoupled payments on acreage

allocation decisions, on acreage idling decisions of producers, and on the acquisition of new owned land. They considered acreage devoted to corn, soybeans and wheat, the principal three crops grown in the Corn Belt region, for 1998 through 2001. Their overall results revealed that decoupled payments had only modest effects on acreage, a fact the authors took to be not surprising given that payments, although large and decoupled, represented relatively small changes in the overall wealth of the average Corn Belt farm. Following their three-fold goal, the empirical analysis was conducted in three segments. The first segment involved estimating acreage response equations for individual farms for corn, soybeans and wheat. The authors allowed AMTA payments to influence acres directly and by including interaction effects with insurance and leverage (debt to asset ratio). While the interaction terms were not statistically significant, AMTA payments had very small but statistically significant acreage responses for corn and soybeans. The marginal effect of one dollar per acre of AMTA payments increased acreage by 0.92 acres in the case of corn and by 0.61 acres in the case of soybeans, with corresponding elasticities of 0.0317 and 0.0204, respectively. Acreage effects for wheat were of 0.36 acres or 0.0428 in elasticity terms, but not significant. The second segment of their analysis involved measuring the extent to which farmland was placed in alternative practices other than crop production, such as conservation reserves, pasture, forest, set-asides, fallow, and other idling practices. In general, the results revealed that decoupled payments led to less idling of land, which could result in more land being in production. Finally, the third segment of the analysis involved estimating a probit model of the decision to acquire new land.[18] Results revealed decoupled payments could lead to more land ownership transactions, though the effect was not significant for the average farm in the sample, and was very small even for farms without insurance or debt, suggesting a general lack of capital constraints that could thwart the acquisition of land.

A limitation of the Goodwin and Mishra analysis stemmed from the use of ARMS data, which does not contain observations on individual farms over time. This made it difficult to account for historical values of key variables and complicated the identification of

[18] The authors noted that for every agent buying land, another was selling, so that it was not clear whether such transactions led to more production.

causal effects of policy variables. The authors noted, for example, that because AMTA payments depend on historical values, it was possible that farms that planted a large number of acres to program crops after the FAIR Act also had significant acreage in program crops before the Act was enacted, and so were receiving large AMTA payments. Hence, a large acreage of program crops would be correlated with large payments, although the payments did not necessarily cause producers to plant those crops. The use of county-level data allowed this problem to be mitigated, although it did not include the basic measures of risk aversion, financial leverage, and wealth. The results of using county-level data were analogous to those using farm-level data, as AMTA payments appeared to have positive albeit small effects on soybean acres, and insignificant effects for corn and wheat. An additional dollar per acre of AMTA payments was shown to increase soybean acres by 168 acres, implying an elasticity of 0.018. In the case of MLA payments, a significant relationship with acreage was implied for corn and soybeans, where an additional dollar per acre of MLA payments raised county acreages by 225 and 118 acres, respectively, representing area elasticities of less than 0.01 in either crop.

2.6. Conclusions

This chapter revealed the potential for decoupled payments to fall short of their aim of supporting farm income without distorting production. Several mechanisms that may connect them to market conditions were discussed, and the difficulty in disentangling their relative importance was pointed out. These mechanisms include, for example, general wealth effects and their impact on farmers' risk aversion or labor choices, credit constraints, and expectations about future revisions of policy. And while several empirical studies suggest the production effects of decoupled payments are pervasive, they are very small in magnitude, with the exception of their impact on land values.

One mechanism of interest in this dissertation involves the presence of credit constraints. Farms are likely to be subject to credit constraints because of the lag between the

purchase of inputs and sale of output, the inflexibility of farm-specific capital, the limited possibility for providing collateral caused by the direct link between private capital and farm capital, and the size of the farm, among others. For the credit constrained farmer, decoupled payments may affect production through their direct impact on the farmer's liquidity, or through their impact on the collateral of the farmer, who is then able to borrow under better conditions or lower costs. This indirect effect is enhanced if the farmer owns land.

The literature review also exposed the main drawback in some of the studies that attempt to estimate the marginal effects of decoupled payments on production decisions, which is the use of survey data. These data typically do not contain observations on individual farms over time (for example, Goodwin and Mishra 2006, and Key *et al.* 2004). The use of survey data, as pointed out by Goodwin and Mishra (2006), makes it difficult to account for historical values of key variables and complicates the identification of causal effects of policy variables.

We now move on to estimate the acreage and consumption expenditures effects of AMTA payments for a panel of KFMA farms.

Chapter 3

Do AMTA payments affect farmers' choices?

3.1. Introduction

The creation of PFC payments by the 1996 Farm Bill reflected an attempt to separate agricultural payments from current market conditions. Even the emergency *ad hoc* MLA payments, created because of unfavorable prices, and in place for the last four years of the bill, were based on past production. Since payments were based on historical acres and yields, there was no connection to current production, prices or resource use, so they were expected not to distort production or trade patterns. But the literature has identified several potential coupling mechanisms of decoupled payments. They can appear through wealth effects and their impact on risk aversion and labor choices, through expectations about futures revisions of policy, and through credit constraints in imperfect capital markets. We focus our attention on the latter mechanism.

Right at the outset, government payments, decoupled or not, may increase the liquidity of a credit-constrained farmer, thereby allowing investment in production to take place. If farmers are credit-constrained and would like to expand production but are unable to obtain the funding to do so, the payments may allow them to invest in the farm and expand or otherwise alter production. Second, the informational asymmetries that characterize credit markets and cause external borrowing to be more expensive than internal borrowing can be

partly overcome by agricultural support policies. This may happen in two ways. First, these subsidies may provide an additional guarantee to lenders that loans will be repaid in the end of the lending period. Second, empirical studies suggest that decoupled payments are capitalized into land values, thus improving the credit-worthiness of farmers when they own land. Implicit in this logic is the assumption that farmers with better credit-worthiness are less credit-constrained, as they can provide better collateral in case they default on the loan.

When surveyed about their allocation of decoupled payments across different farm and household issues in the 2003 ARMS survey, the typical farm reported they would allocate 67.9 percent to farm uses while only 32.1 percent would go to household issues (Goodwin and Mishra 2005). Interestingly, the farmers in the sample not receiving payments responded that 85.2 percent of decoupled payments receipts would be directed towards farm uses, a higher percentage than those that did. This would seem to indicate that decoupled payments would be expected to have significant production effects. But when asked to rate the importance of ten different factors in determining their acreage decisions in particular, 49.9 percent of farmers replied that decoupled payments were unimportant or not at all important to their acreage allocations. As to the specific allocation of decoupled payments into farm and non-farm uses, the farmers replied that the largest share of payments would go into farm operating costs (34.02 percent), followed by spending on capital expenditures (14.10 percent) and to pay down farm debt (10.19 percent). A very small percentage of decoupled payments would be used to buy or rent farmland (9.55 percent). This could explain the traditionally modest effects of decoupled payments in acreage decisions found in the literature. At the same time, the finding that the biggest share of decoupled payments would be directed to farm uses would seem to suggest that decoupled payments are not being put to their intended use, which is to provide income support to farm households.

The goal of our analysis is two-fold. First, we explore how AMTA payments affect acreage decisions in the presence of imperfect capital markets. In doing so we revisit the impact of decoupled payments on farmers' acreage decisions in the presence of credit constraints and observe whether the magnitude of the impact depends on the degree to which farmers are credit-constrained. Our hypothesis is that farmers who are more credit-

constrained will exhibit greater acreage responses to decoupled payments. The intuition underlying this hypothesis is that farmers who exhibit greater credit-worthiness should, in principle, have easier access to outside funds to implement their investment plans and more flexibility to react to short-term price shocks. For these farmers, government payments should play a lesser role in investment decisions. All else constant, the acreage effects of decoupled payments should be greater the more credit-constrained the farmers. This result was found by Goodwin and Mishra (2005) using household survey data, where more highly leveraged farmers were more likely to allocate decoupled payments toward on-farm uses. Our approach resembles Goodwin and Mishra (2006) while improving on its major shortcoming: the lack of observations on individual farms over time. This implied a major reliance on cross-sectional variability. Our use of the farm-level records from the KFMA allows us to observe farms over time and account for time-constant sources of unobserved heterogeneity and so improve on earlier studies.

Our second goal is to, in an effort to analyze the income-stabilization goal of AMTA payments, explore how AMTA payments affect farmers' marginal consumption patterns. Underlying this analysis is the idea that AMTA payments should be used to increase the well-being of farm households, namely consumption expenditures. If in reality these payments are being put to their intended use, we should be able to observe a positive association between these transfers and farmers' living expenditures.

We implement the empirical analysis using three different econometric approaches. We begin with pooled ordinary least squares (OLS) and then move on to exploit the fact that we can observe the same farm over time and implement a fixed effects (FE) estimator to purge the time-constant omitted variables.[19] We compare these results with those obtained from using the OLS estimator. Due to the possibility of endogenous regressors we further use a Generalized Method of Moments (GMM) estimator to analyze the impact of AMTA payments on farmer's choices.

[19] Because of the voluntary nature of participation in the association, not all farms are observed in every year, so we have an unbalanced panel of farms. This lead us to discard the use of a first differences estimator to purge the time-constant omitted variables since it causes the loss of any observation without an immediate lag, thereby exacerbating gaps in the data.

The remainder of this section is organized as follows. The second section presents the empirical framework and data used in our assessment of how AMTA payments affect acreage decisions in the presence of imperfect capital markets. Within this section we study the impact of AMTA payments on total (owned and rented) acres planted and then analyze how AMTA payments affected the decisions of owning crop acres. In addition, we look at how these payments affected crop-specific acreage choices, namely those of corn, sorghum, soybeans and wheat, Kansas' four main crops. In a second step we analyze the effects of AMTA payments on pasture acres. The third section analyzes the effects of AMTA payments on farmers' consumption expenditures. Some concluding remarks are finally presented.

3.2. AMTA payments, acres, and credit constraints

The first segment of our empirical analysis considers crop acreage response equations. Our goal is to analyze how AMTA payments affect acreage decisions in the presence of imperfect capital markets, and to observe whether farmers who are more credit-constrained exhibit greater acreage responses to these payments. We begin by discussing the data used in this segment and then move on to assessing the impact of AMTA payments on total (owned and rented) acres. This is followed by the assessment of how AMTA payments affect the decisions of owning crop acres. We then look at how these payments impacted the corn, sorghum, soybeans and wheat acreage decisions. We finish the segment by evaluating the effects of AMTA payments on pasture acres. The data are now presented.

3.2.1. Data

We use KFMA farm-level records for 1996 through 2001, the period during which the FAIR Act was in place, along with previous years of data for these farms to define some lagged variables in the analysis. These data are supplemented with more highly-aggregate data from a variety of sources. County-level yields come from USDA's National Agricultural Statistics

Service (NASS). Country-level rates for PFC and MLA payments (AMTA payments), and county-level LDP rates come from unpublished USDA data.

The voluntary nature of participation in the KFMA association implies that not all farms are observed in every year. In order to maximize sample size, we work on the full (unbalanced) panel and only exclude a small number of outlying observations, according to the following criteria. Like Goodwin and Mishra (2006) we drop farms with less than 50 acres of total operated land from our sample. For reasons that will become clear shortly, we also drop farms for which we could not observe planted acres of corn, sorghum, or wheat, in any of the years 1986 through 1988. These crops are aggregated across all practices. Hence, the data constitute an unbalanced panel containing 6,797 observations, or an average of over 1,000 farms per year. Of these, between 712 and 807 farms per year grow dryland crops (an average of about 67.43 percent).

Our sample contains 94 to 96 counties out of the 105 counties in Kansas. The most represented county is Marion county (North Central Kansas), with 275 observations (an average of 46 farms per year), followed by Rice county (South Central Kansas), with 225 observations (an average of 38 farms per year) and by Butler county (Southeast Kansas), with 179 observations (an average of 30 farms per year); all other counties have an average of less than 29 observations per year. Most farms are located in Southeast, South Central, and Northeast Kansas, with 27.29 percent, 18.88 percent and 18.85 percent of total observations, respectively.

The KFMA collects information on the total amount of government payments the farms receive, which include PFC payments, MLA payments, Conservation Reserve Program payments, Oilseed payments, Loan Deficiency Payments, and Marketing Loan payments. Because only a single aggregate figure is reported, we estimate the amount of AMTA payments received by the farms as follows. For the years in the sample, estimated AMTA payments include PFC payments and MLA payments for corn, sorghum and wheat. Recall the 1996 Farm bill allocated PFC payments to farms based on their payment quantity of the contract commodity (the product of the farm's program payment yield for that commodity, times 85 percent of the contract acreage, or base acres). The annual payment rate for a

contract commodity was then multiplied by each farm's payment quantity for that commodity. So, PFC payments for farmer j's ith commodity $\left(PFC_{ijt}\right)$ are given by $PFC_{ijt} = 0.85 \times bacres_{ij} \times byield_{ij} \times PFCrate_{it}$, where $bacres_{ij}$ is farmer j's contract acreage of the ith commodity, $byield_{ij}$ is farmer j's payment yield of that commodity, and $PFCrate_{it}$ is the annual national payment rate for the commodity. The sum of these payments across contract commodities is the farm's annual payment. MLA payments were made to recipients of PFC payments according to the same formulae used to calculate PFC payments (but with different payment rates). We follow Serra *et al.* (2006) in approximating payment yields and contract acreage by the 1986-88 average yields and acres. Total estimated AMTA payments are then obtained by summing over the expected PFC and MLA payments. When this total exceeds the reported government payments in the KFMA data, the inconsistent estimate is replaced by total reported payments. This happens to about 21 percent of the observations.[20]

Table 3.1 summarizes the yearly per farm average of total government payments and AMTA payments received by the KFMA farms in our sample (standard deviations are presented in parentheses). We also report state and U.S. expenditures on PFC and government payments obtained from USDA. Because USDA does not distinguish between the several types of *ad hoc* support, expenditures on MLA payments are not reported. Note in addition that because our sample is unbalanced, we do not report the sum of either AMTA or total payments received by KFMA farms. Nevertheless, we can analyze the evolution of country and state totals, and compare them to that of the KFMA farms.

In 1996, the state of Kansas received about 7.56 percent of the country's spending on farm support, a number which decreased by 2.80 percentage points over the duration of the FAIR Act. The state's share of PFC payments started at 8.38 percent, and decreased to 7.23 percent in 2001, while reaching a minimum of 6.62 percent in 1997. The KFMA farm payments followed the tendency of the state of Kansas, with total government payments to

[20] Serra *et al.* (2006) reported a statistic of 7 percent. Nevertheless they use data from 1998 through 2001 and on a balanced of 596 farms. If we drop 1996 and 1997 data from our sample this number decreases to 16 percent. This number drops to 14 percent for our panel of 831 farms.

KFMA farms decreasing by about 6.37 percent from 1996 to 1997, versus the state's 4.47 percent decrease, and increasing by 87.22 and 67.95 percent in the following years, versus the 70.35 and 57.87 percent increase for the state. The last years of the FAIR Act showed another decrease in total payments for the KFMA farms, by 10.56 and 7.97 percent, versus the 16.72 and 14.35 percent decrease verified in the state. The increase in payments in the 1997-1999 period coincided with the average 71.5 percent increase in U.S. government payments, as did the 5 percent decrease in the last part of the FAIR Act. The levels of PFC payments decreased over the period, for the country and state of Kansas, as predefined in the beginning of the FAIR act, although total government spending nearly doubled for the state and nearly tripled for the country.

Table 3.1. Average government payments by KFMA farms and state and country totals

	1996	1997	1998	1999	2000	2001
KFMA average ($1,000)						
Total payments	18.14	16.98	31.80	53.40	47.76	43.96
	(15.12)	(13.83)	(30)	(46.16)	(41.81)	(38.19)
AMTA payments (PFC+MLA)	11.52	12.41	18.89	25.29	22.63	18.56
	(9.62)	(10.42)	(16.11)	(20.94)	(18.83)	(15.19)
PFC payments	11.52	12.41	12.62	12.64	10.85	8.68
	(9.62)	(10.42)	(10.76)	(10.47)	(9.03)	(7.1)
MLA payments	-	-	6.28	12.64	11.78	9.88
	-	-	(5.35)	(10.47)	(9.8)	(8.09)
Number of farms	1249	1229	1151	1122	1053	993
United States ($1,000,000)						
Total payments	7,626.94	7,794.87	13,206.01	22,747.34	23,221.57	22,180.52
PFC payments	6,206.87	6,364.41	6,400.94	5,335.16	5,048.84	3,995.29
Kansas ($1,000,000)						
Total payments	576.72	550.96	938.56	1,481.68	1,233.89	1,056.87
PFC payments	520.40	421.05	431.77	377.50	361.75	289.01

Note: Standard deviations in parentheses.

Overall, the evolution of average PFC payments per farm for the farms in the KFMA follows that of total PFC in the U.S. and the state of Kansas. In relative terms, the share of PFC payments in total payments for KFMA farms is slightly below that for the state and country in the first three years of the FAIR Act, and between the state's and country's shares

for the remaining years. In absolute terms, the three main differences occur in the following periods. First, contrary to what happened in Kansas, total U.S. PFC payments and average KFMA farms PFC payments increased from 1996 to 1997. Second, from 1998 to 1999, there is a big disparity between the KFMA estimated average PFC payments and the state and country total payments, where KFMA PFC payments increased by about 0.21 percent while U.S. and Kansas payments decreased by 12.57 and 16.65 percent, respectively. Given that PFC payment rates for corn, sorghum, and wheat decreased in that period, we attribute part of this disparity to differences in the farms selected for those years. Indeed, for the farms in our balanced panel, average PFC payments decreased by 1.26 percent. Third, from 1999 to 2000, KFMA farms' PFC payments decreased by 14.18 percent, while the state and national changes varied between 4.17 and 5.37 percent.[21] But from 2000 to 2001 KFMA farms' PFC payments followed the tendency of total U.S. and state payments, decreasing by 20.03 percent while the state and national payments decreased by 20.11 and 20.87 percent, respectively. Finally, average AMTA payments had a 87.22 percent increase from 1997 to 1998, largely motivated by the *ad hoc* market assistance payments distributed. From 1999 onward this number decreased, as both PFC and MLA payment rates decreased over the latter years of the FAIR Act.

Our measure of wealth is obtained by subtracting total debts from self-assessed total assets. Assets include current assets, breeding livestock value, non-current accounts receivable, machinery and equipment, buildings, and owned land value. Total debts include current, intermediate, and long term loans. In order to prevent double counting of AMTA payments, we subtract AMTA payment receipts from our measure of wealth, as in Goodwin and Mishra (2006). The degree to which farms are constrained by credit is given by the debt to asset ratio, calculated by dividing total liabilities by total assets.

Expected yields are calculated by assuming each farmer compares the historical yield

[21] While we acknowledge that a portion of these discrepancies might stem from the methodology we use to estimate PFC payments (it is possible that farmers added or subtracted base acres over time, by buying or selling land enrolled in the program, which could cause variations in PFC payments other than those brought about changing rates), we hypothesize they can also be attributed to differences in the accounting reference date (KFMA data use primarily the calendar year).

performance of the farm with that of the county where the farm is located, and uses this relative performance as an adjustment factor to correct expected county yields. The expected yield of the ith crop for farm j located in county c in year t is defined as $EY_{ijt} = \beta_{jt} EY_{ict}$, where EY_{ict} is county c's expected yield and $\beta_{jt} = \frac{1}{3}\sum_{s=1}^{3} \frac{Y_{ijt-s}}{Y_{ict-s}}$ is the performance adjusting factor, measuring the farm's historical performance relative to the county. Expected county yields are the predicted values obtained by regressing yearly county yields on a quadratic trend. The squared time term was not statistically significant for wheat and thus was omitted. Table 3.2 summarizes the variables used in this segment.

The average farm in our sample operated about 1,789 acres, 1,150 acres of those as crop acres. These 69.26 percent of acres devoted to crops by the KFMA farms are similar to the share of cropland reported in the 1997 and 2002 Censuses of Agriculture for the state of Kansas, which varied between 66.6 percent and 62.6 percent, respectively. Following the U.S.'s and state of Kansas tenure tendency, most of those acres were rented, with the share of rented acres on total acres varying between 50.37 percent and 59.96 percent for pasture and crop acres, respectively. These numbers are very close to the 61.61 percent share of rented acres reported in the 1997 Census of Agriculture for Kansas, a number which fell by 0.88 percentage points in the 2002 Census. The share of rented acres in the U.S. is slightly smaller, around 53.47 percent and 53.90 percent in the 1997 and 2002 Censuses, respectively. This tendency for renting is revealed at the crop level as well, where rented acres vary between 56.55 percent and 63.76 percent for corn and sorghum, respectively

The four major crops in Kansas are wheat, corn, sorghum, and soybeans; according to USDA data, in 2007, these crops occupied 18.22 percent, 8.26 percent, 5.93 percent and 5.51 percent of the state's total land in farms, respectively. During the FAIR Act period these numbers averaged 22.30 percent, 6.43 percent, 5.23 percent and 3.61 percent, respectively. The KFMA farms followed this tendency, although average acres devoted to growing soybeans was larger than those devoted to sorghum, and corn was the least grown crop. These four crops occupied an average 79.41 percent of total cropland, with the average farm growing about 381 acres of wheat (31.31 percent of total cropland), 209 acres of soybeans

(20.47 percent), 178 acres of sorghum (16.06 percent), and 149 acres of corn (11.57 percent).

Table 3.2. Summary statistics (nominal variables in $1,000)

Variable	Observations	Mean	Std. Dev.	Min	Max
Number of farms (per year)	6,797	1,132.67	99.11	993	1,249
Total Liabilities	6,797	223.87	274.09	0.00	4,313.30
Wealth	6,797	529.41	523.43	-559.89	5,924.80
Debt to Asset Ratio	6,797	0.3315	0.3220	0.0000	9.2463
Government Payments	6,797	34.42	35.62	0.00	350.37
AMTA payments (PFC+MLA)	6,797	17.95	16.34	0.00	127.32
Production Flexibility Contracts (PFC) Payments	6,797	11.53	9.80	0.00	73.11
Market Loss Assistance (MLA) Payments	6,797	6.42	8.66	0.00	63.66
Operated Acres, Total	6,797	1,789.05	1,342.79	52.00	9,961.00
Operated Acres, Owned	6,797	668.53	764.57	0.00	7,680.00
Operated Acres, Rented	6,797	1,120.47	1,119.77	0.00	8,700.00
Acres of Crops	6,797	1,149.88	872.47	15.00	7,219.00
Acres of Crops, Owned	6,797	401.11	446.03	0.00	5,933.00
Acres of Crops, Rented	6,797	748.66	762.41	0.00	6,066.00
Pasture Acres, Total	6,797	598.92	957.37	0.00	8,860.00
Pasture Acres, Owned	6,797	237.62	488.94	0.00	6,460.00
Pasture Acres, Rented	6,797	361.28	724.40	0.00	7,559.00
Acres of Corn, Total	6,797	148.85	248.30	0.00	2,632.00
Acres of Corn, Owned	6,797	54.31	120.98	0.00	1,425.00
Acres of Corn, Rented	6,797	94.54	192.32	0.00	2,509.00
Acres of Sorghum, Total	6,797	178.04	238.70	0.00	4,488.00
Acres of Sorghum, Owned	6,797	55.92	117.68	0.00	4,409.00
Acres of Sorghum, Rented	6,797	122.13	192.21	0.00	2,249.00
Acres of Soybeans, Total	6,797	209.12	319.32	0.00	3,571.30
Acres of Soybeans, Owned	6,797	69.15	131.34	0.00	1,903.00
Acres of Soybeans, Rented	6,797	139.97	252.43	0.00	3,571.30
Acres of Wheat, Total	6,797	381.02	408.58	0.00	4,200.00
Acres of Wheat, Owned	6,797	119.01	178.99	0.00	2,271.00
Acres of Wheat, Rented	6,797	262.00	353.21	0.00	4,184.00
Estimated Corn Yield (bu/acre)	3,849	105.98	38.34	0.85	218.49
Estimated Sorghum Yield (bu/acre)	6,260	38.82	9.07	1.11	91.75
Estimated Soybeans Yield (bu/acre)	5,531	69.15	20.01	3.03	205.44
Estimated Wheat Yield (bu/acre)	4,675	30.11	11.43	1.08	90.34

The average farm received $34,425 in total government payments, a number ranging from $0 to $350,371 for the full sample; the median farm in our sample received $23,216. Government payments were generally higher per farm in the western areas of Kansas, and declined as one moved east; the North and South western parts of Kansas together received an average of 49.83 percent of total payments. In terms of AMTA payments, the average

farm received $17,952 in estimated AMTA payments, a value which represented about 2.04 percent of the farms' net worth (the median farm received $13,418). The amount of AMTA payments received is somewhat correlated with the size of the farm (total operated acres), as the correlation coefficient between these payments and total operated acres is 0.4140, and even more so with total cropland, as the correlation coefficient between payments and crop acres is 0.6942.

Concerning the financial characteristics of the farms, the average farm had a net worth of $529.411 and $223.867 in debt. The farms between the hinges (the 25 and 75 percentiles) had a net worth varying between $205,745 and $716,004, and the median farm had a net worth of $408,873. The median farm also had about $141,865 in debt, a value which ranged from $44,112 to $305,549 for the farms between the hinges. While the debt to asset ratio of the average farm was 0.3315, the median farm had a ratio of 0.2766, and the farms between the hinges had a ratio that varied between 0.0796 and 0.5098.

3.2.1.1. Evolution of acres in a balanced panel of KFMA farms

We now turn to analyze a balanced panel of 831 farms which are represented in the data for the duration of the FAIR Act. We focus our attention on the evolution of total, owned, and rented acres, in the operated, crop, and pasture categories. We also analyze how government payments and estimated AMTA payments evolved over the period. To have a global perspective on the evolution of KFMA farms' acreage, Table 3.3 reports the yearly averages for operated, crop, and pasture acres, along with their tenure characteristics. Total government payments received and estimated AMTA payments are listed in the last two rows of the table. The last column contains the percent change over the period.

Compared to 1996, average government payments for KFMA farms in 2001 increased by almost 2.4 times. This number was between the 1.83-fold increase in total payments in the state of Kansas, and the 2.9-fold increase in U.S. payments. The 26.45 percent decrease in PFC payments, however, was slightly smaller than that occurred in the state (44.46 percent) and in the U.S. (35.63 percent). This may have been caused by the

previously mentioned drawback in our methodology to estimate these payments.

Table 3.3. Evolution of acres and government payments for selected farms

Acres	1996	1997	1998	1999	2000	2001	% 1996-2001
Operated, Total	1,736	1,752	1,759	1,780	1,788	1,795	3.45
Operated, Owned	601	619	631	644	640	661	10.05
Operated, Rented	1,135	1,133	1,128	1,135	1,149	1,134	-0.05
Pasture, Total	564	567	565	578	587	591	4.80
Pasture, Owned	199	208	212	216	218	228	14.79
Pasture, Rented	365	359	353	363	370	363	-0.64
Crops	1,132	1,146	1,154	1,161	1,161	1,165	2.88
Crops, Owned	374	385	392	399	393	403	7.67
Crops, Rented	758	761	762	762	768	762	0.52
Corn, Total	129	133	150	153	172	176	36.90
Corn, Owned	47	49	53	57	61	61	30.13
Corn, Rented	82	83	96	96	110	115	40.76
Sorghum, Total	208	181	181	176	165	170	-18.18
Sorghum, Owned	62	54	60	61	52	50	-18.08
Sorghum, Rented	146	126	120	116	113	120	-18.21
Soybeans, Total	186	207	227	244	236	240	28.80
Soybeans, Owned	59	67	77	76	79	77	29.98
Soybeans, Rented	127	140	150	168	158	163	28.25
Wheat, Total	404	395	395	345	371	365	-9.79
Wheat, Owned	122	119	121	106	109	115	-6.09
Wheat, Rented	282	276	274	239	263	250	-11.40
Total Government Payments Received ($1,000)	18.05	17.07	32.30	53.89	47.58	43.15	139.04
AMTA payments (PFC+MLA) ($1,000)	11.55	12.59	19.08	25.16	22.36	18.17	57.27
Production Flexibility Contracts Payments ($1,000)	11.55	12.59	12.74	12.58	10.72	8.50	-26.45
Market Loss Assistance Payments ($1,000)	-	-	6.34	12.58	11.64	9.67	-

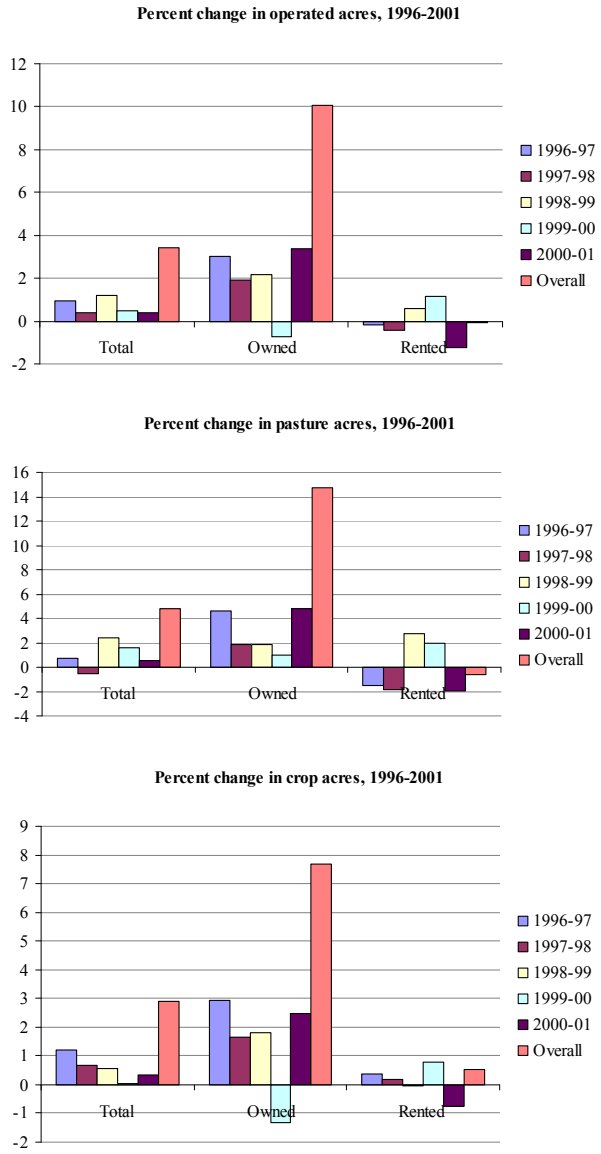
Contrary to what happened in the U.S., where total land in farms decreased by about 1.73 percent, total land in farms in Kansas increased by 1.24 percent. For the balanced panel of KFMA farms, however, total acres operated increased by nearly 3.5 percent. This increase came from owned acres, as rented acres decreased slightly. This tendency to increase farm size by purchasing more land is consistent to that exposed by the 1997 and 2002 Censuses of Agriculture for the U.S. and state of Kansas. From the 1997 to the 2002 Census, the

combined full and part owners' land in farms increased by 0.98 percent and 6.17 percent for the U.S. and Kansas, respectively, while the tenants' land in farms decreased by 22.26 percent and 31.40 percent, respectively. Note, however, that the overall increase in the combined full and part owners' land in U.S. and Kansas farms came mostly through the increase in full owners' land, by 7.50 percent and 60.34 percent, while part owners' land decreased by 3.25 percent and 8.32 percent, respectively. Again, the data appear to suggest that farmers bought more land over the period, and that that land was put into production at the same time as AMTA payments were increasing.

When we look at the evolution of cropland and pastureland, we see that while the KFMA farms did not follow the U.S.'s and Kansas' tendency to decrease cropland (by 2.51 percent and 4.90 percent, respectively), since crop acres increased by 2.88 percent, they did follow the Kansas tendency to increase pastureland (Kansas pasture and rangeland increased by 13.97 percent over the period). As we further disaggregate the data we see that both pasture and crop acres increased, and in both categories the expansion came mostly through owned acres.

Figure 3.1 illustrates the yearly variation in total, owned and rented acres for operated, pasture and crop acres. The graphs help illustrate how most of the increase in operated, pasture, and crop acres occurred through owned acres, and the tendency for owned and rented acres to have opposing variations for a given year. In most periods, the variation in owned acres was greater than that of rented acres. What is most striking, however, is the tendency for opposite changes in owned and rented acres to occur: the growth rates of both categories in rented acres were higher in those years when growth rates in owned acres were the lowest. For example, from 1999 to 2000, rented crop acres had their greatest increase, of 0.78 percent, while owned crop acres decreased for the single time, by 1.34 percent. For pasture acres, rented acres increased the most when owned acres increased the least, from 1998 to 2000.

Figure 3.1. Evolution of operated, pasture, and crop acres, by tenure, for selected farms



We now take a look at the evolution of acres for corn, sorghum, wheat and soybeans. Table 3.4 reports the share of each crop in total, owned and rented crop acres. Following the pattern of Kansas, for the KFMA farms these four crops accounted for between 79.11 percent and 82.53 percent of total crop acres each year. As in the full sample and the state of Kansas, the data on individual crops for the balanced panel reveal a shift from planting sorghum and wheat to planting corn and soybeans. Overall, we see the greatest expansion in acres coming

from corn and soybeans, as the acres devoted to growing sorghum and wheat decreased.

Table 3.4. Percent of crop acres in total, owned and rented crop acres for selected farms

Acres	1996	1997	1998	1999	2000	2001
Total						
Corn	11.37	11.57	12.97	13.19	14.77	15.13
Sorghum	18.37	15.77	15.67	15.18	14.22	14.61
Soybeans	16.46	18.10	19.64	21.03	20.35	20.60
Wheat	35.71	34.50	34.26	29.71	31.99	31.31
Other	18.10	20.07	17.47	20.89	18.67	18.35
Owned						
Corn	12.49	12.80	13.64	14.21	15.56	15.10
Sorghum	16.44	14.08	15.40	15.18	13.28	12.51
Soybeans	15.82	17.47	19.68	19.16	19.98	19.10
Wheat	32.57	30.89	30.91	26.48	27.65	28.41
Other	22.68	24.76	20.36	24.97	23.53	24.88
Rented						
Corn	10.81	10.95	12.62	12.65	14.37	15.14
Sorghum	19.32	16.62	15.80	15.19	14.70	15.72
Soybeans	16.77	18.41	19.62	22.01	20.54	21.40
Wheat	37.26	36.33	35.97	31.40	34.21	32.84
Other	15.84	17.70	15.99	18.75	16.18	14.90

Corn total, owned, and rented acres increased over the period, the greatest increase coming from rented acres, by 4.33 percentage points, while owned acres increased by 2.61 percentage points. As noted before, the share in rented corn acres topped that of owned acres. In acreage terms, and right after wheat, in the beginning of the period, sorghum was the next most important crop for these farms, and like the other three crops, the share of rented acres was greater than the share of owned acres. Sorghum acres decreased in the period, the greatest decrease coming through the fall in owned acres, of 3.93 percentage points. Soybeans acres showed the greatest relative increase of the four crops, increasing by 4.15 percentage points, an increase that came about mostly through rented land, increasing the gap between the shares of owned and rented acres of this crop. As expected, wheat was responsible for the greatest share of crop acres relative to the other three crops. Over the 1996 through 2001 period, total wheat acres decreased by 4.40 percentage points, and this

decrease was caused the decrease in both owned and rented acres. Like sorghum, owned acres decreased by more than rented acres.

Overall, the size of the farms seems to have increased over the period, and this occurred mainly through an increase in owned acres. The crop mix changed as well, with corn and soybean acres increasing their share of crop acres by 3.76 and 4.15 percentage points, respectively, while sorghum and wheat decreased their share of crop acres by 3.76 and 4.40 percentage points, respectively. At the same time, the amount of AMTA payments received by these farms increased about 1.6 times. Overall, the data appear to suggest that over the period of FAIR Act, while AMTA payments were increasing, farmers bought more land, and that land was put into production.

3.2.2. AMTA payments, crop acres, and credit constraints

Our empirical analysis begins by considering total crop acreage response equations. We begin this section by motivating the elements that should be included in the estimating equation. We then move on to discuss the estimation procedure and explain the motivation underlying the use of the different estimators, OLS, FE and GMM. The estimation results are finally reported. We discuss the theoretical framework next.

Suppose farmers solve an optimization problem where they choose acres $Acres_{jt}$ to maximize their expected utility of wealth, where wealth is given by initial wealth, profits derived from production, government payments and non-farm activities. Following Chavas and Holt (1990), the farmers' problem can written as

$$(3.1) \quad \max_{\{Acres_{jt}\}} \left\{ EU\left[W_{t-1} + P_{jt} Y_{jt}\left(Acres_{jt-1}, \varepsilon_t \right) Acres_{jt} - \sum_{k}^{K} c_{kt} Acres_{jt} + G_t \right] \right\}$$

where W_{t-1} is initial wealth, P_{jt} is the price received for the jth crop, $Y_{jt}(\cdot)$ is the per acre output of the jth crop, assumed to be a function of lagged acreage ($Acres_{jt-1}$, representing rotational issues) and an exogenous shock ε_t, c_{kt} is the per acre cost of input k and G_t represents government payments. We now introduce the empirical approach to estimating

this equation. We begin by motivating the variables that we hypothesize influence acreage choices and should be present in the estimating equation.

Crop acres should depend on a set of factors specific to the land including, for example, land quality, in terms of fertility and in terms of moisture content, land accessibility and the variability and type of weather pattern in the area where the farm is located. Other important factors should include the characteristics of the farm itself, such as the experience or skill of the operators, or the resources available, such as labor or equipment.

The financial resources of the farm should also affect acreage choice. For example, when facing changes in opportunities for profit, the farmer may opt to add or subtract acres, by buying or selling or by renting in or out, or to explore already available acres in a different fashion, for example by changing the crop mix or the application rates of inputs such as pesticides, water, and fertilizer. How the farmer deals with these opportunities depends largely on liquidity, both stated and implied. By stated liquidity we mean the actual funds the farmer has available, while by implied liquidity we mean how the financial channels view the collateral and the default probability of the farmer and thus affect the availability of credit. A farmer with lower collateral and/or a higher default probability will be viewed as a greater risk by the financial agent and will either be denied credit or be given credit under less favorable conditions than a farmer with a smaller default probability. For example, given two farmers with identical farms and financial situations except in terms of liabilities, we expect the farmer with the greater debt to asset ratio to be more credit constrained.

The motivation for our analysis is that government transfers, decoupled payments in particular, may help farmers make additional investments (in acreage and/or equipment or labor) or take the place of higher-interest bearing loans in the sources of funds of the farm. In addition to having acreage effects per se, we hypothesize the effects of these payments may vary depending on the financial status (leverage) of the farm. Naturally, following what was described in previous chapters, decoupled payments may also impact farmers' risk aversion characteristics, labor choices, or collateral in case they own land, for example.

We can think of the acreage equation as including variables relative to the farm, to its financial situation and to the amount of decoupled payments it receives. A reduced form

acreage equation can be defined by the set of variables described in

(3.2) $$Acres_{ict} = \left\{ \mathbf{Farm}_{ict}, \mathbf{FV}_{ict}, \mathbf{GP}_{ict} \right\}$$

where subscripts *i*, *c*, and *t* index the ith farm in county *c* at time *t*, $Acres_{ict}$ denotes crop acres, $\mathbf{Farm}_{ict}$ is a vector of farm characteristics, $\mathbf{FV}_{ict}$ is a vector of financial variables and $\mathbf{GP}_{ict}$ is a vector of government payments. We now discuss the variables included in these vectors in our estimation.

Following Chavas and Holt (1990) we include the farm's level of wealth (total assets less total debts and AMTA payment receipts) in our estimating equation. While accounting for differing risk responses and general wealth effects, wealth simultaneously characterizes the availability of internal funds versus the need to borrow capital, and provides information about the credit-worthiness of the farm. To capture the notion of "initial" wealth we use the previous period's wealth.

The measure of how credit-constrained is a farmer is given by the debt to asset ratio, also known as "leverage." Because greater values of leverage indicate lower credit-worthiness, farmers who are more credit constrained should have smaller acreage responses to market stimuli and greater responses to decoupled payments. We thus we expect greater debt to asset ratios to have a negative effect on planted acres. It is also possible, however, that farmers are borrowing to finance more production. All else constant, this implies the debt to asset ratio is growing along with acreage.[22] This simultaneity bias caused by the fact that so many production decisions are made jointly was pointed out by Goodwin and Mishra (2006), who nevertheless were unable to address it due to the nature of the data they used. We address this issue using two approaches. In the first approach, we allow the debt to asset ratio to be jointly determined with the acreage decision, and estimate our model using a GMM estimator. Instruments were constructed from the explanatory variables assumed to be exogenous along with lags two and up from the debt to asset ratio. In the second approach, we reestimate the acreage equation via OLS and FE using lagged debt to asset ratio instead of

[22] On the other hand, if one is willing to accept that assets may be growing due to intensified investment, then the growth in both the numerator and denominator variables could potentially leave the ratio unchanged.

the current period value.

We represent the degree of decoupled support by considering the amount of estimated AMTA payments received by the farmers. Because we also have hypothesized that farmers who are more credit constrained respond differently to decoupled payments, we allow farmers to exhibit differing responses to payments according to their degree of financial leverage by including an interaction term between the decoupled payments variable and the debt to asset ratio. We should point out a limitation stemming from our inability to directly observe decoupled payments received by farmers. We cannot monitor whether farmers changed bases over time, by buying or selling land enrolled in the program, which could cause a change in government payments received over time other than that brought about by changing rates. While we recognize the problem, we assume that for each acre sold, another acre was bought, so that it is not clear whether such transactions led to more or less planted acres. Hence, the overall effect of decoupled payments depends on parameters involving a direct effect and the interaction effect with leverage.

The estimating equation is given by

$$Acres_{ict} = \beta_0 + \beta_1 Size_{ict-1} + \beta_2 Wealth_{ict-1} + \beta_3 DAR_{ict} + \beta_4 GP_{ict} + \beta_5 DAR_{ict} * GP_{ict} + \\ + \eta_{tc} + u_{ict} \tag{3.3}$$

where $Size_{ict-1}$ measures lagged farm size (total operated acres), $Wealth_{ict-1}$ is initial wealth, DAR_{ict} is the debt to asset ratio and GP_{ict} is decoupled or AMTA payments (total PFC and MLA payments). Unobserved factors that have the same influence on acres for all farms are captured by a set of county dummy variables (included only in the OLS estimators), along with year dummy variables. These fixed effects represent, for example, price risk, which we assume constant across all farms in the county in a given year, systemic yield risk and weather, along with other unobservable factors that may be relevant to production. We further allow these unobserved factors to vary between county and year by introducing an interaction term between them. Note that, unlike for example Chavas and Holt (1991), we do not introduce a measure of market returns in our equation. Because prices are essentially the same within counties, and only vary between counties if the market price is below the pre-defined county-level loan rate, the FE estimator and the county dummy variables in the OLS

estimator should capture these effects. Finally, the year to year variation in prices is picked up by the year fixed effects in place.

The error term can be decomposed into two components, the unobserved factors that cause acres to vary from year to year in each county (η_{ct}) and the idiosyncratic term (u_{ict}). The composite error, $\eta_{ct} + u_{ict}$, draws attention to how the covariance matrix is estimated. The correction procedure suggested by Moulton (1986) allows each county-year group to have a different and unrestricted covariance structure but assumes the errors are uncorrelated across groups. We are thus assuming that farms within a county-year "cluster" are correlated as a result of the unobserved cluster effect η_{ct}. We further specify the Huber-White-sandwich estimator of variance, so that the reported standard errors of our three estimators are robust to heteroscedasticity.

The two coefficients of interest are β_4, the *ceteris paribus* marginal acreage effect of decoupled government payments and β_5, the impact of leverage on the marginal effect of government payments. If government payments are not truly decoupled, we would expect to find a significant positive coefficient for β_4. If government payments have greater acreage effects the more leveraged the farms (the more credit-constrained), we would also expect to find a significant positive coefficient for β_5.

A fundamental assumption necessary for consistency of the OLS estimator is that there is no feedback from current or past shocks to current values of the regressors, or if explanatory variables are strictly exogenous conditional on η_{ic}:

$$E\left[u_{ict} \mid \mathbf{Farm}_{ict}, \mathbf{FV}_{ict}, \mathbf{GP}_{ict}, \eta_{ct}\right] = 0, \quad t = 1,...,T \tag{3.4}$$

But we further expect much of the remaining variation in acreage decisions to be explained by unobserved characteristics of the farms, such as the accessibility of the farm or the skill of the operator. The specification with a farm-specific fixed effect a_i becomes

$$\begin{aligned} Acres_{ict} = {} & \beta_0 + \beta_1 Size_{ict-1} + \beta_2 Wealth_{ict-1} + \beta_3 DAR_{ict} + \beta_4 GP_{ict} + \beta_5 DAR_{ict} * GP_{ict} + \\ & + a_i + \eta_{ct} + u_{ict} \end{aligned} \tag{3.5}$$

and for consistency of the OLS estimator we now require

(3.6) $E\left[u_{ict} \mid \mathbf{Farm}_{ict}, \mathbf{FV}_{ict}, \mathbf{GP}_{ict}, \eta_{ct}, a_i\right] = 0, \quad t = 1,...,T$

which implies that once $\mathbf{Farm}_{ict}$, $\mathbf{FV}_{ict}$, $\mathbf{GP}_{ict}$ and the unobserved heterogeneities are controlled for, the variables in these vectors have no partial effect on $Acres_{ict}$, $s \neq t$.

If the unobserved heterogeneity (a_i) is uncorrelated with the regressors, we can estimate equation (3.5) using pooled OLS. But if this term is correlated with any element in $\mathbf{Farm}_{ics}$, $\mathbf{FV}_{ics}$, or $\mathbf{GP}_{ics}$, then pooled OLS is biased and inconsistent. In this case, the FE estimator allows us to purge the unobserved heterogeneity from the model by subtracting from each observation the time-average value for that variable, so that the final expression is time demeaned. While this approach drops any time invariant regressors, including the county dummies, the county-year interaction dummy variables account for events that have particular effects on any given counties in any given year. And because this method does not eliminate the county-year effect (η_{ct}), the covariance matrix for the FE estimates is also corrected for intragroup correlation.

In this setting, our concern about the possible endogeneity of the debt to asset ratio variable leads us to revise our estimation. Our first approach involves using a GMM estimator, where the full set of instruments is built from the explanatory variables assumed to be exogenous (size, initial wealth and government payments) and lagged values of the debt to asset ratio and the interaction term with government payments.[23] These are strong instruments. The correlation coefficient between current debt to asset ratio and its second lag is 0.8352, while that of the current interaction term with its second lag is 0.7653. The correlations between the current values of these variables and the remaining lags vary between 0.7439 and 0.8017 for the debt to asset ratio, and between 0.7521 and 0.8301 for the interaction term, the limits corresponding to the third and fifth lags, respectively. This estimator is similar to that developed by Arellano-Bond (1991) and Arellano-Bover (1995)/Blundell-Bond (1998), since we are estimating a model with endogenous variables by instrumental variables methods using lagged values of the endogenous variables for the

[23] The second, third, fourth, and fifth lags were used.

transformed equations.[24] As Arellano and Bover (1995), we assume that our regressors are potentially correlated with the individual effects and so only estimators based on deviations of the original observations can be consistent.

Like the FE estimator, the GMM estimator purges the time-constant fixed effects by transforming the original regression equations. One transformation method, used by Arellano-Bond (1991), involves first-differencing the original equation by subtracting the equation lagged one period from the current period equation (hence the name "difference GMM"). The drawback of this transformation is that it magnifies gaps in unbalanced panels, since if any observation in a given period is missing, then the differences involving that period are missing in the transformed data. An alternative method, proposed by Arellano and Bover (1995), involves the use of forward orthogonal deviations. This transformation subtracts the mean of the remaining future observations available in the sample to each of the first $T-1$ observations. For a given variable x, the transform is given by

$$(3.7) \quad x_{i,t}^{\perp} = c_t \left(x_{it} - \frac{1}{T-t} \sum_{s>t} x_{is} \right), \quad t = 1, ..., T-1$$

where the sum is taken over available future observations, $(T-t)$ is the number of such observations, and the scale factor $c_t = \sqrt{(T-t)/(T-t+1)}$ is used to equalize the variances. Given that it can be performed for all observations except for the last, this transformation minimizes data loss. Since our data are an unbalanced panel of farms, we prefer this method.

In terms of standard errors, Arellano and Bond (1991) found that the estimated standard errors of the efficient, two-step GMM estimator were severely downward biased in small samples, whereas those of one-step were practically unbiased. Recall that for efficiency, GMM estimation requires moments to be weighed in inverse proportion to their variances and covariances, *i.e.*, by the inverse of their variance matrix. This, however, is not possible since this variance is unknown. One-step estimation assumes some form for the

[24] For endogenous variables, suitable lags include lag two and up. For variables that are predetermined but not strictly exogenous (the current period error term is uncorrelated with current and lagged values of the variable but may be correlated with future values), suitable lags include lag one and up. Finally, all lags of exogenous variables are used as instruments for the transformed equations.

standard errors, with more or less complex patterns of variance, and proceeds to find the feasible and efficient GMM estimator. The two-step estimator performs an initial GMM regression yielding estimates of the parameters and then uses them to construct a variance proxy to be used in a rerun of the GMM estimation. Windmeijer (2005) proposed a finite sample correction for the estimate of the variance so that the two-step standard errors are quite accurate and two-step estimation with corrected errors seems modestly superior to robust one-step. We perform two-step GMM estimation and report standard errors with the Windmeijer correction.

Finally, when using the GMM estimator, we test for serial correlation in the error and examine the validity of the instruments. When purging the fixed effects by using first differences, first-order autocorrelation is expected because the differenced current period errors necessarily correlate with the differenced previous period errors as they share the u_{ict-1} term. So, in order to observe first-order autocorrelation in levels we must look for second-order autocorrelation in differences. While this idea does not apply to orthogonal deviations, since the residuals for any farm are all mathematical interrelated, the test is run on differenced residuals (Roodman 2006). The presence of autocorrelation suggests the lags of the endogenous variables are still endogenous, hence bad instruments. The validity of the instruments is further analyzed by looking at the Hansen J statistic, which is the minimized value of the two-step GMM criterion function. This test, while robust to heteroscedasticity and autocorrelation, is potentially weakened by the use of too many instruments, so we do not include the county-year interaction dummy variables when using the GMM estimator. The instrument count is reported along with the p-values of these tests.

The second approach to deal with the possibility of an endogenous debt to asset ratio replaces the current value of the debt to asset ratio by its first lag. Our revised estimating equation becomes

$$\begin{aligned} Acres_{ict} = {} & \alpha_0 + \alpha_1 Size_{ict-1} + \alpha_2 Wealth_{ict-1} + \alpha_3 DAR_{ict-1} + \alpha_4 GP_{ict} + \\ & + \alpha_5 DAR_{ict-1} * GP_{ict-1} + a_i + \eta_{ct} + u_{ict} \end{aligned} \tag{3.8}$$

where the two coefficients of interest are α_4, the *ceteris paribus* marginal acreage effect of

decoupled government payments and α_5, the impact of leverage on the marginal effect of government payments. We expect these coefficients to be significant and positive.

Table 3.5 reports the results of the OLS, FE and GMM parameter estimates for the total (owned and rented) crop acres LHS variable. We report results for different versions of the OLS (columns (1) to (3)) and FE (columns (4) and (5)) estimators, varying in the dummy variables included. We estimate three versions of the OLS estimator, the first without dummy variables, the second with year and county dummies and the third with year, county and year-county interaction dummies. We also estimate two versions of the FE estimator, the first including year dummies and the second including year and year-county interaction dummies. R squared values are reported for these estimators. The results from using the GMM estimator appear in column (6). Year dummies are included. For this estimator we also report the p-value for the test statistic for AR(2) in first differences, the p-value for the Hansen test of overidentifying restrictions, and the instrument count for this test. Robust standard errors are presented in parentheses throughout.

The basic OLS specification results, without dummy variables, appear in column (1). In this approach, farm and financial characteristics and AMTA payments variables explain about 66.81 percent of the variation in planted acres. As expected, farm size and initial wealth affect crop acres positively, though only size has a statistically significant effect. All else constant, an additional operated acre causes crop acres to increase by 0.29 acres and an additional thousand dollars of initial wealth increase crop acres by about 0.04 acres. The debt to asset variable has a significant positive sign, suggesting a one percentage point increase in the ratio increases crop acres by about 180 acres, or an elasticity of 0.052 (assuming there are no government payments). This positive result questions the extent to which the debt to asset ratio is endogenous to production decisions, as it could be a sign that farmers who plant more acres incur more debt.

Table 3.5. Parameter estimates and summary statistics for crop acres

	OLS			FE		GMM
Crop Acres	(1)	(2)	(3)	(4)	(5)	(6)
Farm size (acres)	0.289 *	0.278 *	0.278 *	0.056 ***	0.059 ***	0.082 *
	(0.018)	(0.016)	(0.016)	(0.029)	(0.03)	(0.026)
Wealth (1,000)	0.044	0.073 *	0.066 **	0.041	-0.010	0.022
	(0.028)	(0.025)	(0.027)	(0.06)	(0.065)	(0.1)
Debt to asset ratio (DAR)	180.029 *	142.355 *	146.027 *	145.213 **	137.723 **	176.461
	(40.293)	(39.907)	(40.561)	(69.201)	(69.607)	(549.749)
AMTA payments ($1,000)	25.901 *	23.737 *	24.325 *	4.856 *	6.038 *	3.921 **
	(1.504)	(1.354)	(1.424)	(1.443)	(1.344)	(1.934)
Interaction term: DAR and AMTA	0.278	2.256	2.360	-0.347	-0.688	2.386
	(2.12)	(1.962)	(1.99)	(3.327)	(3.409)	(4.025)
Year dummies	No	Yes	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-
Year - County dummies	No	No	Yes	No	Yes	No
N	5,291	5,291	5,291	5,291	5,291	4,019
R^2	0.6681	0.7476	0.7650	0.9568	0.9649	-
AR(2) in first differences	-	-	-	-	-	0.612
Hansen J	-	-	-	-	-	0.676
Number of instruments	-	-	-	-	-	18

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Contrary to their "non-distortionary" title, AMTA payments seem to have a considerable effect on planted acres. All else constant, an additional thousand dollars of AMTA payments increases planted acres by 25.9 acres, or an elasticity of about 0.404 (assuming a farm without debt). But notice that these values seem too high when we take into consideration land prices and cash rents: average (current) prices per acre of all land in farms and buildings from the Kansas State University Agricultural Experiment Station and Cooperative Extension Service varied between $553 and $645 for 1996 through 2001, while average prices per acre of all crop land and buildings varied between $638 and $673 for that period.[25] So, it would be unrealistic to consider an additional $1,000 in AMTA payments

[25] http://www.oznet.ksu.edu/library/agec2/mf1100.pdf.

would motivate farmers to add about 26 acres of farm land, as implied by the coefficient. Finally, the results suggest that the planting decisions of more highly leveraged farmers are not significantly affected by AMTA payments, as the interaction term between the debt to asset ratio and AMTA payments is not significant. Considering the average farm's debt level, the AMTA payments elasticity of crop acres is 0.406.

Column (2) contains the results of the OLS specification with year and county dummy variables added as regressors. The magnitude of the coefficient of size decreases slightly, as does that of the debt to asset ratio and the AMTA payments variables, as opposed to the marginal effect of wealth, which increased. For a farmer without debt, an additional thousand dollars of AMTA payments increases crop acres by 23.7 acres, or an elasticity of about 0.371. The interaction term is still not significant. Column (3) lists the results when year-county interaction dummy variables are added to the specification in (2). These interaction terms capture the effects of unobserved events that may have affected certain counties in particular years. The magnitudes of the coefficients on the explanatory variables do not respond to this addition by changing as much as they did when the year and county dummy variables were first added, suggesting these unknown effects are not very important. This is reinforced by the small change in the R squared coefficient.

Columns (4) to (5) represent a move from OLS to a panel data framework. As noted, the FE method purges the time-constant variables that are omitted in the OLS specifications, which may lead to biased coefficients. This procedure causes a big change in the magnitude of some of the coefficient estimates, and even of sign in the case of the wealth of the farm (in the specification including county-year interaction dummy variables). We now discuss how this different method affects the results of the estimation.

Column (4) contains the FE results of estimating the acreage equation including only time dummy variables. When compared to the pooled OLS specification, the farm size coefficient decreased by almost an order of magnitude, now implying that an additional operated acre causes crop acres to increase by about 0.06 acres. The coefficient estimate on AMTA payments also decreased substantially. In this specification, for a farm without debt, an additional thousand dollars of AMTA payments increase planted acres by about 4.9 acres,

or an elasticity of about 0.076 (0.074 for a farm with the average level of relative debt). The coefficient estimate on wealth, while similar to that from using OLS, is no longer statistically significant. The debt to asset ratio still has a positive sign, suggesting that greater levels of relative debt are associated with more planted acres. As before, once the effect of the debt to asset ratio and AMTA payments have been taken into account, the interaction term between these variables has no explanatory power. Column (5) adds county-year interaction dummy variables to the specification. The change in the results is very moderate, as when using OLS. A big change occurs in the wealth coefficient estimate, which is now negative, but still statistically insignificant. AMTA payments have a slightly greater effect on acres. Once we account for special events affecting some counties in particular, an additional thousand dollars of AMTA payments increase planted acreage by almost 6 acres, or an elasticity of 0.094 for a farm without debt; for the farm with the average level of relative debt, the total AMTA payments elasticity of crop acres is 0.091.

Column (6) contains the results of the GMM estimator using year dummy variables. The validity of the instruments was not rejected by the test of AR(2) in first differences or by the Hansen test of overidentifying restrictions. In general, the coefficients and corresponding significance are similar to those of the FE estimator. The possibility of an endogenous debt to asset ratio increased the magnitude of this coefficient, so that the debt to asset ratio elasticity of crop acres is now 0.051 for a farm without government payments. The AMTA payments coefficient estimate decreased by between one and two acres when compared to that under the FE estimator, so the AMTA payments elasticity is now of 0.061 for a farm without debt. The coefficient on the interaction term between AMTA payments and the debt to asset ratio, while remaining insignificant, became positive, increasing the total AMTA payments elasticity of crop acres for a farm with average relative debt to 0.074.

We judged the appropriateness of the estimators using two approaches. First, we implemented a Breusch and Pagan Lagrangian multiplier test for random effects, where the null hypothesis of the one-way random group effect model is that variances of groups are zero. The rejection of the null hypothesis suggested the pooled regression model is not appropriate. Second, we implemented a Hausman test to judge the appropriateness of the

fixed effects estimator. Under the null hypothesis of uncorrelated heterogeneity, the random effects (RE) estimator is both consistent and efficient, while under the alternative of correlated heterogeneity it is inconsistent. The test examines whether the differences in coefficients obtained from using a FE or a RE are not systematic. For the specification including only year dummies this test too had a very high statistic, leading to the rejection of the null hypothesis and the use of the FE estimator. But note that this statistic assumes the model is correctly specified and that the FE estimator is consistent to begin with.

Table 3.6 reports the results of the OLS and FE parameter estimates when lagged values of the debt to asset ratio are used instead of the current values, as in equation (3.8). As before, columns (1) – (3) contain the results of the OLS estimator and columns (4) – (5) contain those of the FE estimator. In terms of size, wealth, and AMTA payments, the results are very similar to those when using the current period debt to asset ratio variable. When using OLS, a $1,000 transfer in AMTA payments for a farm without debt increases acres from 24.2 to 25.7 acres, implying an elasticity ranging from 0.369 to 0.401 for a farm without debt. When using FE, AMTA payments have an elasticity varying from 0.073 to 0.092, slightly lower than that found when using the current value of the variable. While insignificant, the interaction term between the debt to asset variable and payments brings this elasticity very close to that of when using the current value of the variable. For a farm with the average level of debt, the AMTA payments elasticity now ranges between 0.382 and 0.405 in the OLS estimator, and between 0.073 and 0.091 in the FE estimator. The latter is somewhat above that from using the GMM estimator.

In short, our results suggest AMTA payments have statistically significant crop acreage effects. For a farm without debt, considering the estimation using current leverage, AMTA payment elasticities vary between 0.076 and 0.094 when we allow for unobserved effects, and between 0.371 and 0.404 when we do not. In general, the elasticities for a farm with the average level of debt are slightly greater than these. Finally, our hypothesis that AMTA payments affect crop acreage decisions in the presence of credit constraints is not supported by the data, as the interaction term between AMTA payments and the debt to asset ratio was not significant for any estimator. Using lagged debt to asset ratio instead of the

current value did not yield different conclusions. We now move on to analyze the importance of AMTA payments in the decision to own acres to plant.

Table 3.6. Parameter estimates and summary statistics for crop acres (lagged debt to asset ratio)

	OLS			FE	
Crop Acres	(1)	(2)	(3)	(4)	(5)
Farm size (acres)	0.288 *	0.278 *	0.278 *	0.054 ***	0.058 ***
	(0.018)	(0.016)	(0.016)	(0.028)	(0.03)
Wealth (1,000)	0.050 ***	0.074 *	0.068 **	0.068	0.010
	(0.028)	(0.026)	(0.027)	(0.064)	(0.068)
Lagged Debt to asset ratio (DAR_{t-1})	175.330 *	130.314 *	134.630 *	154.786 **	134.659 ***
	(38.883)	(38.406)	(39.134)	(71.252)	(73.561)
AMTA payments ($1,000)	25.670 *	23.626 *	24.172 *	4.681 *	5.901 *
	(1.445)	(1.305)	(1.369)	(1.368)	(1.238)
Interaction term: DAR_{t-1} and AMTA	0.858	2.543	2.754	0.022	-0.264
	(1.97)	(1.797)	(1.815)	(2.696)	(2.671)
Year dummies	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes
N	5,291	5,291	5,291	5,291	5,291
R^2	0.6681	0.7473	0.7649	0.9568	0.9649

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

3.2.3. AMTA payments and owned crop acres

Empirical work suggests that given the importance of the rental market for land, the most important effect of AMTA payments was to increase the value of the principal fixed asset in agriculture, land. For farmers who wanted to expand crop acres, this may have motivated the purchase of additional land, instead of renting. Goodwin and Mishra's (2006) results, for example, suggested AMTA payments could lead to more ownership transactions. We now investigate whether AMTA payments explain the variation in owned planted acres and maintain our additional hypothesis that payments matter more the more highly leveraged the

farmer.

Our estimating equation is identical to equation (3.5), but our dependent variable is now owned crop acres instead of total (owned and rented) crop acres. The results of the OLS, FE and GMM estimators are presented in Table 3.7. As before, we report results for different versions of the OLS (columns (1) to (3)) and FE (columns (4) and (5)) estimators, varying in the dummy variables included. The results from estimation using the GMM estimator appear in column (6).

Table 3.7. Parameter estimates and summary statistics for owned crop acres

		OLS		FE		GMM
Owned Crop Acres	(1)	(2)	(3)	(4)	(5)	(6)
Farm size (acres)	0.020 **	-0.007	-0.007	-0.022	-0.014	-0.009
	(0.008)	(0.007)	(0.007)	(0.021)	(0.019)	(0.017)
Wealth (1,000)	0.543 *	0.572 *	0.573 *	0.159 *	0.139 **	0.096 ***
	(0.021)	(0.021)	(0.022)	(0.057)	(0.057)	(0.057)
Debt to asset ratio (DAR)	141.528 *	132.800 *	133.214 *	-10.625	-48.800	-73.552
	(23.452)	(23.902)	(25.038)	(40.131)	(42.212)	(137.372)
AMTA payments ($1,000)	2.192 *	0.908	0.814	-0.309	-1.117	-0.434
	(0.782)	(0.606)	(0.638)	(1.183)	(1.046)	(0.891)
Interaction term: DAR and AMTA	2.568 **	4.655 *	4.861 *	1.356	1.819	2.433 ***
	(1.14)	(1.009)	(1.068)	(1.41)	(1.327)	(1.361)
Year dummies	No	Yes	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-
Year - County dummies	No	No	Yes	No	Yes	-
N	5,291	5,291	5,291	5,291	5,291	4,019
R^2	0.4327	0.5657	0.5925	0.9113	0.9343	-
AR(2) in first differences	-	-	-	-	-	0.2690
Hansen J	-	-	-	-	-	0.2450
Number of instruments	-	-	-	-	-	18

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Looking at the OLS estimator across its three specifications, we see that wealth significantly contributes to increase owned crop acres, and the magnitude of the coefficient

estimates is much higher than those found in the total acres equation. in the specification without dummy variables, AMTA payments and size also have this positive effect, which becomes insignificant once the specification changes to include the special events that may affect farms in particular years or that may affect particular counties in some years. AMTA payments, while exhibiting an elasticity that varies between 0.04 and 0.098 for a farm without debt, do not seem to have a direct effect on owned crop acres. Noteworthy are the coefficients on the interaction term between AMTA payments and the debt to asset ratio, significant at the 5 percent level, suggesting that AMTA payments and may boost the purchase of crop acres for the more highly leveraged farmers. AMTA payments may thus improve the collateral of the more credit constrained farmers and allow them to purchase land, which also serves as collateral. For the farmer with the average level of debt, the total AMTA payments elasticity varies between 0.109 and 0.136, below the 0.382 to 0.406 elasticity found in the total crop acres case.

Taking unobserved effects into account changes the sign of the AMTA payments and debt to asset coefficient estimates. While still insignificant, the coefficient estimate on AMTA payments becomes negative when we use the FE or GMM estimators, and the coefficient estimate on the debt to asset ratio becomes negative and statistically insignificant. And although the importance of AMTA payments for the more highly leveraged farmers is not recognized by the FE estimator, the coefficient estimate of the interaction term is statistically significant when we account for the fact that the debt to asset ratio may be endogenous to production decisions. Using this estimator, for a farm with the average level of debt, the AMTA payments elasticity is 0.017. the validity of the instruments is not rejected by our AR(2) and Hansen J tests.

As with total crop acres, we estimated the owned crop acres equation using the lagged debt to asset ratio. The estimating equation is similar to equation (3.8) with the dependent variable now being owned crop acres. The results of the OLS and FE estimators are presented in Table 3.8.

Table 3.8. Parameter estimates and summary statistics for owned crop acres (lagged debt to asset ratio)

	OLS			FE	
Owned Crop Acres	(1)	(2)	(3)	(4)	(5)
Farm size (acres)	0.017 **	-0.010	-0.010	-0.024	-0.015
	(0.008)	(0.006)	(0.007)	(0.021)	(0.019)
Wealth (1,000)	0.561 *	0.591 *	0.591 *	0.182 *	0.152 **
	(0.021)	(0.022)	(0.023)	(0.063)	(0.063)
Lagged Debt to asset ratio (DAR_{t-1})	173.167 *	166.648 *	165.628 *	21.977	-35.547
	(23.405)	(24.243)	(25.277)	(47.171)	(47.816)
AMTA payments ($1,000)	1.916 **	0.616	0.534	-0.610	-1.383
	(0.764)	(0.585)	(0.615)	(1.21)	(1.108)
Interaction term: DAR_{t-1} and AMTA	2.931 *	4.923 *	5.128 *	2.118	2.548 ***
	(1.079)	(0.927)	(0.986)	(1.382)	(1.394)
Year dummies	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes
N	5,291	5,291	5,291	5,291	5,291
R^2	0.437	0.5703	0.5968	0.9114	0.9344

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Replacing current with lagged debt to asset ratio does not cause significant changes when the OLS estimator is used. AMTA payments are still significant in the specification that does not include dummy variables, and the interaction term with the debt to asset ratio is statistically significant across the three different specifications. Their magnitude is also very similar. In the FE estimator though, AMTA payments are still not significant, as is the interaction term. When we further compare the elasticities for a farm with average relative debt, they are very similar between the two equations, varying between 0.099 and 0.129 for the OLS estimator, and between -0.024 and 0.004 for the FE estimator, respectively.

In conclusion, while AMTA payments do not seem to affect the decisions of farmers to plant their own acres, they have the potential to affect more highly leveraged farmers. The implied AMTA payments elasticities are, however, very low. We find that using the previous period debt to asset ratio does not change our conclusions.

We now turn to analyzing the effects of AMTA payments on the acres of specific crops, namely corn, sorghum, soybeans and wheat, the four main crops in Kansas.

3.2.4. AMTA payments and crop-specific planted acres

So far our analysis has considered the global impact of AMTA payments on planted acres and has ignored potential effects upon the farmers' choice of crop mix. Our goal in this section is to observe how decoupled payments affected the planted acreage of specific crops, namely corn, sorghum, soybean and wheat. Over the duration of the FAIR Act, the average farm in our sample increased its planted acres of corn and soybeans, both by about 40 percent, while acres planted to sorghum and wheat decreased by 12 and 6 percent, respectively (this resembles the pattern observed in the balanced panel of farms).

The framework for evaluating the effect of decoupled payments on the planted acreage of corn, sorghum, soybeans, and wheat is the one presented before. Acreage is still a function of farm characteristics, financial variables, and government payments. However, the estimating equation now includes expected yields of the crop in question along with those of the other three crops. We do not include expected prices because they are highly collinear with the year dummy variables. For each crop, the basic estimating equation is given by

$$(3.9)\quad \begin{aligned} Acres_{jict} = {} & \lambda_0 + \lambda_1 Size_{ict-1} + \lambda_2 EYield_{jict} + \delta_k \sum_{k=1}^{3} EYield_{kict} + \lambda_3 Wealth_{ict-1} + \\ & \lambda_4 DAR_{ict} + \lambda_5 GP_{ict} + \lambda_6 DAR_{ict} * GP_{ict} + a_i + \eta_{ct} + u_{ict} \end{aligned}$$

where the acres planted of the jth crop $Acres_{jict}$ are a function of expected yields of the crop $EYield_{jict}$ and the alternative crops $EYield_{kict}$, and the farm characteristics, financial variables, and government payment variables defined earlier. The coefficients of interest are now λ_5, the marginal acreage effect of AMTA payments, and λ_6, the impact of leverage on the marginal effect of AMTA payments. As before, we expect to find positive coefficients on these regressors.

We also specify the following alternative equation using the lagged debt to asset instead of the current period value, where the regressors have their usual interpretation:

$$(3.10)\quad Acres_{jict} = \kappa_0 + \kappa_1 Size_{ict-1} + \kappa_2 EYield_{jict} + \delta_k \sum_{k=1}^{3} EYield_{kict} + \kappa_3 Wealth_{ict-1} + \kappa_4 DAR_{ict-1} + \kappa_5 GP_{ict} + \kappa_6 DAR_{ict-1} * GP_{ict-1} + a_i + \eta_{ct} + u_{ict}$$

We again estimate the commodity equations using OLS, FE and the GMM estimators. We include year, county and year-county interaction dummy variables when estimating by OLS, year and year-county interaction dummy variables when estimating by FE, and year dummy variables when estimating using the GMM estimator. Tables 3.9 through 3.12 report the parameter estimates and summary statistics for the estimation for each of the four crops, corn, sorghum, soybeans and wheat, respectively. Each table contains the results from estimating equation (3.9) (columns (1) through (6)), and the results from estimating equation (3.10) (columns (7) through (11)). We follow the previous setup, with the columns within the OLS and FE estimators growing in the number of dummy variables used. We begin by analyzing the coefficients of interest, λ_5 and λ_6 for each crop.

For corn (Table 3.9), OLS and FE estimators' results suggest AMTA payments increase planted acres. While estimation with lagged debt to asset yields slightly higher coefficients for OLS and FE, all else constant, a $1,000 increase in AMTA payments increases corn acres by 4 to 5 acres, or by 1 to 2 acres, for OLS or FE estimators, respectively. The implied elasticities vary between 0.4666 and 0.6506 for OLS (for equations (3.9) and (3.10), respectively), and between 0.1519 and 0.2640 for FE (for equations (3.9) and (3.10), respectively). And while the interaction term with the debt to asset ratio is not significant, for a farm with average relative debt, it nonetheless raises these elasticities to vary between 0.5547 and 0.7054 for OLS, and 0.2394 and 0.3063 for the FE estimator. These elasticities are higher than those found in the total crop acres estimation, which were between 0.382 and 0.406 for OLS, and 0.074 and 0.091 for FE.

For sorghum (Table 3.10), the magnitude and significance of the OLS coefficients on AMTA payments is similar to those of corn. The greatest difference appears in the results from the estimators that can account for unobserved effects, as the GMM and the FE coefficient estimates from equations (3.9) and (3.10) are negative, although not statistically significant. The interaction term, which is negative for the GMM estimator, is also not

significant; due to order-2 serial correlation, we restricted the lags of the endogenous variables to lags three and deeper. As in the case of corn, for a farm with the average level of debt, for the OLS estimator in both equations, the AMTA payments elasticity is higher than that for the total crop acres equation. But this elasticity is negative once unobserved effects are accounted for, varying between -0.1475 and -0.0909 for the GMM estimator and FE estimator with year-county interaction dummy variables, respectively.

The results from the OLS estimator for soybeans (Table 3.11) share some of the features as those of corn, as AMTA payments significantly increase soybeans planted acres. The magnitude of these effects is somewhat smaller, with an additional $1,000 in AMTA payments increasing sorghum acres by between 2.1 to 4.0 acres. For the FE estimator with year dummy variables this effect is also statistically significant, and the magnitude similar to the lower bound of the OLS estimator coefficient estimates. For a farm without debt, the elasticity implied by this estimator is 0.1838 and 0.1796 for equations (3.9) and (3.10), respectively. As before, the interaction term is not significant across estimators and the different equations. For a farm with the average level of relative debt, the total AMTA elasticity associated with the FE estimators varies between 0.1363 and 0.1747 for equations (3.9) and (3.10), respectively. These elasticities are somewhat lower than those found from estimating the corn equations.

Finally, the results for wheat (Table 3.12) seem to be similar to those for sorghum. OLS results from estimating equations (3.9) and (3.10) are positive and significant, while those from the FE estimator with year-county interaction dummy variables are negative and not significant. Contrary to sorghum, however, the GMM coefficient estimate is positive, although still not significant. For these farmers, once unobserved effects are taken into account, AMTA payments do not seem to affect wheat acres, not even the more highly leveraged ones, as the lack of significance of the interaction terms suggests.

Table 3.9. Parameter estimates and summary statistics for corn acres

	Current debt to asset ratio						Lagged debt to asset ratio				
	OLS			**FE**		**GMM**	**OLS**			**FE**	
Corn Acres	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Farm size (acres)	0.016 *	0.014 **	0.011 ***	0.019	0.018	0.009	0.015 *	0.014 **	0.012 ***	0.019	0.019
	(0.006)	(0.006)	(0.006)	(0.018)	(0.021)	(0.015)	(0.006)	(0.006)	(0.006)	(0.018)	(0.021)
Expected Corn Yield (bu/acre)	1.038 *	0.791 *	0.864 *	0.779 *	0.745 **	0.571 *	1.047 *	0.802 *	0.879 *	0.783 *	0.764 **
	(0.195)	(0.175)	(0.216)	(0.224)	(0.334)	(0.209)	(0.196)	(0.179)	(0.218)	(0.225)	(0.332)
Expected Sorghum Yield (bu/acre)	1.044 *	-0.058	-0.300	-0.052	-0.299	-0.008	1.052 *	-0.046	-0.293	-0.043	-0.282
	(0.393)	(0.327)	(0.387)	(0.452)	(0.633)	(0.396)	(0.393)	(0.326)	(0.386)	(0.456)	(0.637)
Expected SoybeansYield (bu/acre)	1.191 ***	0.998 ***	0.731	-0.154	0.260	-0.008	1.194 ***	1.001 ***	0.757	-0.160	0.278
	(0.672)	(0.549)	(0.556)	(0.651)	(0.862)	(0.657)	(0.672)	(0.552)	(0.561)	(0.646)	(0.864)
Expected Wheat Yield (bu/acre)	1.126 ***	0.924 ***	1.590 **	-0.396	0.128	-0.495	1.086 ***	0.857	1.497 **	-0.410	0.094
	(0.66)	(0.552)	(0.619)	(0.531)	(0.592)	(0.5)	(0.659)	(0.554)	(0.622)	(0.524)	(0.583)
Wealth (1,000)	0.106 *	0.084 *	0.088 *	-0.002	0.008	-0.018	0.108 *	0.086 *	0.089 *	0.006	0.013
	(0.013)	(0.012)	(0.013)	(0.035)	(0.037)	(0.042)	(0.012)	(0.011)	(0.012)	(0.038)	(0.041)
Debt to asset ratio (DAR)	90.508 *	87.420 *	93.648 *	-18.051	21.447	-246.952	107.794 *	98.306 *	105.866 *	13.017	55.780
	(23.78)	(25.443)	(28.925)	(54.197)	(65.563)	(239.545)	(25.032)	(25.016)	(28.065)	(60.457)	(75.8)
AMTA payments ($1,000)	3.869 *	5.186 *	5.280 *	1.706 ***	1.259	0.583	4.018 *	5.262 *	5.394 *	2.189 **	1.905 ***
	(0.715)	(0.654)	(0.735)	(1.008)	(1.145)	(1.078)	(0.624)	(0.561)	(0.631)	(1.016)	(1.119)
Interaction term: DAR and AMTA	2.328 **	1.804	1.718	2.448	2.317	2.584	1.767 ***	1.393	1.193	1.067	0.243
	(1.079)	(1.118)	(1.263)	(1.796)	(1.988)	(2.544)	(1.045)	(0.876)	(0.983)	(1.536)	(1.771)
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
N	1,794	1,794	1,794	1,794	1,794	1,178	1,794	1,794	1,794	1,794	1,794
R^2	0.4261	0.6055	0.6554	0.9015	0.9320	-	0.4265	0.6053	0.6551	0.9013	0.9317
AR(2) in first differences	-	-	-	-	-	0.206	-	-	-	-	-
Hansen J	-	-	-	-	-	0.157	-	-	-	-	-
Number of instruments	-	-	-	-	-	18	-	-	-	-	-

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Table 3.10. Parameter estimates and summary statistics for sorghum acres

	Current debt to asset ratio						Lagged debt to asset ratio				
	OLS			**FE**		**GMM**	**OLS**			**FE**	
Sorghum Acres	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Farm size (acres)	0.020 *	0.026 *	0.030 *	-0.051	-0.004	-0.016	0.020 *	0.025 *	0.029 *	-0.051	-0.003
	(0.006)	(0.008)	(0.008)	(0.051)	(0.023)	(0.026)	(0.006)	(0.008)	(0.008)	(0.051)	(0.024)
Expected Corn Yield (bu/acre)	-0.408	-0.367	-0.318	-0.053	0.342	-0.047	-0.407	-0.369	-0.329	-0.051	0.335
	(0.328)	(0.249)	(0.314)	(0.28)	(0.469)	(0.354)	(0.327)	(0.249)	(0.313)	(0.28)	(0.466)
Expected Sorghum Yield (bu/acre)	-0.191	0.688 **	0.789 **	0.163	0.199	0.365	-0.195	0.689 **	0.790 **	0.162	0.172
	(0.338)	(0.306)	(0.359)	(0.322)	(0.397)	(0.391)	(0.338)	(0.305)	(0.358)	(0.323)	(0.394)
Expected SoybeansYield (bu/acre)	-1.899 ***	-2.544 *	-2.977 *	-2.220 ***	-1.977 **	-1.351	-1.902 ***	-2.529 *	-2.940 *	-2.223 ***	-1.971 **
	(1.088)	(0.813)	(0.943)	(1.284)	(0.903)	(0.867)	(1.09)	(0.81)	(0.945)	(1.278)	(0.908)
Expected Wheat Yield (bu/acre)	2.250 *	0.440	0.345	0.907	0.693	0.200	2.245 *	0.433	0.350	0.892	0.688
	(0.605)	(0.566)	(0.659)	(0.811)	(0.815)	(0.567)	(0.612)	(0.572)	(0.665)	(0.817)	(0.817)
Wealth (1,000)	0.032 ***	0.042 **	0.034	0.123 **	0.043	0.119 ***	0.034 ***	0.046 **	0.040 ***	0.119 ***	0.034
	(0.019)	(0.02)	(0.023)	(0.059)	(0.037)	(0.064)	(0.02)	(0.021)	(0.024)	(0.067)	(0.037)
Debt to asset ratio (DAR)	72.818 ***	38.807	36.160	-1.972	-87.388	291.815	67.929 ***	36.729	34.684	-19.516	-120.160
	(40.51)	(42.299)	(48.371)	(80.568)	(81.255)	(461.859)	(39.942)	(41.93)	(47.828)	(101.667)	(92.819)
AMTA payments ($1,000)	5.350 *	3.728 *	3.899 *	-1.203	-1.817	-0.501	5.212 *	3.521 *	3.616 *	-1.125	-1.965
	(0.934)	(0.738)	(0.853)	(1.418)	(1.71)	(2.471)	(0.887)	(0.648)	(0.748)	(1.348)	(1.607)
Interaction term: DAR and AMTA	0.017	0.678	0.506	0.714	1.069	-1.209	0.360	1.129	1.149	0.480	1.483
	(2.105)	(2.022)	(2.353)	(2.166)	(2.383)	(5.686)	(1.836)	(1.718)	(2.038)	(2.164)	(2.544)
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
N	1,794	1,794	1,794	1,794	1,794	1,178	1,794	1,794	1,794	1,794	1,794
R^2	0.2268	0.4437	0.5930	0.7583	0.8897	-	0.2269	0.4446	0.5942	0.7583	0.8899
AR(2) in first differences	-	-	-	-	-	0.222	-	-	-	-	-
Hansen J	-	-	-	-	-	0.118	-	-	-	-	-
Number of instruments	-	-	-	-	-	10	-	-	-	-	-

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Table 3.11. Parameter estimates and summary statistics for soybeans acres

	Current debt to asset ratio						Lagged debt to asset ratio				
	OLS			**FE**		**GMM**	**OLS**			**FE**	
Soybeans Acres	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Farm size (acres)	0.070 *	0.087 *	0.092 *	-0.001	0.005	-0.004	0.070 *	0.088 *	0.092 *	-0.003	0.003
	(0.015)	(0.015)	(0.018)	(0.014)	(0.024)	(0.016)	(0.015)	(0.015)	(0.018)	(0.014)	(0.023)
Expected Corn Yield (bu/acre)	-0.100	1.342 *	1.326 *	-0.045	-0.384	0.074	-0.094	1.353 *	1.340 *	-0.033	-0.350
	(0.324)	(0.304)	(0.391)	(0.275)	(0.402)	(0.297)	(0.329)	(0.309)	(0.398)	(0.279)	(0.41)
Expected Sorghum Yield (bu/acre)	4.736 *	1.215 **	1.254 **	-0.231	-0.262	-0.468	4.738 *	1.224 **	1.261 **	-0.212	-0.229
	(0.536)	(0.495)	(0.62)	(0.33)	(0.457)	(0.352)	(0.535)	(0.494)	(0.619)	(0.328)	(0.452)
Expected SoybeansYield (bu/acre)	-7.095 *	-1.477	-1.815	1.028 ***	1.406	1.102 ***	-7.107 *	-1.486	-1.804	1.060 ***	1.414
	(1.133)	(0.979)	(1.269)	(0.611)	(0.983)	(0.634)	(1.141)	(0.975)	(1.265)	(0.608)	(0.981)
Expected Wheat Yield (bu/acre)	3.499 *	2.099 **	2.281 ***	-0.073	-0.635	-0.361	3.463 *	2.033 **	2.201 ***	-0.086	-0.657
	(1.149)	(0.937)	(1.167)	(0.596)	(0.785)	(0.783)	(1.155)	(0.942)	(1.174)	(0.586)	(0.761)
Wealth (1,000)	0.122 *	0.064 **	0.059 ***	0.065 ***	0.036	0.002	0.122 *	0.064 **	0.058 ***	0.089 **	0.060
	(0.025)	(0.029)	(0.034)	(0.035)	(0.039)	(0.05)	(0.026)	(0.03)	(0.034)	(0.04)	(0.044)
Debt to asset ratio (DAR)	200.541 *	113.759 *	109.355 **	99.298	119.463	-411.627 ***	213.323 *	122.362 *	120.158 **	131.102 **	155.102 **
	(39.075)	(42.816)	(49.254)	(60.748)	(77.768)	(230.122)	(39.74)	(44.296)	(50.668)	(56.958)	(70.215)
AMTA payments ($1,000)	2.194 **	3.601 *	3.818 *	2.141 **	1.896	1.432	2.367 **	3.745 *	3.973 *	2.093 **	1.871
	(1.083)	(1.101)	(1.322)	(0.928)	(1.435)	(1.041)	(1.039)	(1.073)	(1.29)	(0.873)	(1.354)
Interaction term: DAR and AMTA	-1.524	0.368	0.409	-0.264	-0.932	0.210	-2.035	-0.162	-0.167	-0.177	-0.633
	(1.67)	(1.58)	(1.828)	(1.431)	(1.688)	(1.626)	(1.43)	(1.358)	(1.58)	(1.223)	(1.469)
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
N	1,794	1,794	1,794	1,794	1,794	1,176	1,794	1,794	1,794	1,794	1,794
R^2	0.2586	0.5265	0.5549	0.9390	0.9509	-	0.2584	0.5260	0.5546	0.9392	0.9510
AR(2) in first differences	-	-	-	-	-	0.613	-	-	-	-	-
Hansen J	-	-	-	-	-	0.761	-	-	-	-	-
Number of instruments	-	-	-	-	-	18	-	-	-	-	-

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Table 3.12. Parameter estimates and summary statistics for wheat acres

	Current debt to asset ratio						Lagged debt to asset ratio				
	OLS			**FE**		**GMM**	**OLS**			**FE**	
Wheat Acres	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Farm size (acres)	0.123 *	0.119 *	0.121 *	0.021	0.014	0.007	0.123 *	0.119 *	0.121 *	0.018	0.011
	(0.015)	(0.014)	(0.016)	(0.017)	(0.019)	(0.013)	(0.014)	(0.014)	(0.016)	(0.017)	(0.019)
Expected Corn Yield (bu/acre)	0.196	-1.422 *	-1.556 *	0.059	0.077	0.123	0.191	-1.429 *	-1.556 *	0.065	0.065
	(0.381)	(0.365)	(0.448)	(0.277)	(0.349)	(0.239)	(0.383)	(0.367)	(0.449)	(0.276)	(0.347)
Expected Sorghum Yield (bu/acre)	-1.993 *	0.015	0.073	-0.524	-0.276	-0.722 **	-1.992 *	0.014	0.077	-0.517	-0.256
	(0.439)	(0.364)	(0.417)	(0.401)	(0.435)	(0.334)	(0.437)	(0.365)	(0.417)	(0.405)	(0.434)
Expected SoybeansYield (bu/acre)	2.380 **	0.051	-0.148	-0.815	-1.604	-0.647	2.391 **	0.063	-0.168	-0.800	-1.630 ***
	(1.199)	(0.881)	(1.134)	(0.73)	(0.982)	(0.589)	(1.202)	(0.886)	(1.136)	(0.738)	(0.98)
Expected Wheat Yield (bu/acre)	2.761 *	1.310 ***	1.622 ***	0.366	-0.281	-0.036	2.783 *	1.364 ***	1.659 ***	0.430	-0.207
	(0.839)	(0.747)	(0.944)	(0.65)	(0.695)	(0.589)	(0.838)	(0.751)	(0.947)	(0.655)	(0.72)
Wealth (1,000)	-0.175 *	-0.131 *	-0.134 *	-0.061	-0.032	-0.041	-0.174 *	-0.130 *	-0.137 *	-0.034	-0.017
	(0.025)	(0.023)	(0.026)	(0.049)	(0.058)	(0.062)	(0.025)	(0.023)	(0.026)	(0.052)	(0.058)
Debt to asset ratio (DAR)	-81.731 **	-149.419 *	-145.067 *	-81.437	-14.484	77.238	-83.583 **	-147.173 *	-141.953 *	51.919	98.818
	(33.152)	(36.329)	(42.578)	(87.243)	(100.336)	(289.834)	(33.395)	(38.679)	(44.902)	(93.618)	(111.152)
AMTA payments ($1,000)	9.946 *	7.854 *	8.147 *	0.581	-0.711	1.010	9.868 *	7.853 *	8.311 *	0.513	-0.392
	(1.198)	(1.165)	(1.33)	(1.207)	(1.583)	(1.271)	(1.13)	(1.076)	(1.234)	(1.117)	(1.506)
Interaction term: DAR and AMTA	0.406	1.111	1.301	-0.418	-0.586	-1.394	0.620	1.198	0.964	-0.061	-1.446
	(2.111)	(2.318)	(2.65)	(3.553)	(4.631)	(2.922)	(1.793)	(1.968)	(2.233)	(2.898)	(3.527)
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
N	1,794	1,794	1,794	1,794	1,794	1,178	1,794	1,794	1,794	1,794	1,794
R^2	0.4813	0.4813	0.7068	0.9381	0.9586	-	0.4812	0.4812	0.7066	0.9380	0.9586
AR(2) in first differences	-	-	-	-	-	0.192	-	-	-	-	-
Hansen J	-	-	-	-	-	0.647	-	-	-	-	-
Number of instruments	-	-	-	-	-	18	-	-	-	-	-

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

In terms of the other regressors, the FE and GMM estimator results for all four crops suggest the debt to asset ratio, though not always significant, has a negative impact on planted acres. Under these estimators, the coefficient estimates for wealth, though generally positive, are similar in terms of significance. When acknowledging for unobserved heterogeneity, except for corn and soybeans, expected yield from the crop under study is typically not significant.

Overall, our results suggest AMTA payments have statistically significant positive acreage effects for corn and soybeans, and insignificant effects for sorghum and wheat, respectively. These findings are consistent with the observed increases in corn and soybeans acres, and decreases in sorghum and wheat acres. When we account for unobserved time-invariant heterogeneity, AMTA payments have significant positive acreage effects for those commodities whose planted acres increased over the period of the FAIR Act, corn and soybeans, and negligible effects for those whose planted acres decreased, sorghum and wheat, respectively.

3.2.5. AMTA payments, pasture acres, and credit constraints

When we analyzed the evolution of operated, crop and pasture acres for the KFMA farms, we noticed that over the period of the FAIR Act both cropland and pastureland increased. Indeed, the increase in pastureland, 4.80 percent, was greater than the 2.88 percent increase in cropland. This increase in pastureland motivated us to repeat the estimation we performed for crop acres, but now with total pasture acres as the dependent variable. Our estimating equation resembles equation (3.5), but with pasture acres on the RHS. We estimated this equation using OLS, FE, and the GMM estimator and repeated the estimation using the previous period debt to asset ratio as in equation (3.8) using the OLS and FE estimators.

The results of the estimation using the current period debt to asset ratio are reported in Table 3.13. The structure of the table follows the organization of the previous sections. We begin by discussing the parameters of interest, the coefficients on AMTA payments and on the interaction term with the debt to asset variable.

Table 3.13. Parameter estimates and summary statistics for pasture acres

	OLS			FE		GMM
Pasture Acres	(1)	(2)	(3)	(4)	(5)	(6)
Farm size (acres)	0.655 *	0.653 *	0.662 *	0.149 **	0.154 **	0.107 **
	(0.022)	(0.021)	(0.022)	(0.057)	(0.065)	(0.051)
Wealth (1,000)	-0.040	-0.050	-0.050	0.122 ***	0.118	0.132 ***
	(0.033)	(0.032)	(0.033)	(0.07)	(0.075)	(0.075)
Debt to asset ratio (DAR)	-83.877 **	-42.010	-51.683	69.987	76.387	74.533
	(36.513)	(38.024)	(40.407)	(48.215)	(60.328)	(186.301)
AMTA payments ($1,000)	-23.556 *	-20.860 *	-21.663 *	0.461	0.423	-0.677
	(1.542)	(1.378)	(1.47)	(1.072)	(1.239)	(1.344)
Interaction term: DAR and AMTA	-1.570	-3.161 **	-3.137 ***	-0.042	-0.265	3.568
	(1.692)	(1.538)	(1.622)	(1.417)	(1.577)	(2.272)
Year dummies	No	Yes	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-	-
Year - County dummies	No	No	Yes	No	Yes	No
N	5291	5291	5291	5291	5291	4019
R^2	0.6758	0.7449	0.759	5291	0.9579	-
AR(2) in first differences	-	-	-	-	-	0.192
Hansen J	-	-	-	-	-	0.769
Number of instruments	-	-	-	-	-	18

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Both under OLS and GMM, the coefficient estimate on AMTA payments is negative, an effect consistent with AMTA payments affecting production. This effect is, however, insignificant except when OLS is used. This lack of significance is also what we find for the interaction term when we account for unobserved sources of heterogeneity. This suggests AMTA payments do not matter more for those farmers who are more highly leveraged. These results are similar to those of when lagged debt to asset is used in the estimation, presented in Table 3.14.

The results for the other regressors are also similar across these two settings of the debt to asset variable. Across all estimators and their different specifications, all else constant, the greater the number of operated acres, the greater the number of pasture acres in the farm. And when unobserved heterogeneity is accounted for, wealthier farms tend to put

more acres into pasture. Finally, when we take into account the possibility that the debt to asset ratio is endogenous to production decisions, our results suggest the relative debt of the farms does not affect the number of acres put into pasture.

Table 3.14. Parameter estimates and summary statistics for pasture acres (lagged debt to asset ratio)

	OLS			FE	
Pasture Acres	(1)	(2)	(3)	(4)	(5)
Farm size (acres)	0.657 *	0.653 *	0.663 *	0.147 **	0.153 **
	(0.022)	(0.021)	(0.022)	(0.057)	(0.065)
Wealth (1,000)	-0.048	-0.053 ***	-0.055 ***	0.146 ***	0.132
	(0.034)	(0.032)	(0.033)	(0.079)	(0.085)
Lagged Debt to asset ratio (DAR_{t-1})	-77.380 **	-29.314	-44.416	101.353 ***	62.484
	(37.257)	(38.504)	(40.388)	(60.265)	(64.706)
AMTA payments ($1,000)	-23.163 *	-20.617 *	-21.399 *	0.281	0.111
	(1.497)	(1.339)	(1.424)	(1.086)	(1.229)
Interaction term: DAR_{t-1} and AMTA	-2.511	-3.761 **	-3.747 **	0.358	0.627
	(1.599)	(1.446)	(1.522)	(1.291)	(1.394)
Year dummies	No	Yes	Yes	Yes	Yes
County dummies	No	Yes	Yes	-	-
Year - County dummies	No	No	Yes	No	Yes
N	5291	5291	5291	5291	5291
R^2	0.676	0.745	0.7592	0.9531	0.9579

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as $\chi 2$ with degrees of freedom equal to the number of instruments. P-values reported.

Like before, we estimated the model for owned pasture acres (results not shown). Neither AMTA payments nor their interaction with leverage had statistically significant coefficients under the panel data estimators. For these estimators, this summarizes the overall performance of our regressors, opposite that under OLS in its different specifications.

We now move on to last segment in our analysis of the impact of AMTA payments on farmers' decisions and leave the impact upon production decisions and focus on that upon consumption expenditures.

3.3. AMTA payments and consumption expenditures

For the last 70 years, farm policy has been dominated by programs of farm income support (ERS 2000). These programs were originally motivated on the grounds of farm households being economically disadvantaged relative to non-farm households. Traditionally, this support was given through coupled commodity programs. These had a direct impact on the prices received by the producers for commodities or the prices of inputs, thereby changing the marginal returns from production and consequently distorting production. The 1996 FAIR Act changed this policy environment by decoupling income support programs from production. Decoupled payments are fundamentally different from traditional farm income support programs since they are fixed, lump-sum transfers that do not depend on current production activities.

To understand the connection between decoupled payments and the well-being of farm households consider the following. According to the life cycle and permanent income hypothesis theories of consumption, income transfers raise lifetime wealth and reduce the rate of savings necessary to pay for future consumption, thereby making consumption (current and future) more affordable.[26] In this theoretical framework, consumption includes both goods and leisure, the latter intrinsically more enjoyable than work, which households use to generate income. So, when lifetime wealth increases, households respond to this increase by increasing their consumption of goods and leisure, while decreasing the amount of labor.[27] Positive wealth effects are expected because these are both normal goods. In addition, changes in wealth may alter households' tolerance for risk. Using the classification suggested by Hennessy (1998), one may think of transfers as having both income-supporting and income-stabilizing effects, or wealth-effects and insurance-effects, respectively. While wealth effects are linked to the increase in wealth level and can affect risk tolerance if

[26] In the context of the permanent income hypothesis, if these transfers are perceived as permanent, lifetime wealth raises by more than if they are temporary, along with the household's propensity to consume.
[27] The off-farm labor supply responses to permanent and transitory components of farm income were studied by Kwon *et al.* (2006), who showed farm households smooth shocks to farm income by altering their consumption of leisure.

preferences are such that additions to wealth change their risk aversion (for example, DARA or DRRA), the insurance effects may induce the household to undertake riskier choices. Decoupled payments are an example of an income transfer and so are expected to increase farm households' consumption expenditures and leisure, while decreasing the amount of labor. While these payments are also expected to affect farmers' risk aversion, this effect should be quite small because the magnitude of payments usually represents very small changes in overall wealth.

Using farm household survey data, Burfisher and Hopkins (2003) concluded that decoupled payments improved the overall well being of recipient farm households, enabling them to increase spending, better smooth consumption during periods of low income, and reduce their work hours, including non-farm labor. Finally, recipients were found to allocate a large share of their investments to assets unrelated to agricultural production, suggesting these non-farm investments were important in savings allocation and in adjustments to changes in risk attitudes attributable to the payments. While suffering from a few data and methodological limitations, such as the assumption that farm households allocate their decoupled payments in the same fashion as they allocate total income, the results of this study are somewhat at odds with the inclination for allocating the greatest share of decoupled payments to farm uses (67.9 percent) versus household uses (32.1 percent) revealed by the 2003 ARMS survey (Goodwin and Mishra 2005).[28] The findings from this survey seem to suggest that decoupled payments would be expected to have small effects on household consumption, and non negligible effects on production. This questions the extent to which direct payments are being put to their original use.

The effects of government payments on farm households' consumption expenditures were studied by Carriker *et al.* (1993) using KFMA data from 1976-90. The authors examined the households' propensity to consume from separate income sources, including farm income, government payments, and off-farm income. Following the idea devolved by Friedman (1957), the authors found that more volatile incomes were associated with lower marginal propensities to consume (MPC), net farm income being more volatile than off-farm

[28] The issue of fungibility is an important one, and we will return to it in the next section.

income and government payments.[29] Their estimation method, however, did not take into account the correlation between the lagged dependent variable and the error term induced by the presence of omitted variables. More recently, Sand (2002) used a GMM-system estimator to estimate a dynamic consumption model and investigate the MPC farm subsidies, production dependent farm income, off-farm income, and other sources of income. The results from this study, which used data on 258 Norwegian farms from 1976-1997, also supported the hypothesis that MPC of volatile incomes are lower than MPC of stable incomes.

The goal of this section is to analyze the effect of AMTA payments on farm households' consumption expenditures. If, as intended by policy makers, AMTA payments increase the well-being of farm households, we should find a strong relationship between government transfers and farmers' living expenditures. Our use of KFMA data allow us to examine the fungibility of AMTA payments while our use of panel data estimators allow us to condition observed events on farm fixed effects that cause consumption expenditures to change across farm households that were ignored in Carriker *et al.* (1993).

3.3.1. Empirical framework and data

As in Carriker *et al.* (1993), we expect farmers' consumption expenditures to be fundamentally determined by their income. This income has many sources, including farm, AMTA payments, and off-farm income. In fact, the farm business has been playing a smaller role in determining the well-being of farm households, as nearly 90 percent of total farm household income in 1999 originated from off-farm sources, and the contribution of off-farm income alone amounted to 53 percent of total farm household income (Mishra *et al.* 2002). In

[29] Friedman (1957) suggested that income uncertainty increases the need for precautionary saving, and so increases in risky income should not be expected to have the same effects on consumption as increases in less risky income (or the same MPC), as reserves are required to maintain the standard of living. Commenting specifically on the differences in ratios of average consumption to average income for farm and non farm households, Friedman suggested that the lower ratio found in the former could be attributed to "the larger variance in the transitory components of income", which meant that "farmers have a greater need for a reserve against emergencies than nonfarmers" (p. 69).

addition, it is possible that the off-farm work and consumption expenditures decisions are made simultaneously, as farm households attempt to augment their riskier farm income with more stable sources of income. Finally, we expect farmers to attempt to smooth consumption over time, and so exhibit some degree of persistence in their expenditures. The basic estimating equation is given by

$$\begin{aligned} Consumption_{ict} = {} & \beta_0 + \beta_1 Consumption_{ict-1} + \beta_2 FarmY_{ict} + \beta_3 OffFarmY_{ict} + \\ & + \beta_4 GP_{ict} + \beta_5 Wealth_{ict} + \eta_{ct} + u_{ict} \end{aligned} \tag{3.11}$$

where, for the ith farm, $Consumption_{ict-1}$ measures consumption expenditures in the previous period, $FarmY_{ict}$ is net farm income (minus estimated AMTA payments, to avoid double counting), $OffFarmY_{ict}$ is off-farm income, and the remaining variables have the usual interpretation.

We further expect much of the remaining variation in consumption expenditures to be explained by unobserved characteristics of the farms, such as farmers' preferences or willingness to save. To account for the possible correlation between this unobserved time-invariant heterogeneity and the regressors we also specify the following alternative equation with a farm-specific fixed effect a_i:

$$\begin{aligned} Consumption_{ict} = {} & \beta_0 + \beta_1 Consumption_{ict-1} + \beta_2 FarmY_{ict} + \beta_3 OffFarmY_{ict} + \\ & + \beta_4 GP_{ict} + \beta_5 Wealth_{ict} + a_i + \eta_{ct} + u_{ict} \end{aligned} \tag{3.12}$$

Due to the presence of the individual farm effects (a_i), the explanatory variable $Consumption_{ict}$ is positively correlated with the error term $(a_i + \eta_{ct} + u_{ict})$, a correlation that does not vanish as the number of individuals or time periods increases. This causes OLS to be inconsistent; at least in large samples, standard results for omitted variable bias indicate that the OLS estimate of the lagged dependent variable coefficient is biased upwards. The within transformation provided by the FE estimator also induces a non-negligible correlation between the transformed lagged dependent variable and the transformed error term, a correlation that can be shown to be negative. Because this correlation does not vanish as sample size increases, FE is also inconsistent; at least in large samples, standard results for omitted variable bias indicate the FE estimate of the lagged dependent variable coefficient is

biased downwards. The fact that these estimators are biased in opposite directions is helpful. For a correctly specified model, they provide us with bounds for a consistent estimate of this coefficient.[30] This consistent estimate is given by the GMM estimator proposed by Arellano-Bond (1991) and Arellano-Bover (1995)/Blundell-Bond (1998), which is able to accommodate dynamic models. Because lagged levels are often weak instruments for differences when the series have near unit root properties, Blundell and Bond (1998) suggested including the original equations in the estimation, and instrumenting the levels of endogenous variables with lags of their own differences. This is known as the "system GMM" estimator of Arellano and Bover (1995) and Blundell and Bond (1998), which combines the standard set of equations in first differences (with suitably lagged levels as instruments) with an additional set of equations in levels with suitable lagged first differences as instruments. This estimator is preferred when estimating the autoregressive parameters using persistent series, as this can cause the instruments available for the equations in first differences to be weak, and in turn cause large finite sample bias (Bond 2002).

The data used in our study of farmers' consumption response to AMTA payments are a subset of those used in the first segment of our empirical analysis. We dropped observations on farms deemed "incomplete or atypical of farms in the country or region" by the Extension Association Economist of the Department of Agricultural Economics from Kansas State University. This reduced our sample to between 395 farms (in 2001) and 523 farms (in 1996) per year, for a total of 2773 observations.

This segment also involves calculating additional variables, such as the on- and off-farm income and the farm family's living expenses. On-farm income is given by the *Net Farm Income* variable reported in the data, which equals the value of farm production minus cash operating expenses minus depreciation minus an accrued income-expense adjustment (minus our estimate of AMTA payments).[31] Off-farm income is obtained by adding the wages, rent and royalties, and dividends and interest variables. The data include family living expenses for those farmers that kept family living records. These expenses include spending

[30] For more on this issue, see Bond (2002).
[31] Unlike in the previous section, AMTA payments are not subtracted from farmers' wealth.

on items such as medical care, food, clothing, education, and life insurance. Table 3.15 summarizes the data used in this section.

Table 3.15. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Number of farms (per year)	2,773	462.17	51.86	395	523
Government Payments ($1,000)	2,773	37.68	36.47	0.00	350.37
AMTA payments (PFC+MLA) ($1,000)	2,773	20.36	17.18	0.00	127.32
Expenditures on consumption ($1,000)	2,773	18.96	16.52	0.00	144.21
Net farm income ($1,000)	2,773	22.53	67.08	-596.01	605.86
Non farm income ($1,000)	2,773	17.69	21.16	0.00	258.92
Wealth ($1,000)	2,773	489.53	450.78	-460.88	4,578.81
Operated Acres, Total	2,773	1,731.97	1,169.84	52.00	9,961.00
Operated Acres, Owned	2,773	566.85	611.86	0.00	6,771.00
Operated Acres, Rented	2,773	1,165.04	1,043.60	0.00	8,546.00
Acres of Crops	2,773	1,260.57	835.97	48.00	6,066.00
Acres of Crops, Owned	2,773	397.23	424.86	0.00	3,382.00
Acres of Crops, Rented	2,773	863.20	765.26	0.00	6,066.00

For all the farms in our sample (used in the first segment of analysis), wages represent an average of about 42.37 percent of off-farm income. The importance of wages on off-farm income for the smaller set of farms is 48.76 percent. These farms have a net farm income of $22,527 and a non-farm income of $17,690. This net farm income figure is lower than the $43,946 figure reported by Albright (2001), but it must be noted that ours is net of estimated AMTA payments. On average, the farms in this subset operate fewer acres than those used in the previous section, 1,732 acres versus 1,789 acres in the first segment, but they actually plant more acres, 1,261 acres versus 1,150 acres in the first segment.

3.3.2. Empirical results

We estimate equation (3.12) using OLS, FE, and GMM; year dummy variables are included throughout. The first two procedures give us the bounds for what should be the consistent estimator of β_1. We again employ the two-step GMM estimator with the Windmeijer

correction and use orthogonal deviations to purge the unobserved heterogeneity. Table 3.16 reports the estimation results. Column (1) reports the results from the OLS estimator, column (2) reports the results from the FE estimator, and column (3) reports the results from the GMM estimator. In the latter estimator, the endogeneity of non-farm income was evaluated through the difference-in-J statistic, or C statistic. This statistic is a test of the exogeneity of one or more instruments, and it is asymptotically chi-squared with degrees of freedom equal to the number of variables suspected of being endogenous. The C statistic had a value of 0.45 which, for a chi-squared with one degree of freedom, implied a p-value of 0.502. We thus fail to reject the null hypothesis of exogeneity of non-farm income.[32] Along with equation (3.12) we estimate an alternative equation that does not incorporate habit persistence. The results from this estimation appear in columns (4) and (5). Column (4) reports the results from the OLS estimator and column (5) reports the results from the FE estimator under this hypothesis.

Consumption expenditures do not seem highly persistent. The OLS coefficient, while statistically different from zero, is also statistically different from one, suggesting the series is not close to having an exact unit root. The coefficient on the FE estimator is lower, as expected due to the downward bias typical of small samples, and the GMM coefficient estimate lies between the two; the coefficient estimates for this regressor are not statistically different from zero.

Although the coefficient estimate on wealth is positive and statistically different from zero under GMM, it is not different from zero under FE, and is significantly negative under OLS for both equations. But the overall effect is very small, as that found by Langemeier and Patrick (1990).

Non-farm income appears as a significant determinant of consumption expenditures across the three estimators. When habit persistence is incorporated into our model, all else constant, the MPC non-farm income varies between 0.043 and 0.064, which correspond to

[32] To avoid the potential for a large finite sample bias caused by weak instruments, we further used the Arellano-Bover/Blundell-Bond system GMM estimator to estimate equation (3.12). The coefficient estimate of wealth was negative and statistically significant, a result which is not reasonable under the life cycle theory developed by Ando and Modigliani (1963). These results are not shown.

the OLS and GMM estimators. In fact, when using FE to eliminate the unobserved effects, non-farm income is the single determinant of consumption expenditures, with the FE and GMM estimates of the coefficient suggesting that a $1,000 increase in non-farm income raises consumption expenditures by about $70.

Table 3.16. Parameter estimates and summary statistics for consumption expenditures

	OLS	FE	GMM	OLS	FE
Consumption expenditures ($1,000)	(1)	(2)	(3)	(4)	(5)
Consumption expenditures$_{t-1}$ ($1,000)	0.767 *	-0.060	0.015	-	-
	(0.031)	(0.077)	(0.092)	-	-
Wealth ($1,000)	-0.002 *	0.002	0.005 **	-0.007 *	0.002
	(0.001)	(0.003)	(0.003)	(0.001)	(0.002)
Net farm income ($1,000)	0.013 *	0.008	0.007 ***	0.037 *	0.007
	(0.004)	(0.005)	(0.004)	(0.006)	(0.004)
Non farm income ($1,000)	0.043 *	0.068 ***	0.064 ***	0.118 *	0.048 **
	(0.014)	(0.035)	(0.039)	(0.019)	(0.022)
AMTA payments ($1,000)	0.034 **	0.089	-0.014	0.152 *	0.076 ***
	(0.016)	(0.062)	(0.052)	(0.029)	(0.043)
N	1990	1990	1442	2773	2773
R^2	0.5964	0.8090	-	0.0593	0.8029
AR(2) in first differences	-	-	0.1340	-	-
Hansen J	-	-	0.5600	-	-
Number of instruments	-	-	9	-	-

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. AR(2) is test for second-order serial correlation. Hansen J is a test of the overidentifying restrictions of the GMM estimator, asymptotically distributed as χ^2 with degrees of freedom equal to the number of instruments. P-values reported.

Net farm income, while statistically significant under all estimators except FE, has much lower coefficient estimates than non-farm income, ranging from 0.007 to 0.037, under GMM and OLS methods without habit persistence, respectively. This conclusion is consistent with the increasing role of off-farm income in closing the income gap between farm and non-farm households and in reducing income inequality among farm operator

households (Ahearn *et al.* 2005). It is also consistent with Friedman's hypothesis that more volatile income should correspond to a lower MPC. At the same time, the result raises some issues that concern the fungibility of the different sources of income.

Fungibility means that money has no labels, and that the effects of receiving $1,000 in AMTA payments should be equivalent to a $1,000 increase in net farm income or to a $1,000 increase in non-farm income. Furthermore, the MPC these different sources of income should be equal. Along with other conclusions that arise from the permanent income hypothesis, the hypothesis that various forms of wealth should act as close substitutes does not test very well.[33] According to Thaler (1990), fully anticipated or predictable income, such as off-farm wages, would be consumed at a higher rate than less regular income, such as farm income. This is largely related to income variability, as households with more stable incomes have less need to offset income fluctuations with savings. Along with uncertainty, Thaler suggested income variability could lead households to have a system of mental accounts where income was classified as current, asset, and future, and the MPC the first was close to unity, that of the third was close to zero and that of the second was somewhere in between. Thus, households are able to consume incomes from separate sources differently. If farm households view off-farm income and government payments as being less volatile than farm income, the propensity to consume off-farm income and government payments should be higher than the propensity to consume farm income. In this sense, our results support Friedman's hypothesis that less volatile incomes should have greater MPC, as non farm income has a lower "overall", "between", and "within" standard deviations than net farm income.

The coefficient estimates on AMTA payments are not statistically different from zero except under OLS when habit persistence is incorporated into the model, and the coefficient lies between that of net farm and non farm income, and under OLS and FE when it is not, where it lies above that of non farm income. This is consistent with the idea that farm households, having incomes with various risks, may have different MPC by income source.

[33] Other empirical anomalies include the extreme sensitivity of consumption to income and the fact that when compared to expenditure level implied by the present value of wealth, over the life-cycle the middle-aged consume too much while the young and the old appear to consume too little.

Note, however, that the coefficient estimate is negative under difference GMM, suggesting AMTA payments could have a negative effect on farm household spending, although this coefficient is not statistically different from zero.

In conclusion, our results suggest that AMTA payments do not matter for farmers' consumption expenditures and cast a doubt on whether the goal of income support is being met. If farmers are not using government transfers to improve their well-being, the argument underlying the distribution of these payments becomes invalid.

3.4. Conclusions

This section estimated the impact of AMTA payments on farmers' acreage and household consumption expenditures in the presence of credit constraints. Our use of farm-level data from the KFMA allowed us to improve on earlier studies by letting us account for historical values of key variables that could otherwise complicate the identification of causal effects of policy variables. Had AMTA payments been put to their intended use, we should have been able to find insignificant results in our first segment of our analysis and significant results in the second segment. This was not what our results revealed.

In the first segment, we explored the impact of AMTA payments on total crop acres, owned crop acres, on acres of specific crops, and on pasture acres. Overall our results supported our first hypothesis, that AMTA payments have significant, though small, acreage effects. We also found that accounting for unobservable sources of heterogeneity severely decreased the magnitude of these results. For example, using OLS, we found that a $1,000 increase in AMTA payments would bring about a 24 to 26 acre increase in total crop acres, a number which decreased to about 4 to 6 acres when FE and GMM methods were used. For a farmer without debt, these coefficients implied elasticities that ranged from 0.061 to 0.404; these values increased to 0.074 to 0.406 when the average level of debt was considered. These elasticities were somewhat smaller when owned acres were considered, varying between 0.017 and 0.136; in both cases the lower and upper bounds pertain to the GMM and OLS without dummy variables estimators, respectively. We also explored how AMTA

payments affected the farmers' decisions to plant corn, sorghum, soybeans and wheat. When accounting for unobserved sources of heterogeneity, our results revealed that, for the crops whose acreage increased over the FAIR Act period, corn and soybeans, AMTA payments had significant acreage effects, whereas for the crops whose acreage decreased over the period, sorghum and wheat, AMTA payments were not significant determinants of acreage decisions. For these estimators, for a farm with the average level of debt, the AMTA payments elasticities of corn acres varied between 0.1737 and 0.7054, and the AMTA payments elasticities of soybeans acres varied between 0.1290 and 0.3394. These were higher than those found in the total crop acres equation, and also greater than those found by Goodwin and Mishra (2006). Except for owned acres, our results did not support our second hypothesis, that AMTA payments matter more for the more highly leveraged farmer.

In the second segment of our analysis, we analyzed the farm household income support aspect of AMTA payments by estimating the MPC these payments. While fungibility implies that all moneys are equal, we found this not to be the case. When methods that account for the presence of unobserved effects were used, the only common finding was the importance of non-farm income as a determinant of farm household consumption expenditures. In particular, when including habit persistence in the model and accounting for unobserved effects, the effect of AMTA payments was not statistically different from zero. This raises doubts about whether the goal of farm income support measures is being met, or are these subsidies being put to alternative uses, namely production. While in theory decoupled payments should not affect production decisions, wealth effects and their impact on risk aversion, or the presence of credit constraints can thwart their decoupled nature and lead to distortions in production. Using farm-level data that allows us to purge unobserved sources of heterogeneity we found such production distortions, though modest in magnitude.

Finally, note that due to our inability to observe the actual AMTA payments received by the farmers, our estimation was based on estimates of these payments. These estimates did not account for possible changes in base acreage and consequently of the payments themselves except for the change in rates (and the presence of MLA payments after 1998). Future research would benefit from access to these data.

Chapter 4

Acreage and borrowing decisions under risk: a simulation approach for Kansas wheat

4.1. Introduction

Meant to signal a transition away from market intervention by the U.S. government, the 1996 Farm Bill replaced the traditional mechanisms of income support awarded on a per unit basis by PFC payments, fixed annual lump-sum installments based on historical production. These payments, meant to decline each year until the expiration of the Act, were expected not to distort production or trade, and so be consistent with the market liberalization commitments agreed to in the Uruguay Round negotiations. But any perceptions that these payments were temporary were dismissed when the 2002 Farm Bill was passed by Congress, replacing PFC payments by DP (Goodwin and Mishra 2005). The bill also institutionalized the *ad hoc* MLA payments in place in the late 1990s due to the decline in world commodity prices and localized yield shortfalls, making CCP available when market prices went below the target levels defined in the legislation. Like PFC and DP, CCP were calculated using historical base acres and yields. Other highlights of the bill included the opportunity to update crop bases and, under some conditions and only for the purposes of CCP, yield bases. The bill also revised national and county loan rates used to calculate LDP and marketing loans, whose

provisions remained similar for a greater number of products.

From the many controversial issues involved in the Congressional debate leading up to the 2002 Farm Bill, perhaps none was more contentious than the setting of tighter limits on the level of farm payments (Miller *et al.* 2003). This, however, did not happen, and the limits were continued from the previous bill. The limits per individual farmer were set to $40,000 for DP, $65,000 for CCP and $75,000 for marketing loans, a total limit of $180,000, increased two-fold to $360,000 through the still in place "three-entity rule".[34] Despite the fact that payment limits did not change, the 2002 Farm Bill included a requirement for the creation of a special commission to investigate the potential impact of payment limits.

Using a simulation approach similar to Hennessy (1998), Goodwin (2006) evaluated the effects of proposals to strengthen limits on acreage for corn, soybeans, wheat, cotton, and rice in several important producing states under discussion in the Senate. Like in Miller *et al.* (2003), results suggested payment limits were unlikely to affect acreage decisions except for cotton and rice, where the probability that the limits would be binding was greater.[35] Indeed Hennessy's work was paramount in showing how, in the presence of uncertainty, support policies deemed decoupled in a deterministic world affect the decisions of risk-averse producers so that they are not, in effect, decoupled. Using a simulation approach to quantify the changes in input choices brought about by insurance, wealth, and coupling effects of decoupled payments, he showed DARA preferences were sufficient to guarantee input choices increased along the magnitude of support. While Hennessy and Goodwin both assumed a farmer choosing inputs to maximize expected utility of total profits, they did not consider the possibility of the farmer being unable to attain the desired level of inputs due to credit constraints. But studies have shown that farmers facing binding credit constraints will under-invest relative to those who are unconstrained in the credit market (Briggeman *et al.* 2008, Guirkinger and Boucher 2006).

As such, further analysis on whether and by how much the presence of government

[34] Because there was no limit on the use of generic certificates (allowing unlimited LDP and marketing loan gains), $360,000 was not an effective cap.
[35] For these crops, government payments per acre are generally higher than for corn, soybeans or wheat.

payments distorts production decisions, and should stricter payment limitations matter for those decisions, ought to include the presence of capital market imperfections, or credit constraints. Naturally, the probability that the constraint is binding should decrease with the increasing availability of signaling and/or screening devices. These include elements such as a positive credit history, the individual characteristics and skills of the borrower, a sufficiently good performance and satisfactory risk exposure of the credit-funded project. Additionally, the availability of collateral and the interest rate the farmer is willing to accept should also decrease the likelihood that the credit constraint is binding.[36]

The goal of our analysis is to revisit the analysis of farmers' optimal resource allocation in the presence of government payments, decoupled and not, and extend it to incorporate the optimal choice of investment levels in the presence of credit constraints. While decoupled payments depend solely on historical production conditions, so that they are not expected to have production effects, these effects could nonetheless appear through general wealth effects, changes in risk attitudes or through credit constraints. Like DP, CCP depend on historical base acres and yields, but they are triggered by prices falling below a predetermined target level, so that these could bear some influence on the farmers' current production decisions. This could make them at least partially or somewhat coupled (Westcott 2005). Also dependent on current market prices but at the full coupling extreme are Marketing Loans, since they put a base price on the crop and are paid based directly on what farmers produce. And while the loan prices are set at the national level by the 2002 Farm Bill, USDA can adjust them to reflect geographical differences. These payments are, according to Allen Gray, the only one of the three basic support mechanisms that should

[36] The willingness of the farmer to provide greater collateral or accept a higher interest rate does not by itself guarantee unconstrained access to credit. Stiglitz and Weiss (1981) showed that while in principle the excess demand for funds could be solved by raising the cost of the loan (through higher interest rates) or the collateral requirements (thereby increasing the liability of the borrower if the project does not succeed), these mechanisms could affect the riskiness of the pool of loans and so decrease the expected return to the lender through an adverse selection effect or an incentive effect. The adverse selection effect occurs when the borrowers who are willing to accept the higher interest rates or offer more collateral are those with a lower probability of repaying the loan, and so are "worse risks" for the lender. The incentive effect occurs when borrowers prefer riskier projects (with lower probabilities of success) with higher payoffs when successful. Under these circumstances, the authors concluded that rather then limiting the amount of the loan, or increasing the interest rate as the magnitude of the loan increased, lenders should limit the number of loans the bank would make.

impact planting decisions.[37] We then use this framework to perform two analyses. First, we analyze the production effects of a 100 percent increase in DP for a credit constrained farmer. Second, we observe the production effects of more stringent payment limits on FD, CCP and LDP such as those proposed by Senators Grassley, Dorgan, Hagel, and Johnson in February of 2005. The remainder of this chapter is organized as follows. We begin by presenting the theoretical framework that links the acreage and borrowing decisions to the financial conditions of the farm, namely the amount and type of government payments received. Along with the data, the next section discusses the simulation methods and the econometric techniques used to retrieve some of the variables necessary in the study. The results of the simulation for the general framework are then presented. The following section extends the model by considering the possibility of decreasing marginal yields and a wealth-dependent interest rate. The policy application is then performed using this extended model. Some concluding remarks are finally offered.

4.2. Conceptual framework

The model assumes a representative farmer who must make land management decisions while facing unknown future values of prices and yields. For tractability we focus on single crop farms. Given some subjective opinion about the joint distribution of prices and yields, P_t and Y_t, respectively, and her initial endowment of land $\bar{A}_t$ at time t, the farmer must choose δ, the ratio of planted acres to operated acres $(0 \le \delta \le 1)$ so that $A_t = \delta \bar{A}_t$, and B_t, the amount to borrow, to maximize her expected utility of wealth W_t, including changes brought about by discounted future expected profits. This is described by

$$(4.1) \quad V_t = \sum_{t=0}^{T} (1+\beta)^{-t} U[W_t]$$

where the utility function $U[\cdot]$ is assumed to be twice differentiable and quasi-concave and

[37] http://news.uns.purdue.edu/UNS/html3month/030221.Gray.farmbill.html.

β is the discount rate.

Wealth in period *t* is comprised by several categories of income, including market and government support-augmented income, along with initial liquidity and other sources of income. It consists of profits derived from production π_t, government payments GP_t, initial liquidity W_0, and exogenous income OW_t. Because both prices and yields are not observed by the farmer when production decisions are made, revenue from production ($P_t Y_t \delta \bar{A}_t$) is a risky variable. Alternatively, input prices and per acre costs (ω_{jt}, the per acre cost of input *j* and fixed costs FC_t) are known at the time crop acreages are allocated and the other relevant decisions are made. Implied in our profit function is the assumption that technology is linear in acreage and that marginal yields are constant in the neighborhood of the optimal level of acreage such that, all else equal, an additional acre will generate a constant addition to total output. This assumption is relaxed in a later section, and the implications from these different assumptions concerning technology are compared.

Government payments include Direct Payments (DP_t), Counter-Cyclical Payments (CCP_t) and Loan Deficiency Payments (LDP_t). DP, which do not depend on current market conditions but on historical base, are calculated using the payment rate $DP\text{rate}_t$, base acreage *bacres*, and base yield *byield*. They are subject to a payment limit $DP\lim$, defined by the 2002 Farm Bill as $40,000. Additionally, while the bill defines that these payments should not be made sooner than October 1st of the year the crop was harvested, advance payments of up to 50 percent can be made beginning December 1 of the calendar year before the year when the covered commodity was harvested. DP are given by

$$DP_t = \min\left(DP\lim, 0.85 \cdot DP\text{rate}_t \cdot bacres \cdot byield\right) \tag{4.2}$$

Contrary to DP, CCP and LDP depend on market conditions, in particular prices, as they are available for covered commodities whenever the effective price is less than the target price. But like DP, CCP depend on historical acres and yields. CCP are given by

$$CCP_t = \min\left(CCP\lim, 0.85 \cdot CCP\text{rate}_t \cdot bacres \cdot byield\right) \tag{4.3}$$

where $CCP\text{rate}_t$ is the commodity's payment rate given by

(4.4) $$CCP\text{rate}_t = \max\left(0,\ \left(P_t^T - DP\text{rate}_t\right)\ -\ \max\left(\text{LR}_t, \text{P}_t\right)\right)$$

where P_t^T is the target price, LR_t is the national loan rate, and $CCP\lim$ is the payment limit, set at \$65,000 by the 2002 Farm Bill.

Contrary to DP and CCP, LDP depend on current acreage, since they are a loan farmers receive per unit of production. LDP are given by

(4.5) $$LDP_t = \min\left(LDP\lim, \max\left(0,\left(LLR_t - P_t\right)\cdot Y_t \cdot \delta\overline{A}_t\right)\right)$$

where LLR_t is the local (county) loan rate, $LDP\lim$ is the payment limit, set by the Farm Bill at \$75,000, and $\delta\overline{A}_t$ is the number of acres put into production. So, government payments can be rewritten as $GP_t = GP_t\left(\delta\overline{A}_t; P_t, Y_t\right)$, which emphasizes their dependence on market conditions and the farmer's acreage choice, in turn linked to borrowing, as we explain next.

Farmers endowed with relatively little liquidity may ask for a loan to finance production. In this case, the maximum size of the loan depends on the both the borrower and the lender. We assume that in response to asymmetric information all loans are collateralized with the farmer's wealth at the end of the lending period, so that the loan amount is bounded by the relative size of the debt the bank allows the farmer to incur. This implies the upper limit on the loan amount is a certain fraction of the farmer's wealth, γW_t, where $0 \le \gamma \le 1$ is the allowable debt factor, depending on a number of features that typically characterize the financial profile of a potential borrower as viewed by the lending institution. These features include the past relationship of the farmer with the lending institution, the level of assets of the farm (that can act as collateral) and/or the level of liabilities, the number of years the farm has been in business, and the characteristics of the proposed investment. In addition to the limit on potential relative debt, the farmer also faces a credit cost that is increasing in the loan amount. We model this cost as αB_t, where $0 \le \alpha \le 1$ is chosen by the lender to reflect the

financial characteristics of the borrower.[38] This cost decreases the farmer's level of wealth. We begin by modeling this cost as independent of wealth, but relax this assumption in a later section.

Before we move on to presenting the farmer's optimization problem there are two issues that need to be clarified. These relate to the temporal aspects of the model. First, this is a model of farmers' behavior in a single period. It is not a model of farm dynamics. Even though there is borrowing in this model, repayment of loans is not explicitly addressed. The model describes the moment in time when the farmer is making the decision of how many acres to plant and how much money to borrow with only an expectation about future prices and yields (and consequently government payments). Given the acres she owns and the market returns she expects, and that borrowing comes at a cost, the farmer must decide how many acres to plant and how much money to borrow. Recall the greater her expected wealth at the end of the lending period, the greater the loan she can request. This loan, however, comes at a cost, increasing in the debt she incurs.

The second issue that needs to be clarified is the information known by the agents in this model at the moment the loan is negotiated. As mentioned, the farmer has only a subjective opinion about future prices and yields when she goes to bank to borrow to expand acreage. The type of investment we are interested in observing is investment in production, namely how government payments and the availability of credit interact to affect farmers' acreage choices. We assume the lender has the same expectation about future prices and yields, *i.e.* market returns, as the farmer. This symmetry may arise for a number of reasons. For example, the farmer may prepare a budget describing the uses of funds and expected market conditions at the time she asks for the loan. Or the bank's experience in granting

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[38] While we model the credit cost factor α independently of the allowable debt factor, so that total credit cost depends solely on the borrowing amount, we could also have assumed this cost factor is increasing in the fraction of wealth the farmer chooses to borrow, for example $\alpha = \gamma^{\theta} / \left(1-\gamma^{\theta}\right)$, $0 \le \theta \le 1$, further penalizing the farmer for incurring more debt. In spite of Stiglitz and Weiss' (1981) words of caution as to the use of the interest rate as a means of discouraging loan demand, one can think of α as an interest rate cost, which can be arbitrarily chosen by the lender as a reflection of the credit worthiness of the borrower. For example, for $\theta = 3/2$, for a debt factor of 0.15 the cost of credit is 0.061, and for a debt factor of 0.2 the cost of credit is 0.098. These are equivalent to having an interest rate of about 6% or almost 10%.

loans to farmers in the region for similar projects may supply them with similar information as the farmer. As such, the bank evaluates the farmer's expected wealth at the end of the lending period to judge her credit worthiness, whether to lend, and how much to lend at the beginning of the period.

With this background, the farmer's optimization problem of choosing δ and B_t given unknown future values of prices and yields is characterized by equations (4.6) to (4.10).

(4.6) $$\max_{\{\delta, B_t\}} U(W_t)$$

(4.7) $$W_t = W_o + OW_t + \left(P_t Y_t - \sum_{j=1}^{J} \omega_{jt} \right) \delta \bar{A}_t - FC_t + GP_t\left(\delta \bar{A}_t ; P_t, Y_t\right) - \alpha B_t$$

subject to

(4.8) $$W_o + B_t = \left(\sum_{j=1}^{J} \omega_{jt} \right) \delta \bar{A}_t$$

(4.9) $$\gamma W_t \geq B_t, \; 0 \leq \gamma \leq 1$$

(4.10) $$A_t \leq \delta \bar{A}_t, \; 0 \leq \delta \leq 1$$

Equation (4.7) is a statement of the wealth level of the farmer, which depends on initial liquidity W_o and exogenous income OW_t, unknown market returns minus known costs $\left(P_t Y_t - \sum_{j=1}^{J} \omega_{jt} \right) \delta \bar{A}_t - FC_t$, government payments $GP_t\left(\delta \bar{A}_t ; P_t, Y_t\right)$ and the cost of credit αB_t.

Equation (4.8) is the budget constraint, limiting expenditures on inputs to the value of the farmer's liquidity plus borrowing. This constraint can be thought of as a "cash on hands" constraint, limiting production to the farmer's ability to cover variable costs when planting decisions are made. Alternatively, equation (4.8) could have been modeled to include two additional terms. The partial advancement on direct payments created by the 2002 Farm Bill could be an additional source of funds, and fixed costs could be an additional use of funds in this equation. We chose to exclude these terms from equation (4.8) because they would be perfect substitutes for initial liquidity, W_o. More important for our analysis is the role these

terms play in equation (4.7), where they affect the collateral of the farm and thus the degree to which the farm is credit constrained and the degree of risk aversion. Our experiment of doubling the amount of DP captures these effects. Additionally, fixed costs are considered sunk in the short-run, and do not matter for current production decisions.

Equation (4.9) is the credit constraint, rationing the amount of the loan the farmer can request. The farmer is credit constrained if the amount of the loan she would like to borrow is greater than the fraction of wealth the lender specifies as the maximum debt allowed. We further allow the borrowing amount to be negative. While we specifically calibrate the amount of initial liquidity to avoid the situation when the farmer has more liquidity than she can spend on production, poor market conditions could in principle induce the farmer not to produce and set operated acres to fallow. We address this issue in greater detail in the next section. Finally, equation (4.10) simply states the farmer cannot allocate more land to production than her initial endowment.

Given this framework, we can now explore the interaction between the farmer's endowments, the credit constraints, and the various types of government payments set by policy. Recall that government payments are given by the sum of FDP, which depend solely on historical acres and yields, CCP, which depend on historical acres and yields and on whether current prices are lower than the loan rate, and LDP, which depend on current acreage and prices. Like the CCP, LDP are given if current prices are lower than the local (county) loan rate. So, government payments vary with current acreage choices solely when prices are low, specifically if they are lower than the loan rates. We begin by solving the budget constraint with respect to borrowing and substituting this into the cost of credit term in the wealth expression. To avoid clutter let $A_t^* = \delta^* \overline{A}_t$, where δ^* is the optimum ratio of planted to total acreage. At the optimum, the level of wealth given planted acreage and borrowing is given by

$$(4.11)\quad W_t^*\left(A_t^*\right) = \left(1+\alpha\right)\left[W_o + OW_t - FC_{it}\right] + \left(P_t Y_t - \left(1+\alpha\right)\sum_{j=1}^{J}\omega_{jt}\right)A_t^* + GP_t\left(A_t^*; P_t, Y_t\right)$$

which can be thought of as support- and other sources of income-augmented profit function, depending fundamentally on the variable of choice and the parameters of the model. Indeed

we can use the properties of the profit function to illustrate how the planting decision depends on the relationship between the levels of expected per acre market returns and government payments, and production costs. For a nonnegative level of planted acres, the wealth maximizing condition for an optimum is given by

$$\begin{aligned} &\frac{\partial W_t^*(\cdot)}{\partial A_t^*} = \left(P_t Y_t - (1+\alpha)\sum_{j=1}^{J} \omega_{jt} \right) + \frac{\partial GP_t^*(\cdot)}{\partial A_t^*} = 0 \quad \Leftrightarrow \\ &P_t Y_t + \frac{\partial GP_t^*(\cdot)}{\partial A_t^*} = (1+\alpha)\sum_{j=1}^{J} \omega_{jt} \end{aligned} \tag{4.12}$$

which implies acres will be put into production if expected market returns and government payments cover the borrowing-cost-augmented variable production costs. We now describe the three thresholds of interest that may arise. This description will help clarify the role government payments may play in affecting the farmer's choices.

The first threshold occurs when expected market returns and government payments are insufficient to cover the borrowing cost augmented variable production costs. This scenario is associated with expected very bad yields, very low prices, or both. In this case the farmer will choose to set all her land aside and not produce. No borrowing will take place. On the contrary, the farmer should save.

The second threshold involves positive market returns greater than variable costs but smaller than the borrowing cost augmented variable production costs. In this scenario, the farmer will choose to put all her acreage she can afford based on initial income into production, but again not to borrow. However, if prices are low enough that LDP should be in place, these payments may be used to cover borrowing costs and some positive amount of borrowing may take place. In the first and second scenarios, the borrowing constraint is unlikely to be binding.

Finally, the last threshold involves a situation when market returns are sufficiently high to cover production and borrowing costs. The farmer will put all her acres into production and borrow so as to finance expanding acreage, the limit to this expansion being the borrowing cost and credit constraint. In this setting, it is unlikely that coupled government payments have acreage effects, because a situation of high market returns will

probably be associated with high prices. However, even if the only government transfers the farmer is receiving are DP, with are independent of current acreage, the increase in wealth these transfers bring about increases the credit limit, thereby making the credit constraint to be less limitative.

We now turn to the application of this model and observe the impact of different levels of liquidity and credit limits upon the farmer's acreage and borrowing decision in the presence of credit constraints. We then observe the impact of changing the assumptions of a constant marginal productivity technology and of a wealth-invariant cost of credit. Finally, we apply our framework to analyze the effect of two policy changes. First, we change the amount of decoupled payments given to the farmer. Second, we observe the impact of stricter payment limitations on the farmer's optimal production decisions.

4.3. Modeling issues

We model a sole-operator producing winter wheat in Kansas. Following Goodwin (2006) and Hennessy (1998) we use a utility function that is flexible enough to accommodate different degrees of risk aversion. This utility function, first suggested by Pratt (1964), and a modification of the negative exponential form, has the desirable property that risk aversion recedes toward zero as wealth becomes very large. The utility function is given by

(4.13) $U\left[W_t\right] = -e^{-\lambda W_t} + \beta W_t$

where $\{\beta, \lambda\}$, $\beta > 0$ are the parameters characterizing this function. An advantage of this utility function is its ability to accommodate different risk preferences, such as Constant Absolute Risk Aversion (CARA) or DARA preferences; for example, if preferences are assumed to be CARA, $\beta = 0$. This allows us to experiment with different degrees of risk aversion in our calculation of optimal acreage and borrowing choices. Given that the literature typically attributes a very small importance to the role of preferences towards risk in inducing production effects, this exercise is especially interesting. Following Goodwin (2006) we set $\lambda = 1 \times 10^{-4}$ and $\beta = 9 \times 10^{-5}$. The coefficient of absolute risk aversion

associated with this utility function is given by

$$(4.14)\quad \rho\left(\mathrm{W_t}\right)=\frac{\lambda^2 \mathrm{e}^{-\lambda\pi}}{\lambda \mathrm{e}^{-\lambda\pi}+\beta}$$

The farmer is making acreage and borrowing decisions while facing unknown future values of prices and yields. For a given number of random draws N, and letting *i* refer to the ith realization of prices and yields, the expected utility function is given by

$$(4.15)\quad E\left[U\left[W_t\left(\delta\bar{A}_t, B_t; P_{it}, Y_{it}\right)\right]\right]=\frac{1}{N}\sum_{i=1}^{N}U\left[-e^{-\lambda W_t\left(\delta\bar{A}_t, B_t; P_{it}, Y_{it}\right)}+\beta W_t\left(\delta\bar{A}_t, B_t; P_{it}, Y_{it}\right)\right]$$

which highlights the dependence of expected utility on the parameters underlying the joint distribution of prices and yields. We simulate a large number (10,000) of correlated, random, log-normally distributed prices and Beta-distributed yields and define the objective and constraint functions in terms of these simulated values. We choose the ratio of planted to operated acres δ and borrowing B_t that maximize this function for the simulated correlated price-yield pairs.

Aside from conducting the experiment for different levels of payment limits, we alter some parameters of the model to allow us to observe the sensitivity of the solution to the degree to which the farmer is credit constrained. In particular, we experiment with different levels of initial liquidity and allowable debt. These variables are inextricably linked to the financial condition of the farmer, and so to her access to credit. We also carry out our experiment for seven different scenarios for costs, prices, yields and preferences. The first scenario is the baseline. The second scenario depicts a low cost situation, when production costs and rents are 60 percent of those in the baseline. In the third scenario, in addition to the low cost environment, prices are 60 percent lower than in the baseline. This scenario should imply greater CCP than the previous. The fourth scenario maintains the low cost environment but prices are 140 percent higher than those in the baseline. In the fifth scenario the environment is one of low costs, rents, and prices, but yields are above average by 140 percent. This scenario should result in the greatest governmental transfers. The sixth scenario is one of low costs, rents and prices, but preferences are assumed to be CARA (so $\beta=0$). Finally, the seventh scenario is also one of low costs, rents, and prices, but the farmer is risk-

neutral, so that she is simply a wealth maximizer. All else constant, these varying circumstances let us observe three things. First, allowing for different cost and risk preferences scenarios allows us to potentially characterize farmers with different cost structures and/or different behaviors towards risk. Second, we are able to observe how the degree to which a farmer is credit constrained affects her optimal choices of acreage and borrowing under different market conditions. Finally, we are able to observe how the optimal values interact with market conditions and ultimately result in different levels of government payments. While DP are completely based on historical production, recall CCP and LDP both depend on current prices and, in the case of LDP, current production as well.

There is a long-standing belief in the literature that crop yields are skewed, and possibly bimodal. Skewness in yields is expected due to adverse weather conditions and because of the biological constraints that naturally limit the maximum yields attainable during any given year. At the individual farm level, skewness may also depend on chemical applications, soils, and the investment in harvest equipment, all of which reduce the risk of extremely low yields. Because it can exhibit both negative and positive skewness, the Beta distribution is often used in the literature, and it is the distribution chosen to model yields in this study. The Beta probability density distribution is given by equation (4.16), where yields were scaled to lie in the unit interval by defining the maximum possible yield as 150 percent of the average yield

$$f\left(y;\alpha,\beta\right)=\frac{y^{(\alpha-1)}\left(1-y\right)^{(\beta-1)}}{B\left(\alpha,\beta\right)} \tag{4.16}$$

where $\{\alpha,\beta\}$ are the parameters of the distribution and $B(\alpha,\beta)$ is the Beta function appearing as a normalization constant to guarantee the total probability integrates to unity. We discuss this matter further in the next section, where the data are presented.

While the exact magnitude of price-yield correlation varies depending on the level of analysis, prices of agricultural products tend to be high when yields are low, and vice-versa. For a particular farm, yields and prices need not be related because the output of that farm should not affect prices in a noticeable manner. For a region or a state, however, since yields

of individual farms tend to be positively correlated, they also tend to be correlated with prices. Like Goodwin (2006) we assume that correlation to be -0.2 at the state level and use this to convert random draws from a multivariate normal distribution with a known degree of correlation to Beta and log-normal random draws with known correlation. Prices are assumed to follow a log-normal distribution.

We now discuss the data used to model our simulation to reflect the acreage and borrowing decisions of a wheat grower in Kansas, in 2004. Our goal is to observe how optimal acreage and borrowing choices change under different market conditions and varying specifications of risk preferences, alongside liquidity and credit availability conditions.

4.4. Data

The data come from a variety of sources, as information is required on prices, yields, production costs, government policy parameters, and other relevant factors. But because we are trying to model a Kansas farmer, our initial point of reference is the KFMA data. We start by discussing the variables that are taken from these data and then move on to describing the other data sources along with the assumptions we use.

The model refers to 2004, the second year of the 2002 Farm Bill, so we updated some key variables of the farms used in the previous chapter of this dissertation that produced wheat in 2004. All nominal variables were converted to real terms by dividing by the Production Price Index for All Commodities published by Bureau of Labor Statistics, (2004=100). These variables appear in Table 4.1. Columns (1) through (3) list the average, standard deviation and mean values for the 1,212 farms that produced wheat in 2004. Columns (4) through (6) list those statistics for the 577 farms that further produced wheat during the period 1998-2001. This period marks the reference period for base updates allowed by the 2002 Farm Bill.

Table 4.1. Key variables for selected KFMA farms, 2004[39]

	All farms			Farms that produced wheat in 1998-01		
	Average	St. Dev	Median	Average	st. Dev	Median
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Total acres operated	1,933.16	1,455.31	1,548.00	1,872.11	1,335.58	1,520.00
Owned operated acres	603.03	749.29	360.00	592.66	757.54	325.00
Total cropacres	1,433.06	1,142.70	1,146.50	1,430.13	1,079.94	1,165.00
Owned cropacres	417.17	524.08	244.50	435.27	590.43	239.00
Total wheat acres	544.63	505.75	410.60	532.73	456.71	415.00
Owned wheat acres	143.72	208.76	75.00	150.93	235.35	72.00
Yield (bu/acre)	39.70	15.57	42.75	40.02	14.80	42.92
Wheat base acres	383.81	346.36	296.00	408.20	309.93	348.67
Wheat base yield (bu/acre)	34.09	9.24	34.92	34.34	7.11	34.79
Average 98-01 wheat acres	-	-	-	515.60	411.65	427.98
Average 98-01 wheat yield (bu/acre)	-	-	-	44.01	8.32	44.10
Lagged Net Worth ($1,000)	1,380.32	1,062.61	1,116.85	1,359.32	1,076.11	1,089.68
Debt to asset ratio	0.1738	0.1794	0.1366	0.1781	0.1944	0.1335
Number of farms		1,212			577	

As expected, acres variables of the median farm are lower than those of the average farm. Choosing between the average and median farm represents, for all the farms or for the subset of farms that produced wheat in the 1998-2001 period, a difference of 385 acres or 352 acres, respectively. In order to avoid the upward distortion brought about the fact that there are a few very large farms in the data, we use the median farm as our reference. Total operated acres, the maximum number of acres the farmer can operate is then set at 1,520 acres. This variable, along with all the other variables used to calibrate the model, is described in Table 4.2.

[39] Farmers' net worth includes the value of rented land. When this value is not included in the calculation of the variable, average net worth of all farms decreases to $574.32 and that of the farms that produced wheat in 1998-01 decreases to $588.51; the values for the median farm are $408.36 and $428.09, respectively. Incorporating the value of rented land into assets implies the debt to asset ratio is underestimated. Once we subtract the value of rented land from net worth, the average debt to asset ratio of all farms becomes 0.3736 and that of the farms that produced wheat in 1998-01 becomes 0.3770; the values for the median farm are 0.3028 and 0.3020, respectively.

Table 4.2. Parameters for simulation

Variable	Value
Lambda (Utility function)	1.00E-04
Beta (Utility function)	9.00E-05
Alpha (Beta distribution for yields)	13.84
Beta (Beta distribution for yields)	6.92
Maximum yield (bu)	60
Price volatility	0.21
Initial (and maximum) total operated acres	1,520
Initial exogenous income	
Low liquidity ($)	23,189.88
Average liquidity ($)	46,379.76
High liquidity ($)	69,569.64
Other sources of income ($)	200,000.00
Debt factor (fraction of wealth)	
Low allowable debt	0.13
High allowable debt	0.25
Cost of credit	0.05
Variable costs ($ per acre)	41.91
Rents ($ per acre)	59.80
Fixed costs ($ per acre)	102.76
DP limit ($)	40,000.00
CCP limit ($)	65,000.00
LDP limit ($)	150,000.00
Base acres	428
Base yield (bu/yield)	44
FDP rate	0.52
Harvest national price ($)	3.19
Harvest state price ($)	3.00
Target price ($)	3.92
National loan rate (for CCP)	2.75
Local (county) loan rate (for LDP)	2.89

Because the 2002 Farm Bill allowed for base acres to be updated, and for those farmers who did so by adjusting them to reflect the 1998-2001 period, yield base for the purposes of calculating CCP could also be updated, we calculated the average wheat acres and yields for that reference period. For both the average and the median farmer, we found the 1998-2001 average acres and yields were greater than the 1996 Farm Bill acre and yield bases. And while average yields for the KFMA farms seem to have increased by almost 27 percent over the period, they are only slightly above the 43.25 bu/acre average for the state. Because the updated bases would imply greater CCP, we assume the farmer in our model

chose to update her bases to the 1998-2001 values. Since the Farm Bill only allowed the base yield update to be used in the calculation of CCP, and even so only 93.5 percent of the 1998-2001 average yields could be used, we revise the CCP equation as

(4.17) $$CCP_t = \min\left(CCP\,\text{lim}, 0.85 \cdot CCP\text{rate}_t \cdot bacres_{98-01} \cdot 0.935.byield_{98-01}\right)$$

where $bacres_{98-01}$ and $byield_{98-01}$ are the 1998-2001 acres and yields averages, respectively.

There is an assortment of statistical approaches to represent yield distributions. These approaches can be divided into two broad categories, depending upon whether they draw on a parametric distribution, or whether they draw on nonparametric techniques.[40] Most studies that recover the distribution of agricultural yields employ parametric methods, differing mainly in their choice of parent distribution. Each distribution has its merits, and as Ozaki *et al.* (2006) pointed out, "the characteristics of crop yields may be idiosyncratic and may vary by location, crop, and production practice. Thus, it is unlikely that any single parametric approach will be universally supported across different applications." (p. 5). Because of its ability to deal with skewness, we use the Beta distribution to estimate the parameters underlying the yield distribution.

State-level yield data for Kansas from 1970 to 2004 were used to model our yield distribution. These data are readily available online from USDA. As in Goodwin (2006), the data were detrended by assuming that yields over the period are dominated by a linear trend and that deviations from the trend should be proportional to the trend. We regressed yields on time to obtain predicted yields $\hat{y}_t$ and deviations from the trend $\hat{e}_t / \hat{y}_t$. Yields were then re-centered on the predicted yield for 2004 using

(4.18) $$\tilde{y}_t = (1 + \hat{e}_t / \hat{y}_t)\hat{y}_{2004}$$

This specification is common to some crop insurance products such as the Group Risk Plan.

Estimation using Maximum likelihood found $\alpha = 13.84$ and $\beta = 6.92$, and a

[40] Parametric methods have the advantage of working well under small sample conditions, but they require functional form and distributional assumptions. This makes them vulnerable to specification errors. Nonparametric methods do not require a priori assumptions on the distribution nor on the functional form, which makes them less susceptible to specification error and may result in more accurate and robust models. The disadvantage of these methods is that they are subject to the variance-bias trade-off, and they can be problematical when analyzing multiple variables with small samples.

goodness of fit Chi-squared test found Chi2(5) = 1.827 with a p-value of 0.8726, so the appropriateness of the distribution was not rejected by the data. Because state-level data were used to estimate these parameters, and farm-level yields are expected to be show greater variability than more aggregated data, we added a normally-distributed random shock to each replicated state-average yield; these shocks have zero mean and variance equal to 75 percent of the standard deviation of the detrended state average yield series.

Price volatilities are average historical values taken from unpublished data reported by the Chicago Board of Trade and the New York Commodity Exchange. These volatilities are taken from Goodwin (2006) as are rents, variable costs and fixed costs, which came from the State Extension Services from Kansas, and state and national average prices. We defer to the original paper for an overview of the methods employed to recover these values. Because fixed costs are on a per acre basis, we multiplied the total endowment of land by this cost to generate the final value used in the application.

We model three different cases for the initial liquidity of the farmer. These cases represent 25 percent, 50 percent, and 75 percent of the amount necessary to put the farmer's land endowment into production in the low cost scenarios ($92,759.52).[41] To see why we impose the low cost scenario, consider the following. When deciding how many acres to produce and how much money to borrow, the farmer is matching sources and uses of funds so that the equality of the budget constraint always holds. In terms of the optimum use of her endowment of land three situations may arise. First, the farmer may have enough liquidity put all her land into production. This is the case if her liquidity is equal to the endowment of land times variable costs. In this situation, the farmer does not borrow. She does not need to if she decides to put all her land into production (whether she does depends on expected prices and yields). Second, the farmer may have some amount of initial liquidity, but not enough to cover putting all her land into production. If this is the case, and depending on the expectation about futures prices and yields, she may choose to put as much land to

[41] Total variable costs per acre (rents plus variable costs) are $41.91+59.8=$101.71 in the baseline scenario, and $61.026 in the low cost scenarios. Putting all operated acres into production would then cost $154,599.2 in the baseline scenario or $92,759.52 in the low cost scenario.

production as she can by using a combination of her own funds and borrowing or simply by using her own funds. Finally, if the farmer's liquidity is greater than the cost of putting all her land into production, she cannot apply that extra liquidity into production and must save. Since our goal is to model a credit constrained farmer, the first and third possibilities are not interesting and we give the farmer less liquidity than that required to put all her land into production. Given the upper bound defined above we define the low liquidity level as $W_{0,1}$=\$23.189,88, the average liquidity level as $W_{0,2}$=\$46,379.76, and the high liquidity level as $W_{0,3}$=\$69,569.64.

The allowable debt factor represents the proportion of wealth the farmer is allowed to borrow. KFMA debt to asset ratios serve as reference values for this parameter. For both sets of farms, the average debt to asset ratio (about 17 percent) is above that of the median farm (about 13 percent). Also in both samples, the farmer on the 25 percentile has a debt to asset ratio of about 5 percent, while that on the 75 percentile has a debt to asset ratio of about 25 percent. We observe how the optimal solution changes as we first set the percentage debt factor to that of the median farm, so that γ_1=0.13, and then set the factor to that of the farmer on the 75 percentile, so that γ_2=0.25. Note that while we use the debt to asset ratio of the average and 75 percentile Kansas farmer to model our debt factor, this variable is meant to capture the *possibility* of borrowing. It does not represent the amount of debt the farmer already has. If we wanted to account for the possibility of the farmer already being in debt we could do so by subtracting a liability term in the wealth function. This would lower the amount of collateral of the farmer and increase the degree to which she is credit constrained.

Like initial liquidity, the choice of the amount of the other farm income variable requires some attention to the condition that the farmer is credit constrained. If, for example, we set this value to that of the lagged net farm income of the median farmer for the farmers in the smaller sample (\$1,089.68 thousand), excluding other sources of income such as government payments, and considering the lowest allowable debt factor of 0.13, the farmer can borrow up to \$141.64 thousand. This means that, at the lowest level of liquidity (\$23.19 thousand), the credit constraint is not binding and the farmer can afford to plant all her acres

by borrowing. While rescaling the lagged net worth of the KFMA farms by the proportion of planted wheat relative to operated acres (to $297,51 thousand) could be a solution, this too leaves the farmer with an unbound credit constraint in the low cost scenarios. We choose to further lower the other income variable to $200 thousand. Since the credit constraint is not binding for the higher liquidity case, this allows us to observe the different optimal choices under the credit constrained and unconstrained cases.

Finally, the policy variables such as the DP rate, payment limits, target price and the national loan rate came from the 2002 Farm Bill.

4.5. Simulation results

This section presents the results from the simulation, which we perform for different values of liquidity ($W_{0,1}$=\$23.189,88 , $W_{0,2}$=\$46,379.76 , or $W_{0,3}$=\$69,569.64) and allowable debt (γ_1=0.13 or γ_2=0.25). Furthermore, each of our experiments is performed for seven different scenarios. In each scenario we take 10,000 random draws of correlated prices and yields. The first scenario is the baseline, and the second to fifth scenarios vary in their treatment of costs, prices, and yields. Finally, scenarios six and seven vary in their assumption about risk preferences. The remainder of this section is organized as follows. We begin by describing the different scenarios and discussing their implications for the optimal decisions of the farmer. The simulation results from the basic framework are then presented. We then extend this framework to include the possibility of non-constant marginal returns to acres and the possibility of a wealth-dependent interest rate. Table 4.3 summarizes the parameterization of the different scenarios.

Table 4.3. Simulation scenarios

Scenarios	Description	Costs	Prices	Yield	Preferences
1	Baseline scenario	Baseline	Baseline	Baseline	DARA
2	Low costs	60 % of baseline	Baseline	Baseline	DARA
3	Low costs and prices	60 % of baseline	60% of baseline	Baseline	DARA
4	Low costs, high prices	60 % of baseline	140% of baseline	Baseline	DARA
5	Low costs and prices, high yields	60 % of baseline	60 % of baseline	140% of baseline	DARA
6	Low costs and prices, and CARA preferences	60 % of baseline	60 % of baseline	Baseline	CARA
7	Low costs and prices, and risk neutrality	60 % of baseline	60 % of baseline	Baseline	Risk neutrality

Note: Baseline values for costs are described in Table 4.2. Baseline values for prices and yields are those generated by the correlated log-normal and Beta distributions. Parameters for these distributions are described in Table 4.2.

As in Goodwin (2006), our baseline scenario uses the costs taken from the state crop budgets and assumes the 2004 state harvest-time price as a mean value for expected prices.[42] Given the distribution of prices and yields, initial liquidity, allowable debt, and DARA preferences, the farmer chooses the optimal level of acres and borrowing that maximize her expected utility of wealth. We expect increasing levels of liquidity to increase the number of acres planted. The effect of liquidity on borrowing depends on the degree to which the farmer is constrained by credit. To understand why, note that, all else constant, higher levels of liquidity imply a lesser need for borrowing in order to finance current production. So, for the farmer who is not credit constrained, higher levels of liquidity unequivocally lead to less borrowing. However, for the farmer who is credit constrained, higher levels of liquidity also imply greater wealth, which in turn enhances the farmer's ability to borrow. In this case, higher levels of liquidity should lead to more borrowing. Because we can follow the farmer's decisions for different levels of allowable debt for a given level of liquidity, and for different levels of liquidity for a given level of allowable debt, we can observe the production effects of lessening the degree to which the farmer is constrained by credit and those of increasing her liquidity. Finally, greater wealth could further induce positive production effects via its effect on risk aversion. This was shown by Sandmo (1971), who suggested that under DARA preferences, increases in wealth should make producers more willing to take on risk and

[42] Recall we assume that crop prices are log-normally distributed and negatively correlated with yields, which follow a Beta distribution.

increase production.

The second scenario assumes all production costs and rents are 60 percent of the levels reported in the crop budget. These lower costs could represent, for example, farms that are more efficient or that have lower rents. We expect optimal acreage and borrowing to be higher than in the baseline.

In addition to low production costs, the third scenario assumes market prices are 60 percent of those in the previous scenarios. This reduction in marginal returns for a given level of yields causes the acreage and borrowing decisions to be especially sensitive to government payments, namely the coupled type. Indeed, we expect CCP and LDP to be high in this scenario, as both types of payments are triggered by prices falling beneath the target level.

The fourth scenario has low costs and high prices. Specifically, we assume prices are 140 percent of their levels in the baseline scenario. Production should expand relative to the previous scenarios, so that both optimal acres and borrowing should be greater. But this level of prices should lead to much smaller LDP and CCP payments than in all previous scenarios, especially the third.

The fifth scenario still uses low costs and prices, but now yields are assumed to be 140 percent of the baseline. As in the previous scenario, higher returns should expand production. Additionally, the combination of low prices and high yields should bring about the greatest value in government payments, as LDP depend both on current prices and yields.

The sixth scenario, while similar to the third scenario in terms of low costs and prices, assumes that utility is CARA, or that $\beta = 0$. From equation (4.14), the assumption of CARA preferences implies $\rho\left(\mathrm{W_t}\right) = \lambda = 10^{-4}$. How the optimal acreage and borrowing decisions compare to those in scenario 3 under our assumption of DARA depends greatly on the value taken by the absolute risk aversion coefficient, which in turn depends on the level of wealth. Following Sandmo (1971) we expect a greater level of absolute risk aversion to lead to a lower level of production.

Finally, the seventh scenario combines the low cost and price environment with the assumption of risk neutrality. In this scenario, the farmer is maximizing expected wealth, not expected utility of wealth. The following section presents the main results from our

simulation.

4.5.1. Acreage and borrowing decisions in the presence of credit constraints

Table 4.4 through 4.10 report the simulation results. In each table, along with the optimal acreage and borrowing decisions, we report the absolute risk aversion coefficient at the expected utility maximizing level of production and the number of times the payment limits were reached (DP, CCP and LDP). Additionally, we present the average and standard deviation of final wealth, payment receipts (DP, CCP and LDP), yields, and prices.

Table 4.4 reports the results for the baseline scenario. The interaction of costs, expected prices and yields, and DARA preferences keeps optimal acreage under the farmer's endowment (1520 acres) for all levels of liquidity. Beginning with the lowest level of liquidity and allowable debt, the farmer puts only 299 acres to production, borrowing about $7,224. DP receipts are $9,793, well below their limit of $40,000; because they depend on historical acres and yields, these payments are the same across all scenarios. CCP receipts are slightly higher, $10,597; these payments remain unchanged across all scenarios, and across liquidity levels within scenarios, except for the third and fourth scenarios, when price conditions vary. The farmer receives $2,497 in LDP; as acres change across the scenarios, and across levels of liquidity or allowable debt within scenarios, the relative change in these payments equals that of acres. Along with market returns, initial liquidity and other sources of income, government payments provide the farmer with a wealth of $94,764. When liquidity doubles to $46,380, both borrowing and acres increase. Borrowing increases by 11.97 percent, and acres (and LDP) increase by 79.09 percent. This increase in payments, allowed by the additional liquidity and borrowing, combined with the additional liquidity, increase wealth by about $29,269, or 30.09 percent. The direction of the effects is very similar when initial liquidity further increases to its highest level, but the magnitude is smaller. Relative to the average liquidity case, acres (and LDP) increase by 44.16 percent and

borrowing increases by 10.69 percent (this is an increase of 158.18 percent and 23.94 percent relative to the low liquidity case, for acres and borrowing, respectively). Wealth increases by 23.60 percent (this is an increase of 61.77 percent relative to the low liquidity case). Under these cost and price conditions, this is a credit constrained farmer. When allowed to borrow a greater percentage of her wealth, borrowing and acres both increase. Relative to the low allowable debt case, borrowing increases by 77.97 percent across all liquidity levels, and acres (and LDP) increase by 18.52, 11.58, and 8.89 percent in the low, average, and high liquidity cases, respectively. The increased ability to borrow increases farmer's wealth by 1.22 percent, 1.04 percent, and 0.93 percent in the low, average, and high liquidity cases, respectively. Overall, under these cost and price conditions, our results allow us to observe the following. First, increases in liquidity bring about increases in both borrowing and acres. Furthermore, as liquidity increases, the magnitude of the relative changes in borrowing and acres decreases. Second, allowing the farmer to borrow a greater portion of her wealth by increasing the allowable debt factor allows her to expand production. Both of these changes bring about additional LDP receipts, further allowing wealth to increase. Finally, the observed increases in production are consistent with those expected under DARA preferences.

Table 4.5 reports the results for the low cost scenario (scenario 2). Low costs, set at 60 percent of those in the baseline scenario, boost the farmer's overall liquidity, allowing her to plant and borrow more than before. For the lowest level of allowable debt, acres increase between 87.05 percent and 112.58 percent, and borrowing increases between 107.26 percent and 115.96 percent, for the highest and lowest levels of liquidity, respectively. Both these ranges increase for the higher level of allowable debt, with the lower and upper bounds referring to the same levels of liquidity. In the high liquidity case, allowing the farmer to borrow a greater percentage of her wealth finally allows her to put all her acres into production. She actually borrows a lesser amount than in the average liquidity case, suggesting she is no longer credit constrained. As expected, wealth is generally greater under this scenario, and the coefficient of risk aversion is generally lower. Because LDP depend on current production, they are, on average, higher than in the baseline.

Table 4.6 reports the results for the low cost and low price scenario (scenario 3), where both prices and costs are set at 60 percent of the baseline. Price per bushel is now at around $1.80. Compared to the low cost scenario (scenario 2), both acres and borrowing increase despite the price decrease. This positive production effect is explained by the increase in the coupled elements of support CCP and LDP, which are triggered by prices falling below the target level. Additionally, across all levels of liquidity and allowable debt, CCP increase by 64.05 percent, and because they depend on current production, LDP increase between 431 percent and 443 percent, for the high and low levels of liquidity, respectively. This range, which corresponds to the high level of allowable debt case, is slightly higher than that of the low level allowable debt case. Under these poor price conditions, LDP limits are reached, and the number of times this happens increases with the farmer's liquidity and ability to borrow. When the farmer is allowed to borrow up to 13 percent of her wealth, the limit is reached in 1 percent of the replications in the high level of liquidity case, but when she is allowed to borrow up to 25 percent of her wealth, LDP limits are reached in the average and high levels of liquidity. Indeed, when the farmer is endowed with the highest level of liquidity, the number of times the limit is reached more than doubles relative to that in the low allowable debt case. Finally, despite the government outlays, wealth is slightly lower than in scenario 2.

Table 4.7 reports the results for the low cost and high prices scenario (scenario 4), where prices are now set at 140 percent of the baseline, about $4.2/bu. This scenario should bring about the smallest amount of coupled support. In fact, when compared to the low cost scenario (scenario 2), and across both levels of allowable debt, CCP decrease by 78.84 percent in the low and high levels of liquidity cases, and by 33.60 percent in the average level of liquidity case. LDP decrease by about 94 and 76 percent for those levels of liquidity, respectively. Despite the decrease in the coupled amount of support, the increase in revenue is enough to increase wealth, though this increase is very small in magnitude, varying between 1.09 percent and 1.18 percent in the low liquidity and allowable debt case, and in the high liquidity and allowable debt case, respectively. Interestingly, the effect of a 140% percent increase in prices increases planted acres in the average and high liquidity cases

relative to the low price scenario (scenario 3), but not in the low liquidity case, where planted acres decrease by about 3 acres in the low allowable debt case, and remain unchanged in the higher allowable debt case.

Table 4.8 reports the results for the low cost and prices, and high yields scenario (scenario 5), where yields are now set at 140 percent of the baseline, about 56.11 bu/acre. Prices are back to the level defined in the third scenario, where expected coupled government outlays were at their maximum. Because CCP depend on historical bases, given that expected prices are the same across these scenarios, so is their value. On the contrary, LDP are determined by current production, so that the combination of better yields and low prices results in a much higher level of payments. These increase as higher liquidity and higher allowable debt permit the farmer to put more land into production. The payment limit on LDP is reached the greatest number of replications under these cost, price, and yield conditions. For the highest level of liquidity, the limit on LDP is reached about 8 to 9 percent of the replications. This number is slightly lower for the average liquidity case, varying between 0.22 percent and 3 percent of the replications, for the lower and higher levels of allowable debt, respectively. Stricter payment limitations should have their greatest impact in this scenario.

Maintaining the assumption of low costs and prices as in scenario 3, Table 4.9 reports the results for an alternative assumption about preferences. Instead of DARA, preferences are now assumed to be CARA. The coefficient on absolute risk aversion is much higher than in the previous scenario, suggesting the farmer will be less inclined to put acres into production. Indeed, now the farmer uses some of her initial liquidity to save. Furthermore, while acres increase as liquidity increases, they do not respond to changes in allowable debt. This is consistent with the farmer's inclination towards saving. Relative to scenario 3, in the low allowable debt case acres decrease by between 42.12 percent and 49.84 percent, for the average and high levels of liquidity, respectively, and in the high allowable debt case by between 52.00 percent and 58.58 percent, for the high and low levels of liquidity, respectively. Because she is putting fewer acres into production, LDP are also much lower. Combined with the lower LDP proceeds, the lower profits from production explain the

decrease in wealth across the scenarios.

Finally, and again maintaining the assumption of low costs and prices as in scenario 3, Table 4.10 reports the results for the risk neutrality case, where the farmer is maximizing wealth. These results are identical to the DARA case. This suggests that, for the levels of wealth implied by our expected utility maximization exercise, the parameters used to calibrate the utility function place the farmer in a situation closer to risk neutrality than risk aversion.

Table 4.4. Scenario 1: Baseline

	Liquidity scenarios					
Variables	Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	299.03		535.53		772.03	
Borrowing ($)	7,224.29		8,089.14		8,953.98	
ρ(Wealth)	1.22E-08		1.19E-09		1.71E-10	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	94,764.37	8,186.99	124,033.35	13,581.28	153,302.32	19,684.86
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	10,597.34	6,412.61	10,597.34	6,412.61	10,597.34	6,412.61
Loan Deficiency Payments ($)	2,497.41	3,797.84	4,472.62	6,801.57	6,447.83	9,805.30
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	3.00	0.64	3.00	0.64	3.00	0.64
$\gamma = 0.25$						
Acres	354.41		597.54		840.67	
Borrowing ($)	12,856.91		14,396.05		15,935.19	
ρ(Wealth)	1.21E-08		1.31E-09		2.12E-10	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	95,916.34	9,319.11	125,323.22	15,146.14	154,730.10	21,504.68
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	10,597.34	6,412.61	10,597.34	6,412.61	10,597.34	6,412.61
Loan Deficiency Payments ($)	2,959.92	4,501.19	4,990.50	7,589.12	7,021.08	10,677.05
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	3.00	0.64	3.00	0.64	3.00	0.64

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.5. Scenario 2: Low costs and rents

Variables	Liquidity scenarios Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	635.66		1,039.88		1,444.10	
Borrowing ($)	15,601.92		17,080.07		18,558.23	
ρ(Wealth)	2.05E-12		1.22E-13		1.84E-14	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	191,399.14	16,123.36	241,424.52	26,848.41	291,449.91	37,839.42
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	10,597.34	6,412.61	10,597.34	6,412.61	10,597.34	6,412.61
Loan Deficiency Payments ($)	5,308.87	8,073.27	8,684.82	13,207.12	12,060.77	18,340.98
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	3.00	0.64	3.00	0.64	3.00	0.64
$\gamma = 0.25$						
Acres	844.22		1,268.20		1,520.00	
Borrowing ($)	28,329.55		31,013.54		23,189.88	
ρ(Wealth)	1.47E-12		1.52E-13		2.19E-14	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	204,646.84	21,599.12	255,927.33	33,040.75	296,270.82	39,914.97
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	10,597.34	6,412.61	10,597.34	6,412.61	10,597.34	6,412.61
Loan Deficiency Payments ($)	7,050.71	10,722.11	10,591.69	16,106.93	12,694.64	19,304.91
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	3.00	0.64	3.00	0.64	3.00	0.64

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.6. Scenario 3: Low costs and prices

Variables	Liquidity scenarios Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	646.236532		1050.402173		1454.567813	
Borrowing ($)	16,247.35		17,722.08		19,196.82	
ρ(Wealth)	1.63E-12		1.17E-13		1.99E-14	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		10	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	191,296.17	14,183.70	236,588.57	23,003.29	281,869.88	31,803.82
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	28,659.36	12,117.79	46,583.34	19,696.43	64,507.32	27,275.07
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39
$\gamma = 0.25$						
Acres	863.37		1,287.24		1,520.00	
Borrowing ($)	29,498.17		32,175.64		23,189.88	
ρ(Wealth)	1.29E-12		1.58E-13		2.34E-14	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		2		23	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	202,547.60	18,920.67	248,860.27	28,172.07	285,249.10	33,210.15
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	38,288.84	16,189.34	57,086.86	24,137.55	67,409.11	28,502.02
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.7. Scenario 4: Low costs and high prices

Variables	Liquidity scenarios					
	Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	643.44		1,052.61		1,461.78	
Borrowing ($)	16,076.78		17,856.90		19,637.02	
ρ(Wealth)	9.98E-13		4.40E-14		5.53E-15	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	209,184.26	26,055.05	275,832.61	43,510.98	342,480.96	61,032.48
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	2,241.96	4,257.87	2,241.96	4,257.87	2,241.96	4,257.87
Loan Deficiency Payments ($)	329.18	1,922.06	538.50	3,144.32	747.83	4,366.58
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	4.20	0.90	4.20	0.90	4.20	0.90
$\gamma = 0.25$						
Acres	863.17		1,296.68		1,520.00	
Borrowing ($)	29,486.23		32,751.13		23,189.88	
ρ(Wealth)	5.84E-13		5.02E-14		6.10E-15	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	231,899.77	35,415.24	301,063.32	53,958.49	348,499.48	63,527.71
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	2,241.96	4,257.87	2,241.96	4,257.87	2,241.96	4,257.87
Loan Deficiency Payments ($)	441.59	2,578.44	663.36	3,873.38	777.61	4,540.49
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	4.20	0.90	4.20	0.90	4.20	0.90

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.8. Scenario 5: Low costs and prices, and high yields

Variables	Liquidity scenarios: Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	663.10		1,077.67		1,482.98	
Borrowing ($)	17,276.72		19,386.26		20,930.41	
ρ(Wealth)	2.33E-13		1.64E-14		2.93E-15	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		22		737	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	222,910.47	20,338.81	287,940.68	32,969.41	350,799.21	43,807.64
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	41,170.38	17,407.72	66,909.80	28,290.89	92,073.99	38,930.86
Yields (bu/acre)	56.11	10.59	56.11	10.59	56.11	10.59
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39
$\gamma = 0.25$						
Acres	905.17		1,338.08		1,520.00	
Borrowing ($)	32,049.31		35,278.05		23,189.88	
ρ(Wealth)	1.71E-13		2.47E-14		3.19E-15	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	1		313		870	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	246,675.42	27,736.41	313,102.91	40,345.13	354,100.38	44,620.77
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	56,199.88	23,762.51	83,077.97	35,127.14	94,372.75	39,902.82
Yields (bu/acre)	56.11	10.59	56.11	10.59	56.11	10.59
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.9. Scenario 6: Low costs, prices and CARA preferences

Variables	Liquidity scenarios Low liquidity ($23,189.88)		Average liquidity ($46,379.76		High liquidity ($69,569.64)	
$\gamma = 0.13$						
Acres	357.65		608.00		729.60	
Borrowing ($)	-1,364.10		-9,275.95		-25,045.07	
ρ(Wealth)	1.00E-04		1.00E-04		1.00E-04	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	176,342.08	7,901.17	213,664.21	13,350.06	244,314.64	16,001.85
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	15,860.97	6,706.36	26,963.65	11,400.81	32,356.37	13,680.97
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39
$\gamma = 0.25$						
Acres	357.65		608.00		729.60	
Borrowing ($)	-1,364.10		-9,275.95		-25,045.07	
ρ(Wealth)	1.00E-04		1.00E-04		1.00E-04	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		0	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	176,342.08	7,901.17	213,664.21	13,350.06	244,314.64	16,001.85
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	15,860.97	6,706.36	26,963.65	11,400.81	32,356.37	13,680.97
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

Table 4.10. Scenario 7: Low costs, prices, and risk neutrality

Variables	Liquidity scenarios Low ($23,189.88)		Average ($46,379.76)		High ($69,569.64)	
$\gamma = 0.13$						
Acres	646.24		1,050.40		1,454.57	
Borrowing ($)	16,247.35		17,722.08		19,196.82	
ρ(Wealth)	0.00E+00		0.00E+00		0.00E+00	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		0		10	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	191,296.17	14,183.70	236,588.57	23,003.29	281,869.88	31,803.82
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	28,659.36	12,117.79	46,583.34	19,696.43	64,507.32	27,275.07
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39
$\gamma = 0.25$						
Acres	863.37		1,287.24		1,520.00	
Borrowing ($)	29,498.17		32,175.64		23,189.88	
ρ(Wealth)	0.00E+00		0.00E+00		0.00E+00	
Number of DP limit hits	0		0		0	
Number of CCP limit hits	0		0		0	
Number of LDP limit hits	0		2		23	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Wealth ($)	202,547.60	18,920.67	248,860.27	28,172.07	285,249.10	33,210.15
Direct Payments ($)	9,792.64	-	9,792.64	-	9,792.64	-
Counter-Cyclical Payments ($)	17,384.65	900.09	17,384.65	900.09	17,384.65	900.09
Loan Deficiency Payments ($)	38,288.84	16,189.34	57,086.86	24,137.55	67,409.11	28,502.02
Yields (bu/acre)	40.08	7.56	40.08	7.56	40.08	7.56
Prices ($)	1.80	0.39	1.80	0.39	1.80	0.39

Note: The number of DP, CCP, or LDP limit hits is the number of replications the limit on the specific payment was reached.

4.5.2. Extensions

This section extends our general framework. To relax the assumption that all acres are equal, we incorporate decreasing marginal yields into our model. We also allow for the level of wealth to affect the cost of credit. Intuitively, richer borrowers should be better able to overcome the signaling difficulties that arise in imperfect credit markets and obtain credit at better conditions. We begin by discussing the impact of changing our assumption regarding

technology and then move on to discussing that of having a wealth-dependent interest rate.

4.5.2.1. Decreasing marginal productivity of acres

So far, our framework assumes all acres are equal in the sense that yields are stable across space. This assumption is unrealistic, as heterogeneity of various factors within the field should cause yields to vary. For example, differing soil moisture content or irregular fertilizer application should cause yields to differ across individual fields within a farm.[43] In this section we assume that acres differ in their productivity. Furthermore, we assume that the farmer knows the productivity of her field and opts to put the most productive acres into production first.

The assumption of decreasing marginal yields enters our model by multiplying the Beta-distributed randomly drawn yield $yield_t$ by a correction factor. This correction factor acts as a "penalty" function, such that the new, acres-dependent yield $yield_t^P$ is given by

$$yield_t^P = yield_t\left(\tau_0 - \tau_1 A_t^2\right) \tag{4.18}$$

where $A_t = \delta \bar{A}_t$ are the previously defined number of acres produced, and $\tau_0 > 0$ and $0 \le \tau_1 \le 1$ are parameters. This very simple penalty function implies that, for a fixed value of the random draw,

$$\left.\frac{dyield_t^P}{dA_t}\right|_{yield_t} = -2\tau_1 yield_t A_t \le 0 \tag{4.19}$$

$$\left.\frac{d^2 yield_t^P}{d^2 A_t}\right|_{yield_t} = -2\tau_1 yield_t \le 0 \tag{4.20}$$

As more acres are added to production, yields decrease at a decreasing rate. Note that if $\tau_0 = 1$ and $\tau_1 = 0$ we are back to the general framework.

We calibrate parameters τ_0 and τ_1 to reflect some of the characteristics of our data.

[43] The next chapter of this dissertation explores the issue of yield performance in greater detail.

In particular, they satisfy the following two conditions. First, at the value of acres the farmer is endowed with (1520 acres), the acres-dependent value of yield is 80 percent of the Beta-distributed randomly drawn yield. Second, at the average number of acres planted by the KFMA farms that grew wheat in the 1998-2001 years (532.73 acres), there is no "penalty", and $yield_t^P = yield_t$, or $\tau_0 - \tau_1 A_t^2 = 1$. This generates a system of two equations in two unknowns with a single solution at $\tau_1 = 7.70\text{E}-08$ and $\tau_0 = 1.0219$. This parameterization implies that, until the KFMA average number of acres is reached, the acres-dependent yield is above the Beta-distributed randomly drawn yield.

Relative to the general framework, representing yields in this manner gives the farmer an incentive to add acres until the KFMA average is reached, while penalizing her if that threshold is passed. Because in all but the low liquidity, low allowable debt case in the baseline scenario, optimal acres are greater than the KFMA average, we expect planted acres to be above those of the general framework in the low liquidity level in the baseline scenario, and below those of the general framework in the average and high levels of liquidity in the baseline scenario and for all liquidity levels in the other scenarios. Table 4.11 and Table 4.12 report the results from our extended model alongside those of the general framework. The tables differ in the different levels of allowable debt. We report results for optimal acres and borrowing, wealth, LDP receipts, and the number of times the limit on these payments was reached. In each table, columns (1) and (2) refer to the low liquidity case, columns (3) and (4) refer to the average liquidity case, and columns (5) and (6) refer to the high liquidity case. For each level of liquidity, the first column reports the results from the general framework, while the second column reports the results from the extended version.

The effects of acknowledging that not all acres are equal are as expected. For the case when in the general framework acres are below the KFMA average, in the low liquidity level case in the baseline scenario, acres, borrowing, and wealth expand. For both levels of allowable debt, from column (1) to column (2), these variables increase by about 0.06 percent, 0.24 percent, and 0.61 percent, respectively. For the average and high liquidity levels, since acres in the general framework are above the KFMA average, assuming decreasing marginal yields lowers acres, borrowing, and wealth in all but the sixth scenario.

Under CARA preferences, the optimal decisions of the farmer do not change with the new assumption about technology. For the other scenarios, the greatest decrease occurs in the high allowable debt and liquidity case, where in the general framework the farmer was putting all acres into production. In Table 4.12, under low cost and price conditions, from column (5) to column (6) acres decrease by 6.32 percent, borrowing decreases by 25.29 percent, and wealth decreases by 9.51 percent. Finally, the number of times the limit on LDP is reached is also responsive to the change. For example, in Table 4.12, from column (3) to column (4) in scenarios 3 and 7, the number of times the limit on LDP is reached decreases by 100 percent, and from column (5) to column (6) this number decreases by 95.65 percent. The decrease in scenario 5 is slightly smaller, of 80.51 percent and 76.67 percent for those cases, respectively.

4.5.2.2. Wealth-dependent cost of credit

In general, market interest rates are assumed to reflect four elements: (1) a return to productive capital; (2) an adjustment in order to reflect a positive rate of time preference; (3) a premium for expected inflation, and (4) a risk premium (Goodwin and Mishra 1994). It is the fourth element, the risk premium, which would explain why at a point in time and for identical size and term loans, different borrowers face different interest rates. Different borrowers with different financial profiles are expected to exhibit different degrees of creditworthiness and, consequently, represent different probabilities of default. Intuitively, individuals with greater levels of wealth or lower liabilities should have better credit profiles. This, in turn, could lead to lower interest rates. This section extends the model to include a wealth-dependent cost of credit.

Table 4.11. Effects of decreasing marginal yields on selected variables, low allowable debt

$\gamma = 0.13$		Liquidity scenarios					
		Low ($23,189.88)		Average ($46,379.76)		High ($69,569.64)	
		Marginal yields					
		Constant	Decreasing	Constant	Decreasing	Constant	Decreasing
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	299.03	299.20	535.53	535.53	772.03	771.34
	2	635.66	635.29	1,039.88	1,035.86	1,444.10	1,431.68
	3	646.24	645.81	1,050.40	1,046.24	1,454.57	1,423.91
	4	643.44	642.95	1,052.61	1,047.57	1,461.78	1,446.31
	5	663.10	662.38	1,077.67	1,071.30	1,482.98	1,468.85
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	646.24	645.81	1,050.40	1,046.24	1,454.57	1,423.90
Borrowing ($)	1	7,224.29	7,241.29	8,089.14	8,088.67	8,953.98	8,883.79
	2	15,601.92	15,579.10	17,080.07	16,834.91	18,558.23	17,800.04
	3	16,247.35	16,221.60	17,722.08	17,468.27	19,196.82	17,325.59
	4	16,076.78	16,046.69	17,856.90	17,549.09	19,637.02	18,692.63
	5	17,276.72	17,232.61	19,386.26	18,997.46	20,930.41	20,068.21
	6	-1,364.10	-1,364.10	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	16,247.35	16,221.60	17,722.08	17,468.27	19,196.82	17,325.53
Wealth ($)	1	94,764.37	95,339.67	124,033.35	124,017.51	153,302.32	150,926.87
	2	191,399.14	190,626.79	241,424.52	233,127.33	291,449.91	265,790.51
	3	191,296.17	190,505.27	236,588.57	228,793.37	281,869.88	258,107.66
	4	209,184.26	208,057.71	275,832.61	264,308.09	342,480.96	307,122.72
	5	222,910.47	221,555.65	287,940.68	275,752.17	350,799.21	316,097.08
	6	176,342.08	176,840.23	213,664.21	213,197.77	244,314.64	242,694.59
	7	191,296.17	190,505.27	236,588.57	228,793.37	281,869.88	258,107.66
LDP payments ($)	1	2,497.41	2,536.23	4,472.62	4,471.55	6,447.83	6,287.52
	2	5,308.87	5,256.75	8,684.82	8,124.89	12,060.77	10,329.15
	3	28,659.36	28,346.37	46,583.34	43,498.48	64,507.32	54,658.51
	4	329.18	325.64	538.50	502.31	747.83	636.78
	5	41,170.38	40,634.22	66,909.80	62,084.30	92,073.99	78,023.08
	6	15,860.97	16,051.59	26,963.65	26,785.16	32,356.37	31,736.45
	7	28,659.36	28,346.37	46,583.34	43,498.48	64,507.32	54,658.48
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	10	1
	4	0	0	0	0	0	0
	5	0	0	22	6	737	161
	6	0	0	0	0	0	0
	7	0	0	0	0	10	1

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

Table 4.12. Effects of decreasing marginal yields on selected variables, high allowable debt

$\gamma = 0.25$		Liquidity scenarios					
		Low ($23,189.88)		Average ($46,379.76)		High ($69,569.64)	
		Marginal yields					
		Constant	Decreasing	Constant	Decreasing	Constant	Decreasing
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	354.41	354.69	597.54	597.32	840.67	838.87
	2	844.22	841.04	1,268.20	1,253.79	1,520.00	1,499.00
	3	863.37	859.88	1,287.24	1,272.13	1,520.00	1,423.90
	4	863.17	858.94	1,296.68	1,277.96	1,520.00	1,520.00
	5	905.17	899.01	1,338.08	1,320.09	1,520.00	1,520.00
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	863.37	859.88	1,287.24	1,272.13	1,520.00	1,423.90
Borrowing ($)	1	12,856.91	12,886.08	14,396.05	14,373.36	15,935.19	15,751.87
	2	28,329.55	28,135.57	31,013.54	30,134.06	23,189.88	21,908.08
	3	29,498.17	29,285.36	32,175.64	31,253.44	23,189.88	17,325.54
	4	29,486.23	29,227.94	32,751.13	31,608.88	23,189.88	23,189.88
	5	32,049.31	31,673.40	35,278.05	34,180.17	23,189.88	23,189.88
	6	-1,364.10	-1,364.10	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	29,498.17	29,285.36	32,175.64	31,253.44	23,189.88	17,325.51
Wealth ($)	1	95,916.34	96,473.57	125,323.22	124,889.72	154,730.10	151,227.55
	2	204,646.84	200,940.72	255,927.33	239,123.84	296,270.82	265,987.96
	3	202,547.60	198,866.54	248,860.27	232,909.45	285,249.10	258,107.66
	4	231,899.77	226,428.08	301,063.32	276,865.91	348,499.48	308,731.33
	5	246,675.42	240,173.68	313,102.91	287,599.02	354,100.38	316,952.81
	6	176,342.08	176,840.23	213,664.21	213,197.77	244,314.64	242,694.59
	7	202,547.60	198,866.54	248,860.27	232,909.45	285,249.10	258,107.66
LDP payments ($)	1	2,959.92	2,998.40	4,990.50	4,960.57	7,021.08	6,779.22
	2	7,050.71	6,794.80	10,591.69	9,431.39	12,694.64	10,624.41
	3	38,288.84	36,794.75	57,086.86	50,612.26	67,409.11	54,658.49
	4	441.59	424.04	663.36	585.77	777.61	656.12
	5	56,199.88	53,560.70	83,077.97	72,742.89	94,372.75	79,627.89
	6	15,860.97	16,051.59	26,963.65	26,785.16	32,356.37	31,736.45
	7	38,288.84	36,794.75	57,086.86	50,612.26	67,409.11	54,658.47
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	2	0	23	1
	4	0	0	0	0	0	0
	5	1	0	313	61	870	203
	6	0	0	0	0	0	0
	7	0	0	2	0	23	1

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

Recall from equation (4.7) that wealth is a function of initial and other sources of income, profits from production minus fixed costs, government payments, and the cost of

credit, which we assumed to be independent of the level of wealth. However we can think of this cost as being composed by two elements, a fixed element α_0 and a wealth-dependent element $\psi\left(Wealth_t\right)$, $\psi' < 0$, so that the full cost of credit is given by

(4.21) $CC_t = \left(\alpha_0 + \psi\left(Wealth_t\right)\right) B_t$

where B_t is the borrowing amount defined earlier. For simplicity, assume $\psi\left(Wealth_t\right)$ is linear in wealth, so that $\psi\left(Wealth_t\right) = \theta Wealth_t$, $\theta < 0$. Now wealth is given by

(4.22) $W_t = W_o + OW_t + \left(P_t Y_t - \sum_{j=1}^{J} \omega_{jt} \right) \delta \bar{A}_t - FC_t + GP_t\left(\delta \bar{A}_t ; P_t, Y_t\right) - \left(\alpha_0 + \theta Wealth_t\right) B_t$

or

(4.23) $W_t = \frac{1}{1+\theta B_t} \left[W_o + OW_t + \left(P_t Y_t - \sum_{j=1}^{J} \omega_{jt} \right) \delta \bar{A}_t - FC_t + GP_t\left(\delta \bar{A}_t ; P_t, Y_t\right) - \alpha_0 B_t \right]$

which is necessarily greater than the level of wealth given by equation (4.7) because $\theta < 0$. We further require $1 + \theta B \neq 0$.

Using ARMS data for 1997, Goodwin and Mishra (1994) found that farms with higher levels of wealth appeared to have lower farm interest rates. These rates were also decreasing in the term of the loan, the degree of diversification of the farm, the experience of the operator, and the fact that the operator lived on the operation. On the contrary, higher levels of liabilities increased interest rates. We performed a similar experience using KFMA data for 1999 through 2004, and observed the relationship between farm and operator characteristics and their interest payments. There were 2,516 farms in our sample, 993 of which present in the five year period; of these farms, 263 had only one observation. Some summary statistics of these data are reported in Table 4.13.

The table reports a simple average interest rate payment because the data do not allow us to distinguish between the different term loans. Since longer term loans tend to have lower interest rates than shorter term ones, retrieving the interest rate from these totals becomes infeasible. Indeed the average interest rate implied by these aggregates is about 0.6 percent, a value too low to be realistic. Current-term loans are responsible for the greatest loan share,

representing about 38 percent of total loans. Intermediate loans represent the smallest share. On average, total loans represent about 63 percent of the farmers' net worth.

Table 4.13. Summary statistics for selected variables for a panel of KFMA farms, 1999-2004[44]

	Average	St. Dev.
Interest payments ($1,000)	1.80	5.99
Total loans ($1,000)	261.76	330.39
Current loans ($1,000)	104.49	197.17
Intermediate loans ($1,000)	57.52	91.54
Long-term loans ($1,000)	99.75	149.28
Percentage of current loans in total loans	38.02	32.00
Percentage of intermediate loans in total loans	25.56	27.25
Percentage of long-term loans in total loans	36.43	31.27
Net worth ($1,000)	535.58	584.62
Net farm income ($1,000)	45.17	86.34
Debt to asset ratio	0.3850	0.3606
Operator age	53.22	12.94
Tenure	0.3811	0.5140
Operated acres, total	1,785.32	1,385.15
N	8909	

Because we expect the interest payments to be jointly determined by other variables, including loans, net worth, and total operated acres, we estimated a fixed effects model using GMM. In particular, we allowed loans, net worth, net farm income, and the debt to asset ratio to be jointly determined with the interest payments. Our instruments included the proportion of owned acres out of total operated acres (tenure), the age of the operator, and a set of year, region and farm type dummy variables.

Table 4.14 reports the parameter estimates along with those of using the simpler OLS estimator. Our results suggest that, all else constant, net worth decreases the interest payments made by farmers, although this effect is not statistically significant. Additionally, we find that net farm income (the value of farm production minus operating expenses and depreciation), while having a statistically significant negative effect on interest payments

[44] Net worth does not include the value of rented land.

under OLS, has an insignificant effect under GMM. Using these methods, which account for the fact that greater loans necessarily imply greater interest payments, only loans affect interest rate payments, so that an additional $1,000 of loans increases interest rate payments by about $11.53. Once unobserved effects and endogeneity are taken into account, the other variables were not found to be significant determinants of interest payments.

Table 4.14. Parameter estimates and summary statistics for interest payments

	Estimators	
Interest payments ($1,000)	OLS	GMM
Loans ($1,000)	0.0050 *	0.0115 ***
	(0.0008)	(0.0068)
Net worth ($1,000)	-0.0003	-0.0009
	(0.0002)	(0.0065)
Net farm income ($1,000)	-0.0036 **	0.0046
	(0.0014)	(0.0050)
Debt to asset ratio	0.5981 ***	0.0851
	(0.3263)	(1.1183)
Operated acres, total	0.0004 *	0.0006
	(0.0001)	(0.0008)
Tenure	-0.0997	0.0768
	(0.0905)	(0.2766)
Operator age	-0.0024	-0.0037
	(0.0048)	(0.0107)
Year dummies	Yes	Yes
R^2	0.1089	-
N	9,859	9,596

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively.

Because of our inability to actually observe the interest rates paid by the farmers, we turned to the values found by Goodwin and Mishra (1994) to calibrate our wealth-dependent

cost of credit element, and assumed that a $100,000 increase in wealth would lead to a decrease in the interest rate of 0.0865 percentage points.[45] Relative to the general framework, we expect acres to exhibit an increased sensitivity to changes in liquidity, as liquidity simultaneously finances production and adds to the wealth and collateral of the farmer. The effects on borrowing are not so clear. On the one hand, greater wealth implies a lower wealth-dependent cost of credit. On the other hand, the cost of credit is higher than before, which can deter the farmer from borrowing as much as in the general framework. Table 4.15 and Table 4.16 report the results from our extended model alongside those of the general framework. As in the previous extension, the tables differ in the levels of allowable debt. We again report results for optimal acres and borrowing, wealth, LDP receipts, and the number of times the limit on these payments was reached. In each table, columns (1) and (2) refer to the low liquidity case, columns (3) and (4) refer to the average liquidity case, and columns (5) and (6) refer to the high liquidity case. And for each level of liquidity, the first column reports the results from the general framework, while the second column reports the results from the extended version.

Assuming a wealth-dependent interest rate has the expected results. The extra interest rate cost decreases acres, borrowing, LDP receipts, and wealth across both levels of allowable debt, across the different levels of liquidity, and across all scenarios except for the sixth, which assumes preferences are CARA. But the change is very small in magnitude. In the low allowable debt case, the biggest decrease in acres occurs in the fifth scenario for the low liquidity level, where from column (1) to column (2) acres decrease by 0.0061 percent. In the high allowable debt case, this decrease, also the greatest, is of 0.0149 percent. But the new credit cost assumption has no effect upon the farmer's optimal decisions in the high liquidity and allowable debt case, when the farmer can put all her acres into production, though wealth decreases by about 0.02 percent. Finally, as liquidity increases from one level to the next, the relative increase in acres is greater under the wealth-dependent interest rate framework. But this general wealth effect is, as the other changes, very small and almost

[45] In what the denominator in equation (4.23) is concerned, it will be positive for any amount of borrowing below $115,606,936.42, well above the value allowed in our simulation.

negligible in magnitude.

Table 4.15. Effects of a wealth-dependent interest rate on selected variables, low allowable debt

$\gamma = 0.13$		Liquidity scenarios					
		Low ($23,189.88)		Average ($46,379.76)		High ($69,569.64)	
		Interest Rate					
		α	$\alpha+\theta W_t$	α	$\alpha+\theta W_t$	α	$\alpha+\theta W_t$
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	299.03	299.02	535.53	535.53	772.03	772.03
	2	635.66	635.63	1,039.88	1,039.84	1,444.10	1,444.06
	3	646.24	646.20	1,050.40	1,050.36	1,454.57	1,454.52
	4	643.44	643.41	1,052.61	1,052.57	1,461.78	1,461.73
	5	663.10	663.06	1,077.67	1,077.62	1,482.98	1,482.92
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	646.24	646.20	1,050.40	1,050.36	1,454.57	1,454.52
Borrowing ($)	1	7,224.29	7,223.88	8,089.14	8,088.62	8,953.98	8,953.35
	2	15,601.92	15,599.95	17,080.07	17,077.71	18,558.23	18,555.44
	3	16,247.35	16,245.21	17,722.08	17,719.54	19,196.82	19,193.83
	4	16,076.78	16,074.66	17,856.90	17,854.29	19,637.02	19,633.86
	5	17,276.72	17,274.24	19,386.26	19,383.21	20,930.41	20,926.86
	6	-1,364.10	-1,364.10	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	16,247.35	16,245.21	17,722.08	17,719.54	19,196.82	19,193.83
Wealth ($)	1	94,764.37	94,758.37	124,033.35	124,024.56	153,302.32	153,290.32
	2	191,399.14	191,371.26	241,424.52	241,386.40	291,449.91	291,400.23
	3	191,296.17	191,267.48	236,588.57	236,550.15	281,869.88	281,820.56
	4	209,184.26	209,151.59	275,832.61	275,785.59	342,480.96	342,417.46
	5	222,910.47	222,873.18	287,940.68	287,887.52	350,799.21	350,730.49
	6	176,342.08	176,344.16	213,664.21	213,681.36	244,314.64	244,367.58
	7	191,296.17	191,267.48	236,588.57	236,550.15	281,869.88	281,820.56
LDP payments ($)	1	2,497.41	2,497.37	4,472.62	4,472.58	6,447.83	6,447.78
	2	5,308.87	5,308.60	8,684.82	8,684.50	12,060.77	12,060.39
	3	28,659.36	28,657.81	46,583.34	46,581.49	64,507.32	64,505.15
	4	329.18	329.16	538.50	538.48	747.83	747.80
	5	41,170.38	41,167.86	66,909.80	66,906.69	92,073.99	92,070.37
	6	15,860.97	15,860.97	26,963.65	26,963.65	32,356.37	32,356.37
	7	28,659.36	28,657.81	46,583.34	46,581.49	64,507.32	64,505.15
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	10	10
	4	0	0	0	0	0	0
	5	0	0	22	22	737	737
	6	0	0	0	0	0	0
	7	0	0	0	0	10	10

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

Table 4.16. Effects of a wealth-dependent interest rate on selected variables, high allowable debt

$\gamma = 0.25$		Liquidity scenarios					
		Low ($23,189.88)		Average ($46,379.76)		High ($69,569.64)	
		Interest Rate					
		α	$\alpha+\theta W_t$	α	$\alpha+\theta W_t$	α	$\alpha+\theta W_t$
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	354.41	354.40	597.54	597.53	840.67	840.65
	2	844.22	844.12	1,268.20	1,268.08	1,520.00	1,520.00
	3	863.37	863.26	1,287.24	1,287.12	1,520.00	1,520.00
	4	863.17	863.06	1,296.68	1,296.54	1,520.00	1,520.00
	5	905.17	905.04	1,338.08	1,337.93	1,520.00	1,520.00
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	863.37	863.26	1,287.24	1,287.12	1,520.00	1,520.00
Borrowing ($)	1	12,856.91	12,855.71	14,396.05	14,394.54	15,935.19	15,933.34
	2	28,329.55	28,323.42	31,013.54	31,006.19	23,189.88	23,189.88
	3	29,498.17	29,491.52	32,175.64	32,167.73	23,189.88	23,189.88
	4	29,486.23	29,479.44	32,751.13	32,742.75	23,189.88	23,189.88
	5	32,049.31	32,041.08	35,278.05	35,268.50	23,189.88	23,189.88
	6	-1,364.10	-1,364.10	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	29,498.17	29,491.52	32,175.64	32,167.73	23,189.88	23,189.88
Wealth ($)	1	95,916.34	95,905.43	125,323.22	125,307.31	154,730.10	154,708.39
	2	204,646.84	204,590.33	255,927.33	255,851.06	296,270.82	296,211.40
	3	202,547.60	202,490.30	248,860.27	248,784.33	285,249.10	285,191.89
	4	231,899.77	231,829.15	301,063.32	300,963.89	348,499.48	348,429.59
	5	246,675.42	246,593.84	313,102.91	312,992.65	354,100.38	354,029.36
	6	176,342.08	176,344.16	213,664.21	213,681.36	244,314.64	244,367.58
	7	202,547.60	202,490.30	248,860.27	248,784.33	285,249.10	285,191.89
LDP payments ($)	1	2,959.92	2,959.82	4,990.50	4,990.37	7,021.08	7,020.93
	2	7,050.71	7,049.87	10,591.69	10,590.69	12,694.64	12,694.64
	3	38,288.84	38,284.01	57,086.86	57,081.11	67,409.11	67,409.11
	4	441.59	441.53	663.36	663.29	777.61	777.61
	5	56,199.88	56,191.51	83,077.97	83,068.25	94,372.75	94,372.75
	6	15,860.97	15,860.97	26,963.65	26,963.65	32,356.37	32,356.37
	7	38,288.84	38,284.01	57,086.86	57,081.11	67,409.11	67,409.11
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	2	2	23	23
	4	0	0	0	0	0	0
	5	1	1	313	313	870	870
	6	0	0	0	0	0	0
	7	0	0	2	2	23	23

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

4.6. Policy applications

This section performs two policy applications. As in Hennessy (1998) and Goodwin (2006), we use our framework to evaluate the impact of a 100 percent increase in DP on the decisions for how many acres to plant, how much to borrow, wealth, LDP payments, and the number of times the limit on LDP payments was reached. We then move on to observe the impact of stricter payment limitations on these optimal choices. We use our extended framework throughout.

4.6.1. Effects of doubling Direct Payments

In spite of their designation, there are several potential mechanisms through which decoupled payments may have production effects, namely credit constraints. We have hypothesized that these effects could happen in two ways. First, they could be used to finance additional production investment. Second, they could improve the collateral of a liquidity constrained in need of borrowing to finance current production. Our framework describes the latter. The manner in which the farmer's problem was modeled incorporates DP as enhancing the farmer's wealth (see equation (4.7)), thereby increasing her ability to borrow (see equation (4.9)), but not her current liquidity (given by equation (4.8)). The addition of DP exclusively in equation (4.7) implies that any change in this term alters only the collateral of the farmer.

We now examine the acreage and borrowing effects of a 100 percent increase in DP while holding everything else constant. We are not interested in the event that caused this change. However, we assume it was not caused by a change in base acres or base yields, since this would alter the amount of CCP received. Since our goal is to observe the production effect of this change, *ceteris paribus*, we just assume that DP doubled.

Table 4.17 and Table 4.18 report the simulation results from doubling DP, from the initial value assumed so far, $9,792.64, to twice that, $19,585.28. As before, the tables differ in the levels of allowable debt. We again report results for optimal acres and borrowing,

wealth, LDP receipts, and the number of times the limit on these payments was reached. In each table, columns (1) and (2) refer to the low liquidity case, columns (3) and (4) refer to the average liquidity case, and columns (5) and (6) refer to the high liquidity case. And for each level of liquidity, the first column reports the results from the original level of DP, and the second column reports the results from the doubled DP. There was no change to the number of times the CCP limit was reached and the new value assumed for DP still falls below the $40,000 limit for these payments.

Under DARA preferences and risk neutrality, for the combination of liquidity and allowable debt levels that cause the farmer to be credit constrained, our results reveal that decoupled payments do have production effects. In Table 4.17, in the low allowable debt case, for all but the CARA preferences scenario, acres increase by between 3.0 percent to 3.8 percent in the low liquidity case, by between 1.8 percent and 2.1 percent in the average liquidity case, and by between 1.3 percent and 1.5 percent in the high liquidity case. In all these cases, the baseline scenario always shows the greatest change. This is also valid for borrowing, which increases by 16.0 percent, 14.3 percent, and 13.0 percent for this scenario and across these three levels of liquidity, respectively. In Table 4.18, in the high level of allowable debt, for all but the CARA preferences scenario, acres increase by between 4.0 percent and 5.7 percent for the low liquidity case, and by between 2.6 percent and 3.4 percent in the average liquidity case. In this table, in the high level of liquidity, because the farmer is not constrained by credit in the low cost scenarios, the additional collateral has no effects except for in the baseline scenario, where acres increase by 2.4 percent. The relative changes in wealth are very similar across the tables, varying between 5.1 percent and 10.6 percent in the low liquidity level, between 3.8 percent and 8.0 percent in the average liquidity level, and between 3.1 percent and 6.5 percent in the high liquidity case. Finally, the increase in the number of acres planted also brings about an expansion in both the amount of LDP payments received, since these are proportional to acres, and in the number of replications in which the limit on these payments is reached.

Overall, our results suggest DP have production effects. Moreover, these effects are exacerbated by the presence of credit constraints. Even though the farmer's liquidity did not

change, DP enhance the farmer's collateral so that she can put more acres into production.

Table 4.17. The effects of doubling DP on selected variables, low allowable debt

$\gamma = 0.13$		Liquidity scenarios					
		Low liquidity ($23,189.88)		Average liquidity ($46,379.76)		High liquidity ($69,569.64)	
		Direct Payments					
		$9,792.64	$19,585.28	$9,792.64	$19,585.28	$9,792.64	$19,585.28
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	299.19	310.61	535.52	546.92	771.34	782.71
	2	635.25	654.68	1,035.83	1,055.06	1,431.64	1,450.60
	3	645.78	665.20	1,046.20	1,065.43	1,422.12	1,422.05
	4	642.91	662.56	1,047.53	1,066.93	1,446.26	1,465.33
	5	662.34	682.22	1,071.25	1,090.83	1,468.79	1,487.76
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	645.78	665.20	1,046.20	1,065.43	1,422.12	1,422.05
Borrowing ($)	1	7,240.88	8,402.67	8,088.15	9,247.93	8,883.17	10,039.83
	2	15,577.14	16,762.76	16,832.65	18,006.58	17,797.55	18,954.93
	3	16,219.48	17,404.69	17,465.84	18,639.26	17,216.36	17,212.34
	4	16,044.59	17,243.34	17,546.61	18,730.87	18,689.87	19,853.79
	5	17,230.16	18,443.11	18,994.53	20,189.49	20,065.04	21,222.13
	6	-1,364.10	-1,364.11	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	16,219.48	17,404.69	17,465.84	18,639.26	17,216.54	17,212.39
Wealth ($)	1	95,333.61	105,362.72	124,008.76	133,969.81	150,915.24	160,771.18
	2	190,599.36	201,438.25	233,092.11	243,535.88	265,749.36	275,632.94
	3	190,477.04	201,098.06	228,757.82	239,017.04	258,069.11	267,860.29
	4	208,025.71	219,592.94	264,265.36	275,290.64	307,071.89	317,335.70
	5	221,519.22	232,992.48	275,704.06	286,623.48	316,041.21	326,181.23
	6	176,842.32	186,635.07	213,214.87	223,008.30	242,747.18	252,541.94
	7	190,477.04	201,098.06	228,757.82	239,017.04	258,069.11	267,860.29
LDP payments ($)	1	2,536.20	2,631.63	4,471.51	4,562.37	6,287.48	6,371.27
	2	5,256.50	5,406.69	8,124.65	8,248.21	10,328.97	10,414.74
	3	28,344.94	29,139.49	43,497.12	44,148.65	54,614.57	54,612.95
	4	325.62	334.90	502.29	509.87	636.76	641.95
	5	40,631.93	41,763.98	62,082.04	62,995.78	78,021.39	78,629.36
	6	16,051.59	16,051.59	26,785.16	26,785.16	31,736.45	31,736.45
	7	28,344.94	29,139.49	43,497.12	44,148.65	54,614.64	54,612.97
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	1	1
	4	0	0	0	0	0	0
	5	0	0	6	8	160	177
	6	0	0	0	0	0	0
	7	0	0	0	0	1	1

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

Table 4.18. The effects of doubling DP on selected variables, high allowable debt

$\gamma = 0.25$		Liquidity scenarios					
		Low liquidity ($23,189.88)		Average liquidity ($46,379.76)		High liquidity ($69,569.64)	
		Direct Payments					
		$9,792.64	$19,585.28	$9,792.64	$19,585.28	$9,792.64	$19,585.28
Variable	Scenarios	(1)	(2)	(3)	(4)	(5)	(6)
Acres	1	354.68	375.00	597.30	617.54	838.85	858.99
	2	840.94	875.78	1,253.68	1,287.73	1,497.41	1,497.34
	3	859.78	894.58	1,272.02	1,306.02	1,422.12	1,422.05
	4	858.84	894.29	1,277.84	1,312.29	1,520.00	1,520.00
	5	898.89	934.97	1,319.95	1,353.95	1,520.00	1,520.00
	6	357.65	357.65	608.00	608.00	729.60	729.60
	7	859.78	894.58	1,272.02	1,306.02	1,422.12	1,422.05
Borrowing ($)	1	12,884.87	14,951.06	14,371.86	16,430.56	15,750.07	17,797.73
	2	28,129.62	30,255.69	30,127.38	32,205.40	21,811.20	21,807.31
	3	29,278.92	31,402.68	31,246.27	33,321.43	17,216.56	17,212.42
	4	29,221.40	31,385.05	31,601.45	33,704.16	23,189.88	23,189.88
	5	31,665.58	33,867.77	34,171.60	36,246.15	23,189.88	23,189.88
	6	-1,364.10	-1,364.11	-9,275.95	-9,275.95	-25,045.07	-25,045.07
	7	29,278.92	31,402.68	31,246.27	33,321.43	17,216.52	17,212.43
Wealth ($)	1	96,462.58	106,651.64	124,874.00	134,920.12	151,206.90	161,042.15
	2	200,887.41	212,225.97	239,059.36	249,480.09	265,937.68	275,728.47
	3	198,812.54	209,772.26	232,845.22	242,964.46	258,069.11	267,860.29
	4	226,362.46	238,887.34	276,784.91	288,019.16	308,669.41	318,460.09
	5	240,098.77	252,415.09	287,509.01	298,451.19	316,889.24	326,679.92
	6	176,842.32	186,635.07	213,214.87	223,008.30	242,747.18	252,541.94
	7	198,812.54	209,772.26	232,845.22	242,964.46	258,069.11	267,860.29
LDP payments ($)	1	2,998.30	3,166.45	4,960.45	5,118.77	6,779.10	6,922.89
	2	6,794.10	7,041.84	9,430.79	9,615.19	10,617.75	10,617.48
	3	36,790.77	38,093.20	50,608.88	51,570.35	54,614.65	54,612.98
	4	424.00	439.31	585.73	596.91	656.12	656.12
	5	53,554.06	55,407.84	72,737.49	74,021.71	79,627.89	79,627.89
	6	16,051.59	16,051.59	26,785.16	26,785.16	31,736.45	31,736.45
	7	36,790.77	38,093.20	50,608.88	51,570.35	54,614.63	54,612.99
Number of LDP limit hits	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	1	1
	4	0	0	0	0	0	0
	5	0	1	61	78	203	203
	6	0	0	0	0	0	0
	7	0	0	0	0	1	1

Note: The number of LDP limit hits is the number of replications the limit on LDP was reached.

4.6.2. Production effects of stricter payment limits

The usual argument set forth to tighten government payments is one of equity among farmers, as larger farms receive the bulk of these payments. Supporters of tighter payments claim they facilitate farm consolidation, raise the price of land, and put smaller, family-sized farming operations at a competitive disadvantage. Aside from large farms, other controversial recipients of the payments include, among others, millionaire and businessman Maurice Wilder and billionaire businessman David Rockefeller.[46] Despite the fact that in principle farm support programs should not discriminate among recipients, it is becoming increasingly politically difficult to justify the escalating concentration of payments to a few large farms (and/or millionaires with other sources of income). Along with being extremely costly to the federal budget, this undermines the public support for farm subsidies. To alleviate the problem of non-farmers collecting subsidies and income supports, recall the 2008 Farm Bill denies commodity payments to individuals with non-farm income of more than $500,000 and discontinues DP for individuals with more than $750,000 in net farm income. But big payments go to big farms because support is generally tied to units of production. Larger farms usually have greater historical acreage and thus receive larger payments.

In February of 2005, Senators Grassley and Dorgan introduced Senate Bill 385, where they proposed DP, CCP and LDP payment limits to be reduced to $40,000, $60,000, and $150,000, respectively, per farmer. This section evaluates the production effects of this measure. Relative to our general framework, the policy merely decreases the limit on CCP by $5,000. For the wheat farmer in our model, whose historical acres and yields have caused CCP to vary between $2,241.96 and $17,384.65 in the high price and low price scenarios, respectively (scenarios 4 and 3), this policy change should not affect production. Indeed, this is the case. For the base yield assumed and the levels of prices implied in our scenarios, the lower payment limit for CCP could only be attained by a farmer with much higher base

[46] See, for example, the article "Farm aid going to millionaires" by the Environmental Working Group, August 2008, found in http://www.ewg.org/node/27007.

acres. For the average price in the baseline scenario, $3/bu, it would take a base of about 1,467 acres to reach the payment limit, and for the average price in the lower price level scenarios, $1.80, it would take a base of about 2,348 acres to reach the payment limit (in principle, under the high price scenario, price, CCP should not be collected). Only very large farms have these base acres. In our KFMA data, for the farms that produced wheat over the 1998-2001 period, the farm at the 90 percentile had a base acreage of 833 acres, and even the farm at the 95 percentile had a base acreage of 1,116 acres. Only the farm at the 99 percentile had a base acreage of 1,625 acres, greater than the required minimum base acreage to reach the payment limit in the baseline price scenario. And out of the 914 acres in the sample, only nine farms had greater yield acreage (the maximum base was 2,471). These were, in general, very large farms. Six out of these nine farms operated more than 1,351 acres in 2004. According to the 2002 Census of Agriculture, out of the 24,236 farms that produced wheat in Kansas, 1,773 had 1,000 acres or more, about 7.3 percent. Of these large farms, the vast majority was in the 1,000 to 1,999 category, 1,519 farms, or 6.3 percent of total Kansas farms. However, the 1,000 acres or more farms represent about 32.77 percent of wheat growing Kansas acres. Given that large farms are expected to have large historical bases, while this tighter limit would presumably affect only a small number of farms, it could nonetheless represent non-negligible savings for the Federal budget.

4.7. Conclusions

This section extended the general framework used by Hennessy (1998) and Goodwin (2006) to incorporate the presence of capital market imperfections, or credit constraints. We find that credit constraints matter. When the farmer is not endowed with enough liquidity to put all her acres into production, and the market conditions are such that she would like to do so, allowing her to borrow a greater percentage of her wealth expands acreage by expanding borrowing. For example, in the baseline scenario, allowing the farmer to borrow more increased planted acres by 18.52 percent in the low liquidity case, by 11.58 percent in the

average liquidity case, and by 8.89 percent in the high liquidity case. These values were close to 33 percent, 22 percent, and 5 percent, respectively, in the second and third scenarios.

Along with experimenting with different levels of liquidity and allowable debt, our simulation considered several different cost, price, and yield possibilities, along with different assumptions concerning risk aversion. Specifically, we experimented with DARA, CARA, and risk neutrality preferences. Our results let us observe two things. First, when preferences were CARA, the risk aversion coefficient was much higher than in the DARA cases. This caused the farmer to save instead of borrowing, to produce less, and consequently, to have less wealth. In the low allowable debt case, wealth decreased by 7.82 percent, 9.69 percent, and 13.32 percent in the low, average, and high levels of liquidity, respectively. These values increased in magnitude under the high allowable debt case, with wealth decreasing by 12.94 percent, 14.14 percent, and 14.35 percent for those liquidity levels, respectively. Second, given our parameterization of the utility function, even though the farmer's utility function is defined as DARA, her level of wealth puts her closer to risk neutrality than risk aversion. Indeed, our results from scenarios 3 and 7 were exactly the same under all the different cases explored. Both these results are consistent with Sandmo (1971), who observed that expected wealth should be greater for those producers who came very close to being risk neutral and hence have high output values.

We also extended our general framework to include the possibility of decreasing marginal yields and a wealth-dependent interest rate. The results were as expected. When the farmer was planting fewer acres than the KFMA average in the general framework, incorporating the hypothesis that not all acres were equal increased planted acres. But when she was planting more acres than the KFMA average, allowing for decreasing marginal yields decreased planted acres. The effects of a wealth-dependent interest rate were very small in magnitude, and mainly decreased the number of acres planted. However, this decrease diminished across liquidity levels. For example, in the low allowable debt case for the baseline scenario, imposing a wealth-dependent interest rate decreased acres by 0.0014 percent in the low liquidity case, by 0.0009 percent in the average liquidity case, and by 0.0008 percent in the high liquidity case.

Finally, we applied the extended framework to analyze two different policy measures, a 100 percent increase in DP and a tightening of payment limits. While the tightening of payment limits is likely to have no effect on average sized farmers, our results showed that, in the presence of credit constraints, DP have important and nonnegligible production effects. Indeed, when farmers are liquidity constrained, the presence of these payments has a collateral enhancement effect such that more production can take place even though the actual liquidity of the farmer does not change. For example, in the baseline scenario, in the low allowable debt case, doubling DP increased planted acres by 3.8 percent, 2.1 percent, and 1.5 percent in the low, average, and high liquidity cases, respectively. In the high allowable debt case, these values increased to 5.7 percent, 3.4 percent, and 2.4 percent, respectively.

Chapter 5

Farm characteristics and yield performance

5.1. Introduction

Drawing on different methodologies, the previous two chapters in this dissertation analyzed the production effects of decoupled payments. The earlier chapter used KFMA data for the FAIR Act period to estimate the acreage effects of AMTA (PFC and MLA) payments in the presence of credit constraints. The second chapter used simulation methods to observe the effects of DP on the acreage and borrowing decisions of an average Kansas wheat farmer. In both chapters, decoupled payments were found to have nontrivial production effects by affecting planted acres. Yet, other avenues remain for decoupled payments to affect production. The additional funds or enhanced collateral may be used to, for example, invest in yield improving production methods. And despite the fact that the latter analysis recognized the fact that not all acres are equal, in the sense that acres were allowed to differ in their productivity, no attempt was made to study the elements that may cause this difference. Indeed, the farm-level determinants of yield performance have been largely ignored by the economics literature. Goodwin *et al.* (2002), who found that farmers' experience in growing the crop or alternative crops improves yield performance, are one exception.

Aside from the biological constraints that cause yields to vary from farm to farm, or

from field to field within a farm, understanding the farm-level individual characteristics that cause yields to differ is important, and this importance may be linked to the increased tendency for farm support to be awarded through decoupled payments. With the creation of PFC payments and the elimination of deficiency payments, the 1996 Farm Bill provided farmers with payments that were independent of market prices. Together with the increasing willingness of the U.S. government to forestall future *ad hoc* assistance programs, the effects of these two policies could be thought of as increasing farmers' risk exposure, as deficiency payments helped offset low prices and disaster assistance programs helped offset low yields, low prices, or both.

Alternatively, the joint effect of these changes could be viewed as establishing the Federal crop insurance program as a major component of the U.S. farm safety net, adhering to the goal of the 1980 Federal Crop Insurance Act, which was to replace the expensive disaster assistance programs by a strengthened insurance one. Since then, crop insurance has been promoted over disaster payments as a primary tool for addressing risk. An example of this was the inclusion of premium subsidies of up to 30 percent in the Act, followed by the Crop Insurance Reform Act of 1994, and by the Agricultural Risk Protection Act of 2000, which raised subsidy levels and provided other incentives to participate in the program. But despite significant progress in establishing rates that more accurately reflect producer risks and thus mitigate adverse selection problems, the program is costly, and the level of its subsidies raises concerns over the potentially distorting effect on production (Glauber 2005). However, even if crop insurance subsidies are less efficient than lump sum transfers as a mechanism for supplying agricultural subsidies (although arguably less distorting than those tied to production), because they provide farmers with *ex ante* revenue protection, they are preferable to *ex post* forms of disaster assistance (Innes 2003).

The purchase of subsidized crop insurance is a risk management option available through USDA's Risk Management Agency to producers of specific crops. These insurance policies make indemnity payments to producers based on current losses related to either below average yields (Yield-based Insurance Coverage) or below average revenue (Crop

Revenue Coverage (CRC)).[47] For many of these policies, indemnity payments and the premium rates are based upon the farmer's history of producing a crop. For example, under the Actual Production History (APH) program, coverage levels are based on a farmer's expected yield, which is calculated from the farm's APH (average yields over the last 4 to 10 years, also called approved yield). The farmer then selects the yield election (amount of average yield she wishes to insure) and the indemnity price. If harvest yield is less than the yield guarantee (the approved yield multiplied by the yield election), the farmer receives an indemnity payment equal to the yield shortfall multiplied by the indemnity price and the number of acres insured. Intuitively, a higher yield election increases the yield guarantee, so that for the same actual yield below the yield guarantee, a higher yield election has a larger indemnity payment that does a lower yield election. Because per acre premiums depend on the yield election, higher yield elections and indemnity prices result in higher premiums. For farmers with less than four consecutive years of available data, a proportion of a transition or T yield is assigned to replace the missing years.[48] This yield is based on the ten year county average yield. But if the county average yield is not representative of the farmer's expected yield, then both the level of insurance coverage and the premium rate will not be correct. Therefore, any means that can be used to better predict the yield performance of a specific crop should improve on the calculation of the insurance coverage and the premium rate.

Our goal is to revisit the determinants of yield performance at the farm level as studied by Goodwin *et al.* (2002) and explore the ability of additional variables to account for the remaining unexplained variation. In particular, we observe whether the financial

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[47] The first class includes Actual Production History coverage, the oldest and most common product, Multiple Peril Crop Insurance, Catastrophic Coverage, and the Group Risk Plan. The first three policies protect farmers against losses due to natural causes such as drought, excessive moisture, hail, wind, frost, insects, and disease, and the latter pays an indemnity when the county yield for the insured crop falls below the trigger level. CRC protects a producer from loss of revenue resulting from low prices, low yields, or a combination of the two, guaranteeing a declared amount of revenue based on commodity futures prices. With a CRC policy the farmer does not necessarily have to experience an insurable yield loss to receive an indemnity payment. But if the county does not have a yield shortfall, she may actually not receive the payment when a loss occurs.

[48] For growers who have grown the crop in previous years, the proportion varies according to the number of years of available production. A new farmer or one who has never planted the crop to be insured will receive 100 percent of the T yield for the APH, and if she continues to plant the crop for four years, the T yields will be replaced with the actual production each year (Edwards 2003).

characteristics of the farms may help explain differing yield performances; among these characteristics we include farmers' wealth and debt to asset ratio, along with government payments. In addition, and keeping in line with the idea that decoupled payments may have production effects, we also observe whether AMTA payments can be used to enhance yield performance. Our hypothesis is that these payments may be used to boost investment in inputs or equipment that can lead to better yields.

We use a large sample of KFMA farms for eight different crop/practice combinations (dryland and irrigated corn, sorghum, soybeans, and wheat) for 1994 through 2006. Our access to historical farm level data allows us to overcome some of the problems related with our inability to observe so many factors that should influence yield performance at the farm level, such as the experience of the operator or the soil-water characteristics of the farm. The results of our study have implications for current risk management policies. To the extent that these results may be used to improve insurance premium rating procedures, so can the actuarial performance of the program. Our econometric techniques involve the use of OLS and panel data methods, FE and RE.

This chapter is organized as follows. The second section discusses the factors that affect yield performance at the farm level. Along with the empirical framework and econometric approach, the following section presents the data used. The results of the estimation are then discussed. Some concluding remarks are finally offered.

5.2. Factors affecting yield performance

Crop yields depend on a number of factors, whether naturally occurring, like the soil-water properties of the field or rainfall, or management induced, like the variety selected or the amount of fertilizer applied. These factors, and the degree of their impact, vary from year to year and from field to field, and they also interact with each other in space and time. Consider the role of water. The importance of water in the soil is clear as one thinks about how spring rains can delay planting or when crops are endangered by summer droughts. And

water interacts with the characteristics of the soil to determine the availability to crops of soil nutrients, fertilizers, and pesticides over the course of the growing season. To see this, think about how the movement of water through soil determines the amount of fertilizer or pesticide/herbicide that remains available to crops in contrast to how much is carried downward to the groundwater. For example, a sandy soil holds less water for the crops (thereby reducing yield in a dry year) than a clay soil, and it also has lower nutrient levels. But the clay soil holds the water more tightly in smaller pores, making drainage slower and the water less readily available to plant roots.[49] Moreover, if the spring was cold and wet, the sandy soil will warm up sooner and guarantee a better germination (Begg and Enright 2003). Hence, the interactions between these factors can minimize or cause a more extreme impact from a single factor.

Other naturally occurring factors that influence yield performance include the weather, the physical and chemical properties of the soil, the slope and geographical orientation of the site, and the susceptibility to pest infestations. In terms of weather, the amount, frequency and distribution of precipitation, the temperature, the solar radiation, and the wind may significantly affect the yield performance of a crop. The physical and chemical properties of the soil include the texture, topsoil depth, nutrient availability, ph, and organic matter. These are related to the aforementioned soil-water relationships, which are related to drainage, soil depth, and water holding capacity. The topography and direction of a site (North, South, East or West) include characteristics as soil erosion, temperature, and machinery operations. Finally, crop pest infestations include weed, insects and diseases.

Along with naturally occurring factors, management practices may also affect crop yields. In broad terms, these factors include the choice of crop inputs, the field history, and past cultural practices and/or mistakes. An example of a performance improving choice of crop inputs is the adoption of plants bred to include resistance to diseases and insects, tolerance to heat and drought, reduction in the time to crop maturity, greater yield, and better

[49] For an overview of the interaction between water and soil characteristics see Trautmann *et al.* (1985). The sources of yield variation on a field were taken from this source.

agronomic quality.[50] The field history is concerned with the historical use of herbicide or pesticide, and with fertilizer/manure inputs. Poor management practices such as the inappropriate use of pesticides and monocropping could induce resource degradation that injures yield performance. These could be considered as cultural practices and/or mistakes, which also include crop rotation, tillage and compaction, manure applications, land leveling, ditch cleaning, misapplication of nutrients or pesticides etc. Other management induced factors influencing yield performance include those studied by Goodwin *et al.* (2202). Using KFMA over the 1980 through 1998 period, the authors found that more years of experience in growing a crop tended to be correlated with higher relative yields, as did superior historical performance on other crops.

Finally, note that differing yields may happen for completely different reasons, and indeed factors that limit or boost yields will vary from field to field, and from place to place within a field. And what may be a yield-boosting factor for one crop or in a given year does not necessarily have the same effect on a different crop or in the next year.

5.3. Empirical framework and data

Given the naturally occurring factors that influence yield performance, proper management should be able to minimize the influence of yield-decreasing factors and enhance the influence of yield-boosting factors. For a given crop/practice combination, a reduced form yield performance equation can be defined by

(5.1) $$Yield_{ict} = \{\mathbf{Natural}_{ict}, \mathbf{Management}_{ict}\}$$

where the subscripts *i*, *c*, and *t* index the ith farm in county *c* at time *t*, $Yield_{ict}$ denotes crop yields, $\mathbf{Natural}_{ict}$ is a vector of naturally occurring factors, and $\mathbf{Management}_{ict}$ is a vector of management induced factors.

[50] Besides yield performance, other reasons underlying the adoption of such varieties are associated with the use of mechanical harvesting, which calls for uniformity of plant characteristics such as germination and stand establishment, growth rate, maturity, and fruit size.

But yields cannot be compared across time and space without normalization. A common means of normalization is to divide the individual farmer's yield by the average yield for the county in which the farm is located. We use NASS county average yields in the normalization. This procedure deals with the deterministic time effects associated with yield trends while at the same time picking up some of the effects of localized weather events. It also specifically addresses the issue of farmers in areas with higher than average yields exhibiting this pattern as well. For a given crop/yield combination, normalized yields are given by

(5.2) $\hat{y}_{ict} = Yield_{ict} / Yield_{ct}$

where $\hat{y}_{ict}$ is the normalized yield for the ith farm in county c at time t and $Yield_{ct}$ is the NASS county average yield for all producers in the ith farm's county. Normalized yields, which we represent as a percentage of the county average yield, can be used to compare yield patterns across different crop/practice combinations and years.

We now turn to the variables that should be included in the estimating equation. These are variables that are included in the $\mathbf{Management}_{ict}$ vector. Our discussion of the estimation methodology explains how we deal with the unobserved variables that are included in the $\mathbf{Natural}_{ict}$ vector.

Successful crop production should depend on careful management of the soil, water, and chemicals, so that plant needs are met as they occur in the growing season.[51] For example, we hypothesize that greater per acre expenditures on seed and chemicals (fertilizer and herbicide) should be correlated with better yield performance. Likewise, investment in machinery and equipment is expected to increase productivity.

We also expect farm size to be correlated with yield performance. In order to see this, consider the association between the adoption of newer and improved technology and farm size. One reason farms have been growing is to make more economical use of machines capable of covering more ground with less labor. And larger farms can typically get volume

[51] A positive externality occurs as meeting these requirements efficiently may help with the protection of groundwater. Several observable characteristics of the farms should be correlated to these practices.

discounts on inputs such as chemicals and seed. Conversely, larger farms may have lower average yields due to decreasing marginal productivities, as we assumed in the previous chapter. Indeed, the inverse relationship between farm size and land productivity is an "old and puzzling empirical regularity" (Assunção and Braido 2007).[52]

Like Goodwin *et al.* (2002), we hypothesize that yield performance may be affected by the diversification of the farm. We consider three measures of diversification. The first measure connects the performance in growing crops to that of growing livestock. Given the considerable differences in expertise required by these practices, we hypothesize that farmers who receive greater sales shares from livestock will exhibit less proficiency in producing crops, and vice-versa. The authors found that farm operations with a significant share of sales coming from livestock production tended to have lower relative crop yields.

The second measure is related to the dispersion of expertise over too many enterprises. While we expect dispersion of the farmers' attention over too many activities to hinder yield performance, so that more highly diversified farms could face lower yields on individual crops, we also expect some degree of expertise to be transferable across crops, so that an individual farmer with a good performance on one crop could have high expected yields on a different crop. For example, a producer with a historical above-average performance in soybeans would be expected to also have an above-average performance in corn. Goodwin *et al.* found diversification over enterprises yielded varied results. They also found a positive effect on the historical performance in alternative crops. The authors also considered the presence of knowledge spillovers, the idea being that farmers in counties with more production in recent years tended to have higher relative yields. While the results did not indicate the presence of those neighboring effects, we include all these measures of diversification, relative performance in alternative crops, and learning from neighbors in our estimating equation. We also account for the farmers' production experience in the

[52] First documented by Chayanov (1926) for small Russian farms, this relationship has been found in a number of developing countries, such as India, Brazil, Pakistan, Malaysia and Honduras. Explanations for this paradox include labor market imperfections, variable soil quality, size-sensitive cropping patterns, heterogeneity of farmers' skills, credit market imperfections, and uncertainty. For further reading on the inverse productivity paradox see Assunção and Braido (2007) and Barret (1993).

crop/practice under analysis by observing the average number of years the crop was grown in the previous four years.

Our third measure of diversification includes the hypothesis of a relationship between relative crop performance and the relevance of farming activities in overall income. Intuitively, farmers whose greatest share of income comes from off-farm activities could have less incentives to invest in crop yield-boosting methods than farmers whose greatest share (or sole source) of income comes from the farm. The logic underlying this regressor is similar to that of the potential negative impact of diversification over too many enterprises on yield performance.

Finally, and even though we cannot observe the quality of the land in the farm, we hypothesize that farms with better land quality will put a greater share of this land into crop production. Alternatively, we expect farms with higher land quality to be likely to have less waste and set-aside than other farms.

For a given crop/practice combination, the estimating equation for the ith farmer in county *c* is given by

$$\begin{aligned}\hat{y}_{ict} = {} & \alpha_0 + \alpha_1 Seed_{ict} + \alpha_2 Chemical_{ict} + \alpha_3 Machinery_{ict} + \alpha_4 Size_{ict} + \alpha_5 Cropacres_{ict} + \\ & + \alpha_6 Livestockshare_{ict} + \alpha_7 Diversification_{ict} + \alpha_8 Ownership_{ict} + \\ & + \alpha_9 Meancrops_{ict} + \alpha_{10} Experience_{ict} + \alpha_{11} Countyacres_{ct} + \\ & + \alpha_{12} Cropsacresshare_{ict} + \eta_{ct} + u_{ict}\end{aligned} \tag{5.3}$$

where $Seed_{ict}$, $Chemical_{ict}$, and $Machinery_{ict}$ measure per crop acre expenditures on seed, chemicals (herbicide and fertilizer), and machinery investment, respectively, $Size_{ict}$ is the number of operated acres in the farm, $Cropacres_{ict}$ is the number of acres devoted to the crop/practice under analysis, $Livestockshare_{ict}$ is the share of livestock sales in total sales, $Diversification_{ict}$ is a Herfindahl index of diversification over enterprises calculated from sales shares, $Ownership_{ict}$ is the share of farm income in total (farm and off-farm) income. $Meancrops_{ict}$ measures the farmer's performance on other crops, $Experience_{ict}$ is the number of years the farmer produced the crop/practice in question over the past four years, $Countyacres_{ct}$ is the average number of acres in the county where the farm is located devoted

to the crop/practice over the past four years, and $Cropsacresshare_{ict}$ is the proportion of total acres engaged in crop production.

The last two terms in the equation correspond to the error term, where u_{ict} is the idiosyncratic term and η_{ct} are the unobserved factors that cause yield performance to vary from year to year in each county. As in Chapter 3, the covariance is matrix is estimated by allowing each county-year group to have a different and unrestricted covariance structure but assumes errors are uncorrelated across groups (Moulton 1986). Additionally, the estimating equation includes year dummy variables, which account for unobserved factors that have the same influence on yield performance for all farms, and county dummy variables, which allow these unobserved factors to vary by county.

After including these regressors, a large variation in yield performance remains unexplained, since so many characteristics that determine it are unobserved. Factors like rainfall, nutrient availability, or border shading from trees are not included in equation (5.3). Indeed, in spite of our inclusion of $Cropsacresshare_{ict}$ to represent overall land quality, none of the factors in the $\mathbf{Natural}_{ict}$ vector appear. So, we specify the estimating equation with a farm-specific fixed effect f_i as

$$\begin{aligned}\hat{y}_{ict} = {} & \alpha_0 + \alpha_1 Seed_{ict} + \alpha_2 Chemical_{ict} + \alpha_3 Machinery_{ict} + \alpha_4 Size_{ict} + \alpha_5 Cropacres_{ict} + \\ & + \alpha_6 Livestockshare_{ict} + \alpha_7 Diversification_{ict} + \alpha_8 Ownership_{ict} + \\ & + \alpha_9 Meancrops_{ict} + \alpha_{10} Experience_{ict} + \alpha_{11} Countyacres_{ct} + \\ & + \alpha_{12} Cropsacresshare_{ict} + f_i + \eta_{ct} + u_{ict}\end{aligned} \tag{5.4}$$

We further hypothesize that the logic underlying the importance of size can be extended to the financial characteristics of the farm. In principle, more financially sound farms, with greater net worth and/or smaller debt to asset ratios, should be able to implement better production practices and, in turn, generate better yields. Including wealth in our estimating equation further allows us to account for differing risk responses and general wealth effects. Another component of the financial characteristics of the farm is government payments. By providing farms with additional liquidity, we expect government payments to allow investment in production to occur, and credit constraints to be less binding. Hence,

these payments can be invested in technology or inputs, and we expect them to have a positive influence on yield performance.

So, we expand equation (5.4) to include the financial characteristics of the farm, along with government payments, so that

$$\begin{aligned}\hat{y}_{ict} = {} & \beta_0 + \beta_1 Seed_{ict} + \beta_2 Chemical_{ict} + \beta_3 Machinery_{ict} + \beta_4 Size_{ict} + \beta_5 Cropacres_{ict} + \\ & + \beta_6 Livestockshare_{ict} + \beta_7 Diversification_{ict} + \beta_8 Ownership_{ict} + \\ & + \beta_9 Meancrops_{ict} + \beta_{10} Experience_{ict} + \beta_{11} Countyacres_{ct} + \\ & + \beta_{12} Cropsacresshare_{ict} + \beta_{13} Networth_{ict} + \beta_{14} DAR_{ict} + \beta_{15} GP_{ict} \\ & + f_i + \eta_{ct} + u_{ict}\end{aligned} \tag{5.5}$$

where $Wealth_{ict}$ is the net worth of the farm, DAR_{ict} is the debt to asset ratio, and GP_{ict} is the amount of government payments received. In our analysis we further address the potential for AMTA payments to distort production via improved yield performance for a subset of farms by replacing GP_{ict} by the amount of AMTA payments received by farmers for the 1996-2001 period (when the FAIR Act was in place).[53]

We use KFMA data collected over the thirteen year period from 1994 to 2006. As before, our sample only contains observations on farms that operated more than 50 acres. Our panel contains 23,255 observations on 3,273 farms. The lower number of observations in a year occurs in 2003 (1,137 farms) and the highest number occurs in 1995 (2,237 farms). We have observations on 766 farms for the thirteen years in the sample. Because we do not impose that all farms grow all four crops and their different practices, we actually have a smaller number of farms which we observe over the period for each crop/practice combination. For the farms that are present for the 13 years in the sample, we always observe more farms growing the dryland practice, a number which varies between 161 farms and 468 farms, for corn and wheat, respectively. For the irrigated practice, the number of farms that grow each crop for all years of the sample varies between 2 farms and 73 farms, for sorghum and corn, respectively. Table 5.1 reports the summary statistics for the data used in our estimation.

[53] Note that because AMTA payments are based on historical acres and yields, larger AMTA payments should be associated with size, so these effects may be difficult to disentangle.

Table 5.1. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Number of farms (per year)	23,255	1,789	535	1,137	2,237
Operated Acres, Total (1,000)	23,255	1.76	1.40	0.05	15.83
Share of Crops in Total Operated Acres	23,255	0.6885	0.2777	0.0034	1.0000
Wealth ($1,000)	23,255	440.47	501.10	-794.82	8,722.76
Total Liabilities ($1,000)	23,255	224.61	277.39	0.00	6,957.17
Debt to Asset Ratio	23,255	0.3848	0.3602	0.0000	11.1993
Government Payments ($1,000)	23,255	27.02	33.07	0.00	582.38
Net Farm Income ($1,000)	23,255	40.75	78.50	-2,465.68	1,706.14
Non Farm Income ($1,000)	23,255	15.66	21.48	-75.31	379.08
Seeds (per 1,000 crop acres) ($1,000)	23,255	0.08	1.07	-5.32	87.76
Chemical (per 1,000 crop acres) ($1,000)	23,255	0.27	2.84	-3.41	132.15
Machinery (per 1,000 crop acres) ($1,000)	23,255	122.78	166.82	0.00	12,730.45
Ownership Interest	23,255	0.6845	5.8491	-273.3977	241.7512
Diversification	23,083	0.5192	0.2033	0.0000	0.8670
Livestock Share of Sales	23,083	0.2774	0.3309	0.0000	1.0000
Normalized Yields,Irrigated Corn	3,861	98.39	21.67	0.00	185.12
Normalized Yields, Dryland Corn	4,490	100.47	40.74	0.00	384.25
Normalized Yields, Irrigated Sorghum	937	94.98	36.81	0.00	251.89
Normalized Yields, Dryland Sorghum	11,889	101.03	32.65	0.00	338.97
Normalized Yields, Irrigated Soybeans	1,994	102.29	27.88	0.00	210.00
Normalized Yields, Dryland Soybeans	7,500	101.75	36.56	0.00	383.81
Normalized Yields, Irrigated Wheat	1,695	98.71	37.99	0.00	393.48
Normalized Yields, Dryland Wheat	19,198	100.27	27.97	0.00	337.50
Acres, Irrigated Corn (1,000)	23,255	0.06	0.19	0.00	4.08
Acres, Dryland Corn (1,000)	23,255	0.09	0.20	0.00	3.34
Acres, Irrigated Sorghum (1,000)	23,255	0.01	0.04	0.00	2.66
Acres, Dryland Sorghum (1,000)	23,255	0.15	0.22	0.00	5.44
Acres, Irrigated Soybeans (1,000)	23,255	0.02	0.08	0.00	1.36
Acres, Dryland Soybeans (1,000)	23,255	0.18	0.32	0.00	4.13
Acres, Irrigated Wheat (1,000)	23,255	0.02	0.08	0.00	2.26
Acres, Dryland Wheat (1,000)	23,255	0.36	0.42	0.00	4.54
County Acreage, Irrigated Corn (1,000)	17,838	13.58	20.52	0.10	123.72
County Acreage, Dryland Corn (1,000)	19,016	7.33	9.20	0.10	72.38
County Acreage, Irrigated Sorghum (1,000)	14,729	2.70	3.66	0.10	25.74
County Acreage, Dryland Sorghum (1,000)	22,444	31.57	24.75	0.23	100.78
County Acreage, Irrigated Soybeans (1,000)	18,072	3.42	4.24	0.10	21.41
County Acreage, Dryland Soybeans (1,000)	20,497	25.76	24.85	0.10	106.01
County Acreage,Irrigated Wheat (1,000)	9,777	8.64	13.25	0.10	78.66
County Acreage, Dryland Wheat (1,000)	23,255	95.99	79.98	0.64	452.08
Years Produced, Irrigated Corn	23,255	1.18	1.64	0.00	4.00
Years Produced, Dryland Corn	23,255	1.90	1.69	0.00	4.00
Years Produced, Irrigated Sorghum	23,255	0.74	1.27	0.00	4.00
Years Produced, Dryland Sorghum	23,255	2.92	1.51	0.00	4.00
Years Produced, Irrigated Soybeans	23,255	0.92	1.43	0.00	4.00
Years Produced, Dryland Soybeans	23,255	2.47	1.72	0.00	4.00
Years Produced, Irrigated Wheat	23,255	0.82	1.36	0.00	4.00
Years Produced, Dryland Wheat	23,255	3.49	1.11	0.00	4.00
Mean other crops, Irrigated/Dryland Corn	23,255	0.9117	0.3356	0.0000	6.7728
Mean other crops, Irrigated/Dryland Sorghum	23,255	0.9098	0.3372	0.0000	6.7728
Mean other crops, Irrigated/Dryland Soybeans	23,255	0.9078	0.3082	0.0000	2.2112
Mean other crops, Irrigated/Dryland Wheat	23,255	0.8528	0.4396	0.0000	10.9809

Overall, in terms of relative performance, the farms in our sample appear to have similar yields to the counties where they are located, although on average the performance in irrigated corn, irrigated sorghum, and irrigated wheat was slightly below the counties'. The farms in our sample operated an average of 1,763 acres, 68.85 percent of those as cropland. As suggested by the greater number of farms growing the dryland practice, there were more acres put into growing dryland crops than otherwise. The farms in our sample grew and average of 91 acres of dryland corn, 151 acres of dryland sorghum, 182 acres of dryland soybeans, and 361 acres of dryland wheat, while growing 60 acres of irrigated corn, 5 acres of irrigated sorghum, 20 acres of irrigated soybeans, and 16 acres of irrigated wheat. But since we are using an unbalanced panel where many farms do not grow all the crop/practices, our summary statistics undervalue the farms' acreages. When the farms that did not grow the crop/practice in question were eliminated from the sample, average acres devoted to growing the dryland crops above became 217 acres, 233 acres, 323 acres and 438 acres, respectively. For the irrigated practice, the number of acres devoted to these crops was 315 acres, 110 acres, 169 acres, and 202 acres, respectively.

In general, the counties where these farms are located devoted a greater number of acres to growing dryland crops. They grew an average of 95.99 thousand acres of dryland wheat, 31.57 thousand acres of dryland sorghum, 25.76 thousand acres of dryland soybeans, and 8.64 thousand acres irrigated wheat, 2.70 thousand acres of irrigated sorghum, and 3.42 thousand acres of irrigated soybeans. Following the tendency of all the counties in the state, these counties grew more irrigated corn than dryland, 13.58 thousand acres and 7.33 thousand acres, respectively.[54] Note that when we eliminate the farms that did not grow dryland or irrigated corn in our sample, the average number of acres devoted to growing irrigated corn is also greater than that devoted to growing dryland corn.

The average farm had a net worth of about $440.47 thousand, and $224.61 thousand in debt; the average debt to asset ratio of these farms was 38.48 percent. As before, to avoid double counting, we subtracted government payments from farmers' wealth. Non farm

[54] For the period in our sample, the counties in Kansas grew an average of 11.85 thousand acres of dryland corn and 21.17 thousand acres of irrigated corn.

income was a source of revenue for the farms in our sample, of about $15.66 thousand. And while on average this number was smaller than that of net farm income, $40.75 thousand, the ratio of net farm income to total, non- and net farm income, (ownership interest), was only of 0.6844.

The measure of ownership interest is one of three measures of farm diversification used. The other two measures include the share of livestock sales to total sales of the farm and the Herfindahl index of sales diversification. For each farm, this index calculated as

$$(5.6) \quad diversification_{ict} = 1 - \sum_{k}^{K} h_k^2$$

where h_k^2 represents the share of total farm sales accounted for by enterprise k (and enterprises include the eight crop/practices under analysis and the different livestock raised in the farm). The advantage of this representation is that the diversification index is growing with the degree of diversification of the farm. The average farm had a livestock share of sales of 27.74 percent, and the sales diversification index was 0.5192 (note that if sales are completely concentrated in one enterprise, this index takes value 0, while approaching 1 the more diversified the farm).

The number of years growing the crop in the previous four years and the mean performance in other crops capture the effect of experience in farming. On average, the farmers in our sample grew dryland wheat in the previous 3.49 years, dryland sorghum in the previous 2.92 years, dryland soybeans in the previous 2.47 years, and dryland corn in the previous 1.90 years. Again, there was greater experience in growing the dryland practice of these four crops. The relative performance in alternative crops was calculated as in Goodwin *et al.* (2002), where the relative yield measures were normalized by their respective means and then averaged across all other crops for the preceding four years. This variable did not include the relative yield performance on the other practice of the crop, so that, for example, for dryland corn, the mean of other crops included all sorghum, soybeans, and wheat production, but not irrigated corn. This explains why, for a given crop, the relative performance in other crops is the same across practices.

5.4. Empirical results

We begin our econometric approach by estimating equations (5.4) and (5.5) using simple, pooled OLS. This estimator is, however, biased and inconsistent if the unobserved heterogeneity is correlated with any of the regressors. For that reason, we use FE methods to purge the unobserved heterogeneity from the equations, and estimate the slope parameters using OLS on the transformed data. This transformation leaves the term η_{ct} unaffected, so that we continue to assume that farms within a county-year "cluster" are correlated as a result of the unobserved cluster effect, and errors are uncorrelated across year-county clusters. Alternatively, if the regressors in equations (5.4) and (5.5) are not correlated with the unobserved heterogeneity, we can exploit the serial correlation in the composite error, $f_i + \eta_{ct} + u_{ict}$, in a generalized least squares framework by using random effects analysis (Wooldridge 2002). Of course, if the model does not contain an unobserved effect, pooled OLS is efficient. We tested the presence of unobserved effects by using the Breusch and Pagan Lagrange Multiplier test. The test results for all eight crop/practice combinations had a p-value of 0.00, hence rejecting the hypothesis of zero variance of the unobserved heterogeneity. In addition, we chose between the FE and RE estimators by using a Hausman test. For both equations, the null hypothesis that the RE estimator is consistent and efficient was rejected for all the dryland crops and for all irrigated crops except sorghum at the 1 percent level of significance (10% in the case of irrigated wheat). Thus, we use FE methods to estimate the equations for all dryland crops and for irrigated corn, soybeans, and wheat, and use RE methods to estimate the equations for irrigated sorghum.

Tables 5.2 through 5.9 report the results of estimating relative yield performance for the eight crop/practice combinations of corn, sorghum, soybeans, and wheat. Each table contains the results for a given crop/practice combination. The first four tables report the results for the dryland crops and the following four tables report the results for the irrigated crops. So, tables 5.2 through 5.5 report the results for dryland corn, sorghum, soybeans, and wheat, and tables 5.6 through 5.9 report the result for the irrigated version of those crops,

respectively.

In each table, columns (1) through (5) report the results from estimating equation (5.4) and columns (6) through (10) report the results from estimating equation (5.5); recall these equations vary in their inclusion of the financial characteristics of the farms. Each equation is estimated using OLS and panel data methods, FE or RE, using specifications that vary in the dummy variables included. For each estimator, the first specification does not include any dummy variables and the second includes year dummy variables. When using the OLS estimator, we use a third specification, which includes county dummy variables along with the year dummies. In each table, columns (1) and (6) contain the results from the OLS estimation without dummy variables, columns (2) and (7) contain the results from the OLS estimation with year dummy variables, and columns (3) and (8) contain the results from the OLS estimation with both year and county dummy variables. Columns (4) and (9) contain the results from the FE or RE estimators without dummy variables and columns (5) and (10) contain the results from the FE or RE estimators with year dummy variables. Along with the parameter estimates and robust standard errors, the tables include the number of observations and the R^2 statistic; for the RE estimator, this statistic is the overall statistic. Finally, the last row in each table reports the p-value associated with the partial F-test for the joint significance of the additional three variables in equation (5.5), the net worth of the farm, the debt to asset ratio, and the amount of government payments received.

Overall, our results reveal that the effects of the different farm characteristics on relative crop yield performance are crop and practice specific. For example, under the FE estimator, relative performance in other crops has a statistically significant positive effect on relative dryland wheat yields, but a statistically significant negative effect on relative dryland sorghum yields; they do not affect the irrigated practice of these crops.

Table 5.2. Parameter estimates and summary statistics for dryland corn

		OLS		FE			OLS		FE	
Corn, Dryland	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	0.2957	0.2119	0.5717	0.7116	0.6647	0.5019	0.4229	0.7190	0.7493	0.6963
	(0.7742)	(0.741)	(0.763)	(1.306)	(1.269)	(0.746)	(0.71)	(0.743)	(1.305)	(1.27)
Chemical ($1000/crop acres)	-0.1027	-0.0793	-0.1220	0.2353	0.2458	-0.0401	-0.0124	-0.0707	0.2078	0.2241
	(0.1919)	(0.186)	(0.198)	(0.153)	(0.165)	(0.177)	(0.17)	(0.181)	(0.154)	(0.168)
Machinery ($1000/crop acres)	0.0068	0.0076	0.0058	-0.0008	-0.0012	0.0019	0.0021	0.0016	-0.0010	-0.0014
	(0.0075)	(0.009)	(0.005)	(0.004)	(0.003)	(0.005)	(0.006)	(0.004)	(0.004)	(0.004)
Operated acres	0.1295	0.4151	1.8302 *	0.7875	1.6385	-0.8296	-0.6499	0.8781	0.3946	0.9199
	(0.5458)	(0.569)	(0.535)	(2.195)	(2.032)	(0.707)	(0.703)	(0.68)	(2.262)	(2.143)
Acres of crop/practice	7.1459	6.0576	3.5169	0.0868	-3.7245	6.7688	5.6498	2.9640	-1.2119	-4.6102
	(4.8344)	(4.755)	(4.894)	(10.631)	(10.285)	(4.794)	(4.702)	(4.879)	(10.478)	(10.262)
Livestock share of sales	-0.8140	-0.8594	-4.1397	-12.5361	-9.9354	-2.6156	-2.6453	-5.0922 **	-12.3914	-9.6348
	(2.5709)	(2.508)	(2.517)	(7.679)	(7.382)	(2.581)	(2.495)	(2.49)	(7.727)	(7.415)
Diversification	4.3370	4.6596	0.9105	9.1318	7.6276	5.5914	5.9370	1.8071	8.3437	7.7324
	(4.4029)	(4.349)	(4.243)	(8.379)	(8.285)	(4.433)	(4.379)	(4.274)	(8.447)	(8.272)
Ownership interest	0.0591	0.0412	0.0569	-0.2011	-0.2255	0.0523	0.0325	0.0507	-0.2038 ***	-0.2315
	(0.0988)	(0.098)	(0.091)	(0.122)	(0.143)	(0.099)	(0.099)	(0.092)	(0.122)	(0.145)
Mean other crops	-1.5358	-1.4695	-2.7612	-3.9442	-5.7721	-1.8735	-1.7531	-2.8881	-3.9786	-5.3515
	(2.2428)	(2.209)	(2.184)	(4.017)	(3.77)	(2.226)	(2.206)	(2.199)	(3.968)	(3.731)
Number of years	2.0312 *	2.0393 *	0.8836	-2.9784 **	-2.8938 **	1.8268 *	1.8628 *	0.8247	-2.8935 **	-2.7714 **
	(0.5829)	(0.607)	(0.576)	(1.214)	(1.145)	(0.586)	(0.598)	(0.575)	(1.204)	(1.135)
Average county acres (1,000)	-0.3907 *	-0.3255 *	-0.9406 **	-0.7871 ***	-0.5234	-0.3823 *	-0.3177 *	-0.9434 *	-0.8347 ***	-0.5202
	(0.119)	(0.098)	(0.367)	(0.443)	(0.504)	(0.118)	(0.097)	(0.361)	(0.452)	(0.5)
Crops acres share of operated acres	6.1510	8.8070 **	9.8706 **	-5.3399	-3.7304	4.5742	6.7600 ***	8.4486 **	-5.9891	-5.1823
	(4.113)	(3.966)	(3.966)	(11.555)	(11.142)	(4.287)	(4.108)	(4.11)	(11.81)	(11.397)
Wealth ($1,000)						0.0070 *	0.0067 *	0.0040 *	-0.0021	0.0020
						(0.002)	(0.002)	(0.002)	(0.007)	(0.007)
Debt to asset ratio						-2.8417	-3.4450	-4.2584 ***	-7.7612	-8.2878
						(2.513)	(2.566)	(2.458)	(8.088)	(8.092)
Government payments ($1,000)						0.0004	0.0089	0.0226	0.0662 ***	0.0908 **
						(0.023)	(0.022)	(0.023)	(0.04)	(0.041)
Constant	91.2403 *	90.4460 *	97.8781 *	121.0744 *	120.5215 *	93.4284 *	93.2522 *	99.7971 *	125.1165 *	123.7795 *
	(5.809)	(6.183)	(5.728)	(13.575)	(12.905)	(5.867)	(6.355)	(5.86)	(14.004)	(13.398)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	4,301	4,301	4,301	4,301	4,301	4,301	4,301	4,301	4,301	4,301
R^2	0.0145	0.0460	0.1286	0.4548	0.4825	0.0231	0.0548	0.1332	0.4564	0.4844
F-test	-	-	-	-	-	0.0000	0.0000	0.0001	0.2588	0.0800

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.3. Parameter estimates and summary statistics for dryland sorghum

		OLS		FE			OLS		FE	
Soghum, Dryland	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	0.3387	0.2705	0.3682	0.4715	0.3933	0.5441 **	0.4585	0.5467 ***	0.4748	0.3913
	(0.2833)	(0.288)	(0.301)	(0.369)	(0.372)	(0.274)	(0.28)	(0.281)	(0.367)	(0.369)
Chemical ($1000/crop acres)	-0.2359 **	-0.2430 **	-0.2285 **	0.1984 ***	0.1913 ***	-0.1466	-0.1520	-0.1560 ***	0.1959 ***	0.1882 ***
	(0.107)	(0.104)	(0.093)	(0.108)	(0.105)	(0.099)	(0.095)	(0.085)	(0.109)	(0.105)
Machinery ($1000/crop acres)	0.0384 *	0.0434 *	0.0376 *	-0.0167 **	-0.0025	0.0229 *	0.0275 *	0.0240 *	-0.0161 **	-0.0023
	(0.0043)	(0.004)	(0.004)	(0.008)	(0.007)	(0.004)	(0.004)	(0.004)	(0.008)	(0.007)
Operated acres	0.4098	0.6376 ***	1.6797 *	-2.6523 *	-1.2605	-0.7729 ***	-0.8185 **	0.3530	-2.5776 **	-1.7769 ***
	(0.3533)	(0.349)	(0.33)	(0.968)	(0.963)	(0.402)	(0.398)	(0.37)	(1.02)	(1.003)
Acres of crop/practice	10.3953 *	10.0120 *	8.8377 *	-0.4244	-2.5074	9.0255 *	8.1955 *	7.0485 *	-0.5898	-2.8955
	(2.523)	(2.482)	(2.567)	(2.605)	(2.567)	(2.47)	(2.396)	(2.52)	(2.616)	(2.56)
Livestock share of sales	-8.8429 *	-8.6779 *	-9.8075 *	-6.0623 **	-5.4918 **	-10.5691 *	-10.3940 *	-11.0705 *	-6.1118 **	-5.3930 **
	(1.3016)	(1.297)	(1.285)	(2.378)	(2.383)	(1.309)	(1.303)	(1.296)	(2.387)	(2.401)
Diversification	12.6077 *	12.7643 *	9.8574 *	11.3204 *	11.1418 *	13.5584 *	13.5967 *	10.0422 *	11.3292 *	10.8584 *
	(2.1745)	(2.163)	(2.106)	(2.929)	(2.901)	(2.159)	(2.149)	(2.105)	(2.92)	(2.899)
Ownership interest	0.0680	0.0609	0.0554	0.0761	0.0678	0.0723	0.0647	0.0565	0.0765	0.0666
	(0.0517)	(0.051)	(0.051)	(0.064)	(0.063)	(0.05)	(0.049)	(0.05)	(0.064)	(0.063)
Mean other crops	-5.4368 *	-5.3630 *	-6.2445 *	-2.3688 ***	-2.2589 ***	-5.9771 *	-5.8355 *	-6.7605 *	-2.4273 ***	-2.3136 ***
	(1.184)	(1.19)	(1.156)	(1.309)	(1.327)	(1.161)	(1.17)	(1.145)	(1.315)	(1.326)
Number of years	3.0226 *	3.0769 *	1.8886 *	-0.4087	-0.3078	2.9589 *	3.0495 *	1.8244 *	-0.4506	-0.3474
	(0.5233)	(0.517)	(0.495)	(0.799)	(0.787)	(0.516)	(0.508)	(0.491)	(0.797)	(0.786)
Average county acres (1,000)	-0.0291	-0.0366 **	0.0001	0.0129	0.0077	-0.0327 ***	-0.0396 **	0.0164	0.0029	0.0086
	(0.0186)	(0.018)	(0.075)	(0.07)	(0.076)	(0.018)	(0.018)	(0.074)	(0.07)	(0.075)
Crops acres share of operated acres	6.4563 *	7.2285 *	14.6901 *	-13.3113 *	-9.4493 **	5.5054 *	5.3142 *	13.0578 *	-13.3142 *	-10.4157 *
	(1.8682)	(1.839)	(1.821)	(4.058)	(3.966)	(1.943)	(1.914)	(1.888)	(4.108)	(4.006)
Wealth ($1,000)						0.0066 *	0.0066 *	0.0048 *	-0.0040	0.0008
						(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
Debt to asset ratio						-5.0576 *	-5.1958 *	-6.5996 *	-1.7627	-1.3262
						(1.129)	(1.126)	(1.121)	(3.198)	(3.145)
Government payments ($1,000)						0.0101	0.0367 ***	0.0524 *	0.0261	0.0635 *
						(0.019)	(0.022)	(0.02)	(0.02)	(0.023)
Constant	79.4111 *	78.3567 *	90.3476 *	115.4401 *	109.1838 *	83.6902 *	83.5738 *	95.0700 *	117.6171 *	110.4495 *
	(3.0524)	(3.159)	(4.95)	(6.138)	(5.922)	(3.086)	(3.224)	(5.026)	(6.35)	(6.08)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	11,765	11,765	11,765	11,765	11,765	11,765	11,765	11,765	11,765	11,765
R^2	0.0451	0.0518	0.0978	0.4705	0.4766	0.0601	0.0680	0.1110	0.4709	0.4773
F-test	-	-	-	-	-	0.0000	0.0000	0.0000	0.3086	0.0362

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.4. Parameter estimates and summary statistics for dryland soybeans

		OLS		FE			OLS		FE	
Soybeans, Dryland	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	-0.8966	-0.9818	-0.4012 *	-0.1622	-0.2039	-0.6710	-0.7516	-0.2253	-0.1658 *	-0.2175
	(0.9592)	(0.971)	(-0.42)	(1.003)	(1.002)	(0.962)	(0.975)	(0.966)	(-0.17)	(1)
Chemical ($1000/crop acres)	-0.6617 *	-0.6133 *	-0.5738 *	-0.2180	-0.2036	-0.5805 *	-0.5258 *	-0.5086 *	-0.2422	-0.2208
	(0.1659)	(0.151)	(0.145)	(0.194)	(0.193)	(0.158)	(0.139)	(0.135)	(0.194)	(0.193)
Machinery ($1000/crop acres)	0.0293 *	0.0331 *	0.0276 *	-0.0057	-0.0050	0.0197 *	0.0233 *	0.0197 *	-0.0109	-0.0070
	(0.0079)	(0.009)	(0.008)	(0.009)	(0.009)	(0.007)	(0.008)	(0.007)	(0.009)	(0.009)
Operated acres	2.5139 *	2.9172 *	2.8090 *	0.2465	0.3321	1.6007 **	1.5297 **	1.4619 **	-0.4193	-0.2281
	(0.5701)	(0.581)	(0.577)	(1.499)	(1.496)	(0.685)	(0.666)	(0.675)	(1.563)	(1.54)
Acres of crop/practice	1.5192	0.5012	1.4154	-8.8784 **	-10.1026 **	1.0115	-0.0424	0.5227	-10.5545 **	-10.8161 **
	(2.2065)	(2.11)	(2.038)	(4.348)	(4.301)	(2.223)	(2.126)	(2.052)	(4.4)	(4.378)
Livestock share of sales	-4.2586 **	-4.6451 *	-5.7799 *	-10.2726 **	-11.4691 **	-5.6193 *	-5.8781 *	-6.7101 *	-10.5226 **	-11.5767 **
	(1.7842)	(1.782)	(1.721)	(4.233)	(4.459)	(1.748)	(1.743)	(1.698)	(4.227)	(4.463)
Diversification	4.2146	3.8261	5.8426 ***	7.8439	6.8760	4.6179	3.5805	5.3798	7.3104	6.5654
	(3.5929)	(3.501)	(3.413)	(5.126)	(4.983)	(3.576)	(3.502)	(3.42)	(5.07)	(4.978)
Ownership interest	0.0600	0.0690	0.0658	0.0230	0.0350	0.0690	0.0777	0.0696	0.0191	0.0328
	(0.0735)	(0.07)	(0.07)	(0.067)	(0.063)	(0.072)	(0.069)	(0.069)	(0.068)	(0.063)
Mean other crops	-0.7380	-0.1044	-0.4199	-1.2895	-1.3261	-1.4195	-0.7685	-1.0103	-1.4390	-1.2524
	(1.6542)	(1.649)	(1.596)	(2.122)	(2.101)	(1.638)	(1.629)	(1.582)	(2.103)	(2.092)
Number of years	3.0835 *	3.0820 *	2.3632 *	-1.3032	-1.3847	3.0045 *	2.9605 *	2.3240 *	-1.2267	-1.3544
	(0.6367)	(0.612)	(0.655)	(1.05)	(1.056)	(0.637)	(0.61)	(0.653)	(1.048)	(1.055)
Average county acres (1,000)	-0.0023	0.0068	-0.3388	-0.2351	-0.1990	0.0018	0.0125	-0.3306	-0.2853	-0.1826
	(0.0325)	(0.032)	(0.222)	(0.172)	(0.25)	(0.033)	(0.032)	(0.219)	(0.175)	(0.249)
Crops acres share of operated acres	10.8997 *	12.1584 *	10.3255 *	6.3409	6.2449	9.6609 *	9.2512 *	8.2192 *	4.9656	5.0671
	(2.857)	(2.856)	(3.004)	(6.037)	(5.963)	(3.096)	(2.98)	(3.114)	(6.025)	(5.964)
Wealth ($1,000)						0.0044 *	0.0037 **	0.0031 **	0.0014	0.0013
						(0.001)	(0.002)	(0.002)	(0.004)	(0.004)
Debt to asset ratio						-4.7762 *	-5.4038 *	-5.2045 *	-5.5428	-5.5279
						(1.784)	(1.861)	(1.791)	(4.6)	(4.585)
Government payments ($1,000)						0.0183	0.0740 **	0.0777 *	0.0654	0.0655
						(0.028)	(0.029)	(0.029)	(0.04)	(0.043)
Constant	74.8297 *	74.9638 *	104.4478 *	110.6181 *	110.6546 *	78.8699 *	81.5021 *	109.4449 *	115.5638 *	113.4129 *
	(4.5912)	(4.74)	(15.582)	(9.503)	(11.404)	(4.681)	(4.92)	(15.569)	(9.925)	(11.853)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	7,194	7,194	7,194	7,194	7,194	7,194	7,194	7,194	7,194	7,194
R^2	0.0320	0.0470	0.0824	0.4656	0.4716	0.0386	0.0547	0.0888	0.4666	0.4722
F-test	-	-	-	-	-	0.0000	0.0000	0.0000	0.1883	0.2304

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.5. Parameter estimates and summary statistics for dryland wheat

	OLS			FE		OLS			FE	
Wheat, Dryland	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	-0.3217 **	-0.3157 **	-0.2694 ***	-0.0603 *	-0.0491	-0.2460	-0.2375	-0.2060	-0.0585	-0.0528
	(0.1581)	(0.159)	(0.155)	(-0.41)	(0.149)	(0.156)	(0.157)	(0.151)	(0.146)	(0.148)
Chemical ($1000/crop acres)	-0.2478 *	-0.2409 *	-0.2130 *	-0.0494	-0.0353	-0.2047 *	-0.1962 *	-0.1773 *	-0.0529	-0.0376
	(0.0564)	(0.056)	(0.058)	(0.062)	(0.061)	(0.057)	(0.056)	(0.058)	(0.062)	(0.061)
Machinery ($1000/crop acres)	0.0114 *	0.0122 *	0.0112 *	-0.0029	0.0005	0.0065 **	0.0072 **	0.0067 **	-0.0030	0.0003
	(0.0037)	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Operated acres	0.2213	0.2452	1.1392 *	-1.6422 *	-1.0026 ***	-0.6532 **	-0.6834 **	0.2502	-1.7162 *	-1.3342 **
	(0.268)	(0.266)	(0.237)	(0.591)	(0.583)	(0.328)	(0.315)	(0.279)	(0.623)	(0.609)
Acres of crop/practice	0.9770	1.0276	1.7709 **	0.2949	0.3802	1.5009	1.5106 ***	1.4314 ***	0.4961	0.3612
	(0.9052)	(0.886)	(0.814)	(1.543)	(1.513)	(0.925)	(0.912)	(0.838)	(1.543)	(1.506)
Livestock share of sales	-4.8265 *	-5.0283 *	-6.3509 *	-8.6313 *	-10.0978 *	-5.7566 *	-5.9333 *	-6.9202 *	-8.6919 *	-10.0306 *
	(1.0014)	(0.997)	(0.957)	(1.624)	(1.633)	(1)	(0.994)	(0.96)	(1.623)	(1.637)
Diversification	11.0318 *	11.1492 *	5.9051 *	5.5709 *	5.0592 **	11.4949 *	11.5992 *	5.9673 *	5.3983 *	4.7821 **
	(1.6739)	(1.634)	(1.295)	(2.045)	(1.993)	(1.653)	(1.627)	(1.285)	(2.027)	(1.974)
Ownership interest	0.0562 ***	0.0596 ***	0.0421	0.0392	0.0413	0.0593 ***	0.0628 **	0.0436	0.0375	0.0403
	(0.0313)	(0.032)	(0.03)	(0.031)	(0.032)	(0.031)	(0.031)	(0.03)	(0.031)	(0.032)
Mean other crops	1.6440 *	1.5514 *	0.9280 ***	2.1465 *	2.1078 *	1.5278 *	1.4239 **	0.8646	2.0381 **	2.1004 *
	(0.5724)	(0.564)	(0.533)	(0.806)	(0.763)	(0.562)	(0.553)	(0.527)	(0.795)	(0.762)
Number of years	0.4216	0.2923	0.2285	-0.8485	-1.3110 ***	0.2606	0.1146	0.0454	-0.8130	-1.3372 ***
	(0.4596)	(0.46)	(0.456)	(0.7)	(0.705)	(0.459)	(0.46)	(0.458)	(0.7)	(0.701)
Average county acres (1,000)	-0.0070	-0.0076	-0.1245 *	-0.0285	-0.1315 *	-0.0056	-0.0062	-0.1246 *	-0.0274	-0.1281 *
	(0.005)	(0.005)	(0.041)	(0.036)	(0.046)	(0.005)	(0.005)	(0.04)	(0.037)	(0.045)
Crops acres share of operated acres	6.3788 *	6.4805 *	11.3032 *	-2.8254	-0.5790	4.8561 *	4.7922 *	9.6850 *	-3.2338	-1.3037
	(1.5955)	(1.592)	(1.398)	(2.796)	(2.748)	(1.642)	(1.646)	(1.451)	(2.811)	(2.752)
Wealth ($1,000)						0.0039 *	0.0038 *	0.0023 *	-0.0020	0.0006
						(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Debt to asset ratio						-2.9125 *	-3.0769 *	-3.8083 *	-1.1668	-1.4012
						(0.734)	(0.726)	(0.779)	(1.18)	(1.169)
Government payments ($1,000)						0.0098	0.0156	0.0422 *	0.0217	0.0433 *
						(0.01)	(0.01)	(0.009)	(0.013)	(0.014)
Constant	86.4986 *	88.2590 *	104.6337 *	109.0441 *	122.9785 *	89.1852 *	91.4565 *	108.1457 *	110.0672 *	123.6677 *
	(2.443)	(2.568)	(3.952)	(5.303)	(6.373)	(2.44)	(2.619)	(3.973)	(5.41)	(6.398)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	19,159	19,159	19,159	19,159	19,159	19,159	19,159	19,159	19,159	19,159
R^2	0.0188	0.0253	0.0767	0.3526	0.3614	0.0266	0.0335	0.0834	0.3530	0.3621
F-test	-	-	-	-	-	0.0000	0.0000	0.0000	0.1657	0.0115

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.6. Parameter estimates and summary statistics for irrigated corn

		OLS		FE			OLS		FE	
Corn, Irrigated	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	0.1406	0.1491	0.2360	0.2408	0.2557	0.1915	0.2017	0.2933	0.2497	0.2508
	(0.1338)	(0.136)	(0.181)	(0.237)	(0.22)	(0.134)	(0.138)	(0.189)	(0.236)	(0.222)
Chemical ($1000/crop acres)	-0.0715	-0.0720	-0.0692	-0.0095	-0.0051	-0.0644	-0.0647	-0.0666	-0.0108	-0.0050
	(0.0499)	(0.047)	(0.047)	(0.056)	(0.054)	(0.049)	(0.046)	(0.046)	(0.057)	(0.055)
Machinery ($1000/crop acres)	0.0040	0.0024	0.0021	-0.0003	-0.0020 ***	0.0029	0.0015	0.0012	-0.0005	-0.0020 ***
	(0.0033)	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
Operated acres	0.5770 ***	0.4881	0.7035 **	-0.4032	-0.6896	0.2961	0.3692	0.5063	-0.4966	-0.7073
	(0.3402)	(0.336)	(0.332)	(0.663)	(0.639)	(0.393)	(0.391)	(0.397)	(0.649)	(0.626)
Acres of crop/practice	5.0487 *	5.2209 *	3.4347 *	-5.1704 **	-5.9798 **	4.8644 *	6.1717 *	4.1204 *	-5.6656 **	-6.2252 **
	(1.2262)	(1.198)	(1.134)	(2.547)	(2.498)	(1.316)	(1.447)	(1.339)	(2.665)	(2.567)
Livestock share of sales	-8.0496 *	-8.2457 *	-7.1702 *	-5.3051	-4.9173	-8.5637 *	-8.8541 *	-7.7243 *	-5.4275	-4.7748
	(2.0937)	(2.05)	(2.079)	(3.852)	(3.771)	(2.112)	(2.065)	(2.103)	(3.858)	(3.79)
Diversification	-0.9798	-1.6217	0.0397	5.9273 ***	5.6754 ***	-0.8035	-1.1612	0.6453	5.8827 ***	5.4814 ***
	(2.5994)	(2.628)	(2.815)	(3.286)	(3.313)	(2.602)	(2.634)	(2.825)	(3.31)	(3.307)
Ownership interest	0.0994	0.0869	0.0315	-0.0249	-0.0570	0.0984	0.0878	0.0370	-0.0270	-0.0581
	(0.1246)	(0.136)	(0.121)	(0.092)	(0.101)	(0.126)	(0.138)	(0.122)	(0.092)	(0.101)
Mean other crops	2.1845 ***	1.8940	1.0023	0.4891	0.7564	2.0696 ***	1.7941	0.9032	0.4236	0.7312
	(1.2548)	(1.238)	(1.235)	(1.434)	(1.442)	(1.252)	(1.241)	(1.231)	(1.422)	(1.438)
Number of years	1.4164 **	1.3481 **	1.1937 **	-1.5210 **	-1.7017 *	1.3489 **	1.2441 **	1.1119 ***	-1.5169 **	-1.7042 *
	(0.6025)	(0.594)	(0.599)	(0.613)	(0.617)	(0.598)	(0.588)	(0.593)	(0.614)	(0.618)
Average county acres (1,000)	-0.1031 *	-0.1094 *	-0.0486	0.0886	-0.0085	-0.1000 *	-0.1060 *	-0.0370	0.0726	-0.0129
	(0.0193)	(0.02)	(0.127)	(0.104)	(0.119)	(0.02)	(0.02)	(0.126)	(0.108)	(0.12)
Crops acres share of operated acres	4.4150	3.7071	5.8921 **	1.3170	-0.5269	3.9564	3.6554	6.1719 **	1.1495	-0.6443
	(2.7266)	(2.661)	(2.84)	(4.607)	(4.509)	(2.738)	(2.691)	(2.842)	(4.608)	(4.517)
Wealth ($1,000)						0.0015 **	0.0015 **	0.0019 *	0.0016	-0.0013
						(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Debt to asset ratio						-0.9020	-0.9870	-0.8768	0.0088	-0.7613
						(1.169)	(1.164)	(1.129)	(2.897)	(2.699)
Government payments ($1,000)						0.0014	-0.0139	-0.0126	0.0060	0.0075
						(0.01)	(0.012)	(0.012)	(0.011)	(0.013)
Constant	88.6163 *	89.5722 *	110.9859 *	99.5406 *	105.6544 *	89.5789 *	89.8265 *	110.6543 *	99.5106 *	106.8792 *
	(4.6267)	(4.852)	(5.978)	(7.492)	(7.081)	(4.636)	(4.858)	(5.833)	(7.846)	(7.343)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	3,815	3,815	3,815	3,815	3,815	3,815	3,815	3,815	3,815	3,815
R^2	0.0341	0.0531	0.1064	0.4485	0.4630	0.0362	0.0557	0.1093	0.4486	0.4632
F-test	-	-	-	-	-	0.0790	0.0129	0.0018	0.8242	0.8344

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.7. Parameter estimates and summary statistics for irrigated sorghum

		OLS		RE			OLS		RE	
Sorghum, Irrigated	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	-3.1982	-2.8719	-2.8063	-0.1944	0.5042	-2.4799	-2.0102 *	-2.2778	-0.1318	0.7052
	(2.7164)	(2.641)	(2.767)	(2.98)	(2.908)	(2.618)	(-0.8)	(2.68)	(3.025)	(2.893)
Chemical ($1000/crop acres)	-0.1351	-0.2764	-0.6403	-0.5523	-0.7336	0.1297	-0.0166	-0.4652	-0.4539	-0.6838
	(0.8626)	(0.936)	(0.981)	(0.784)	(0.828)	(0.852)	(0.91)	(0.984)	(0.799)	(0.834)
Machinery ($1000/crop acres)	0.0174	0.0168	0.0198	0.0071	0.0066	-0.0238	-0.0254	-0.0132	-0.0147	-0.0129
	(0.0177)	(0.018)	(0.02)	(0.021)	(0.021)	(0.018)	(0.018)	(0.02)	(0.021)	(0.021)
Operated acres	1.9346 **	1.7587 ***	2.8830 *	1.3774	1.2059	-0.3205	-1.2128	0.7205	-0.9405	-1.4821
	(0.9194)	(0.939)	(0.997)	(1.211)	(1.225)	(1.181)	(1.232)	(1.302)	(1.406)	(1.425)
Acres of crop/practice	19.6264	21.0507	31.3087 **	30.8956 **	31.3747 **	12.8389	12.6724	24.5494 ***	27.5205 **	27.2704 **
	(13.2371)	(13.777)	(14.33)	(13.578)	(13.642)	(13.091)	(13.855)	(14.637)	(13.042)	(13.309)
Livestock share of sales	-0.6454	-1.1016	7.4550	5.5221	5.3882	-3.1734	-3.3386	4.3634	4.6974	4.8109
	(6.7587)	(6.682)	(6.719)	(8.148)	(8.07)	(6.803)	(6.684)	(6.89)	(8.207)	(8.121)
Diversification	12.4935	10.3298	4.6844	13.8340 ***	12.7266 ***	12.5041	10.2467	3.1536	14.0656 ***	12.2443
	(8.1205)	(8.118)	(8.377)	(7.548)	(7.715)	(8.153)	(8.069)	(8.374)	(7.577)	(7.716)
Ownership interest	-0.1335	-0.1497	-0.2943 *	-0.2729 **	-0.2901 **	-0.1905	-0.2126	-0.3156 *	-0.2786 **	-0.2990 **
	(0.166)	(0.172)	(0.104)	(0.12)	(0.123)	(0.157)	(0.156)	(0.107)	(0.123)	(0.127)
Mean other crops	4.3023	4.1807	3.0731	4.4750	3.9021	3.6738	3.4896	2.7984	4.1636	3.6716
	(4.667)	(4.81)	(4.842)	(3.709)	(3.743)	(4.609)	(4.753)	(4.838)	(3.639)	(3.651)
Number of years	-0.0957	0.0973	0.2687	0.0026	0.2624	-0.4347	-0.3909	-0.0465	-0.1874	0.0163
	(1.0964)	(1.163)	(1.137)	(1.154)	(1.216)	(1.083)	(1.139)	(1.115)	(1.147)	(1.202)
Average county acres (1,000)	-0.3159	-0.3138	-0.0883	-0.3235	-0.3470	-0.3925 ***	-0.4182	0.0230	-0.2958	-0.3841
	(0.2258)	(0.251)	(0.64)	(0.259)	(0.298)	(0.232)	(0.259)	(0.638)	(0.261)	(0.3)
Crops acres share of operated acres	22.9973 *	23.0692 *	47.0015 *	29.2594 *	29.9216 *	23.5514 **	21.2383 **	44.3573 *	24.0460 **	23.8697 **
	(8.5788)	(8.463)	(9.581)	(9.731)	(9.826)	(9.346)	(9.188)	(9.756)	(10.26)	(10.206)
Wealth ($1,000)						0.0089 *	0.0087 *	0.0074 *	0.0058 ***	0.0057 ***
						(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Debt to asset ratio						-5.3517 **	-5.7706 **	-5.3918 **	-1.3733	-1.5113
						(2.127)	(2.221)	(2.263)	(2.126)	(2.048)
Government payments ($1,000)						0.0260	0.0763 ***	0.0415	0.0696 **	0.1012 *
						(0.03)	(0.044)	(0.042)	(0.031)	(0.039)
Constant	59.1539 *	61.0274 *	79.3911 *	52.8966 *	54.0707 *	67.2754 *	73.3039 *	95.9895 *	60.5499 *	64.0251 *
	(10.9584)	(11.501)	(16.481)	(11.265)	(11.286)	(11.062)	(11.931)	(16.954)	(11.597)	(11.656)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	928	928	928	928	928	928	928	928	928	928
R^2	0.0288	0.0433	0.2047	0.0251	0.0364	0.0553	0.0726	0.2214	0.0443	0.0592
F-test	-	-	-	-	-	0.0000	0.0000	0.0001	0.0061	0.0045

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.8. Parameter estimates and summary statistics for irrigated soybeans

	OLS			FE		OLS			FE	
Soybeans, Irrigated	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	-1.8525 **	-1.8374 **	-1.5571 *	-0.1737	-0.1527	-1.6259 **	-1.6051 **	-1.3188 ***	-0.2121	-0.1920
	(0.8526)	(0.805)	(-2.18)	(1.008)	(1)	(0.8)	(0.748)	(0.671)	(1.013)	(0.999)
Chemical ($1000/crop acres)	-0.0159	-0.0358	-0.0186	0.1203	0.1245 ***	0.0085	-0.0199	-0.0137	0.1355 ***	0.1378 ***
	(0.0572)	(0.055)	(0.054)	(0.08)	(0.073)	(0.056)	(0.054)	(0.052)	(0.081)	(0.075)
Machinery ($1000/crop acres)	0.0118 ***	0.0124 ***	0.0097	0.0084	0.0275 ***	0.0051	0.0058	0.0040	0.0138	0.0301 ***
	(0.0063)	(0.007)	(0.006)	(0.016)	(0.016)	(0.005)	(0.005)	(0.005)	(0.016)	(0.015)
Operated acres	2.4612 *	2.6303 *	2.2664 *	3.4400	4.6264 **	1.4199 **	1.1323	1.1150	3.9442 ***	4.5249 **
	(0.5647)	(0.565)	(0.654)	(2.1)	(2)	(0.72)	(0.691)	(0.772)	(2.083)	(1.999)
Acres of crop/practice	2.2213	4.4030	2.8344	-22.1316 **	-12.0694	0.8480	1.6195	1.2973	-21.7019 **	-12.6905
	(4.3697)	(4.454)	(3.931)	(10.116)	(9.021)	(4.708)	(4.9)	(4.455)	(10.162)	(9.091)
Livestock share of sales	-6.3127	-6.6358 ***	-4.6691	1.4801	0.9809	-8.0546 **	-7.4445 ***	-5.6211	1.7783	1.3558
	(3.8527)	(3.844)	(4.146)	(6.921)	(7.262)	(3.898)	(3.855)	(4.066)	(6.918)	(7.282)
Diversification	3.5819	1.9540	1.7009	7.2867	7.2388	4.7655	3.4772	3.2393	7.4767	7.0299
	(6.5393)	(6.25)	(5.428)	(6.855)	(6.904)	(6.501)	(6.185)	(5.379)	(6.906)	(6.909)
Ownership interest	0.1182	0.0772	0.0717	-0.1722	-0.2311	0.1415	0.1016	0.0908	-0.1591	-0.2155
	(0.3216)	(0.338)	(0.366)	(0.395)	(0.4)	(0.339)	(0.357)	(0.379)	(0.394)	(0.396)
Mean other crops	0.3099	1.5269	0.8205	-3.9131	-1.7546	-0.3014	1.0025	0.2746	-3.6331	-1.6420
	(2.8938)	(2.845)	(2.646)	(3.383)	(3.155)	(2.808)	(2.76)	(2.575)	(3.332)	(3.171)
Number of years	1.2715 **	1.0462 ***	1.1252 ***	-0.7194	0.0533	1.1972 **	0.9475	1.0086 ***	-0.6562	0.0973
	(0.5854)	(0.587)	(0.589)	(0.985)	(0.965)	(0.596)	(0.594)	(0.595)	(0.983)	(0.956)
Average county acres (1,000)	-0.1596	-0.0675	-0.1593	-1.2681 **	0.0011	-0.1923	-0.0890	-0.2160	-1.2112 **	0.0478
	(0.1901)	(0.189)	(0.67)	(0.635)	(0.734)	(0.187)	(0.186)	(0.663)	(0.612)	(0.727)
Crops acres share of operated acres	12.2768 *	9.9239 **	9.3536 ***	14.9631	17.1201	11.0007 **	7.4441	8.6965	15.7301	16.1957
	(4.4587)	(4.501)	(5.228)	(11.108)	(10.738)	(4.569)	(4.565)	(5.315)	(11.117)	(10.843)
Wealth ($1,000)						0.0018	0.0013	0.0013	-0.0025	-0.0016
						(0.001)	(0.001)	(0.001)	(0.004)	(0.004)
Debt to asset ratio						-7.0176 *	-7.0075 *	-6.9317 *	3.5313	4.3251
						(1.782)	(1.744)	(1.701)	(3.776)	(3.309)
Government payments ($1,000)						0.0328	0.0677 *	0.0475 ***	-0.0189	0.0207
						(0.024)	(0.025)	(0.026)	(0.034)	(0.038)
Constant	80.0985 *	83.6149 *	29.7166 **	96.6253 *	79.1234 *	85.4404 *	90.5383 *	33.7741 *	93.7468 *	77.8803 *
	(7.0956)	(7.826)	(11.667)	(15.864)	(16.192)	(7.146)	(7.957)	(11.678)	(15.814)	(16.257)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950
R^2	0.0261	0.0602	0.1760	0.5086	0.5361	0.0425	0.0774	0.1897	0.5096	0.5369
F-test	-	-	-	-	-	0.0000	0.0000	0.0000	0.5564	0.4863

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively.

Table 5.9. Parameter estimates and summary statistics for irrigated wheat

		OLS		FE			OLS		FE	
Wheat, Irrigated	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed ($1000/crop acres)	-3.5604 **	-3.3796 **	-2.8991 ***	0.3803	0.0971 *	-3.1317 ***	1.5110 *	-2.3888	0.4371	0.1504
	(1.6464)	(1.555)	(1.614)	(1.791)	(0.05)	(1.603)	(-1.96)	(1.562)	(1.8)	(1.8)
Chemical ($1000/crop acres)	-0.2913	0.0712	0.1771	-0.0312	0.3511	-0.2261	0.1433	0.2186	-0.0341	0.3426
	(0.8119)	(0.815)	(0.852)	(1.239)	(1.219)	(0.812)	(0.815)	(0.854)	(1.241)	(1.22)
Machinery ($1000/crop acres)	0.0061	0.0089	0.0071	-0.0075 *	-0.0038	0.0046	0.0072	0.0061	-0.0075 *	-0.0038 ***
	(0.0086)	(0.008)	(0.007)	(0.003)	(0.002)	(0.008)	(0.007)	(0.006)	(0.003)	(0.002)
Operated acres	1.5864 **	1.6747 **	1.8870 **	-1.0424	-0.7276	0.9462	1.0099	1.4068	-0.9894	-0.7456
	(0.6508)	(0.656)	(0.728)	(1.432)	(1.45)	(0.807)	(0.804)	(0.907)	(1.428)	(1.456)
Acres of crop/practice	6.3543	7.1607	3.8846	20.3967 ***	20.9718 ***	8.1354	8.7288	6.0884	20.1757 ***	20.8277 ***
	(5.0558)	(5.363)	(5.728)	(11.879)	(11.839)	(5.35)	(5.673)	(5.953)	(11.981)	(11.924)
Livestock share of sales	-15.1454 **	-14.3187 **	-15.3158 **	-22.2757 ***	-19.8852 ***	-16.1313 **	-15.3576 **	-16.5282 **	-22.4324 ***	-20.1251 ***
	(7.3267)	(7.211)	(6.438)	(12.528)	(11.701)	(7.384)	(7.261)	(6.481)	(12.514)	(11.76)
Diversification	17.4139 *	16.7187 *	12.5842 **	16.1815 ***	14.7280 ***	18.2820 *	17.6175 *	13.8428 **	16.4476 ***	14.9781 ***
	(6.1692)	(5.654)	(6.016)	(8.426)	(8.151)	(6.226)	(5.684)	(6.009)	(8.462)	(8.187)
Ownership interest	0.3873 *	0.4663 *	0.4746 *	0.3113 **	0.4114 *	0.3744 *	0.4499 *	0.4730 *	0.3105 **	0.4116 *
	(0.1256)	(0.132)	(0.128)	(0.149)	(0.129)	(0.133)	(0.136)	(0.134)	(0.149)	(0.13)
Mean other crops	2.4720	2.2892	2.1593	5.5211	4.8778	2.6797	2.4208	2.1907	5.7092	4.9280
	(3.0749)	(2.935)	(2.963)	(3.882)	(3.775)	(3.061)	(2.936)	(2.966)	(3.838)	(3.79)
Number of years	-2.1942 **	-2.7412 **	-2.2525 **	-2.3290	-2.3920	-2.1967 **	-2.7612 **	-2.2325 ***	-2.2818	-2.3467
	(1.0387)	(1.075)	(1.121)	(2.085)	(1.918)	(1.049)	(1.079)	(1.136)	(2.089)	(1.914)
Average county acres (1,000)	-0.1425 **	-0.1799 *	-0.0868	0.0106	-0.3560	-0.1466 **	-0.1829 *	-0.0959	-0.0207	-0.3849
	(0.0705)	(0.064)	(0.339)	(0.298)	(0.41)	(0.071)	(0.065)	(0.34)	(0.318)	(0.416)
Crops acres share of operated acres	20.3539 *	23.0167 *	18.9398 **	-10.6320	0.4626	20.5646 *	22.9654 *	19.5324 **	-10.2420	0.9126
	(7.4085)	(7.322)	(7.281)	(15.309)	(15.617)	(7.571)	(7.412)	(7.515)	(15.537)	(15.608)
Wealth ($1,000)						0.0033 ***	0.0030 ***	0.0027	0.0018	0.0041
						(0.002)	(0.002)	(0.002)	(0.006)	(0.006)
Debt to asset ratio						-3.9290	-4.1916 ***	-5.7080 **	-1.2019	-0.1856
						(2.475)	(2.509)	(2.773)	(3.766)	(3.817)
Government payments ($1,000)						-0.0083	-0.0041	-0.0130	-0.0087	-0.0017
						(0.018)	(0.017)	(0.017)	(0.025)	(0.024)
Constant	75.6161 *	78.6690 *	88.2564 *	102.7941 *	104.4627 *	76.5531 *	79.7921 *	93.2258 *	102.5557 *	102.5357 *
	(8.8298)	(8.378)	(13.647)	(19.975)	(20.486)	(8.973)	(8.521)	(13.747)	(20.176)	(20.18)
Year dummies	No	Yes	Yes	No	No	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes	No	No	No	No	Yes
N	1,682	1,682	1,682	1,682	1,682	1,682	1,682	1,682	1,682	1,682
R^2	0.0388	0.0668	0.1300	0.4516	0.4706	0.0455	0.0730	0.1369	0.4518	0.4708
F-test	-	-	-	-	-	0.0085	0.0115	0.0052	0.9478	0.9211

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Overall, expenditures on seed, chemicals, and machinery seem to play a small role in affecting the relative yield performance of these crops.[55] When using OLS, greater spending on seed has a statistically significant effect solely on wheat (both practices), an effect which becomes insignificant for dryland wheat and positive for irrigated wheat when FE methods are used. Spending on chemicals (fertilizer and herbicide) decreases relative dryland sorghum, soybeans, and wheat yields when using OLS, but the coefficient estimates become significantly positive or insignificant when we switch to FE methods for dryland sorghum and for dryland soybeans and wheat, respectively; these methods generate a significantly positive coefficient for irrigated soybeans. Investment on machinery increases relative yields of dryland sorghum and soybeans (both practices), while decreasing those of dryland wheat when using OLS. Acknowledging unobserved effects keeps the positive significance of the coefficient for irrigated soybeans while changing the sign for dryland sorghum; a statistically significant negative coefficient is further found for irrigated corn and wheat.

When we take unobserved effects into account, we see that decreasing marginal productivities seem to matter for dryland sorghum and dryland wheat, where farm size has a statistically significant negative effect on yield performance. Across both equations and their different specifications, larger farms have lower relative yields. For dryland sorghum, an additional 1,000 operated acres decreases relative sorghum yields by 1.3 to 2.7 percentage points, while for dryland wheat this increase in operated acreage brings about a decrease in relative wheat yields of between 1 to 1.7 percentage points. On the contrary, for irrigated soybeans, the relationship between farm size and productivity is significantly positive, and an additional 1,000 operated acres increase relative soybeans yields by 3.9 to 4.6 percentage points. The coefficient estimates on the number of acres devoted to each crop/practice further suggest this is the case. Using panel data methods, we find a statistically significant negative effect for irrigated corn and soybeans, and for dryland soybeans, although an opposite effect is found for irrigated sorghum and wheat. OLS results reveal the same positive effect for irrigated sorghum, as well as for irrigated corn and dryland sorghum and wheat.

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[55] Recall these are aggregate expenditures at the farm level, and do not necessarily reflect expenditures on a single crop.

Like Goodwin *et al.* (2002), we find statistically significant negative coefficient estimates on the livestock share of sales. Having a greater share of sales coming from livestock significantly decreases relative yields in all crops but corn and irrigated sorghum and soybeans. Except for dryland sorghum, the magnitude of this effect is greater under the FE estimator. And as the authors, we find that diversification over different enterprises has a significantly positive effect on relative yields. This occurs for sorghum, wheat, and irrigated corn, an effect that is slightly smaller under the FE estimator for dryland wheat. Our last measure of diversification, ownership interest, while surprisingly significantly negative for dryland corn in equation (5.5) and irrigated sorghum across both equations, is significantly positive for irrigated wheat and not significant for the remaining crops.

Experience also does not affect the four crops in the same fashion. For dryland wheat, better performance in alternative crops raises relative yields, the magnitude of this effect being greater under the FE estimator. But the effect is opposite for dryland sorghum, where performance in other crops decreases relative yields, less so under the FE estimator. For some crops, the number of years growing the crop in question also has a negative effect on relative yields. When using panel data methods, except for irrigated sorghum, where no significant effect is found, the number of years growing the crop decreases relative corn and dryland wheat yields; this negative effect is found for both OLS and FE estimators solely for the latter crop/practice. Indeed, for corn, OLS coefficient results are significantly positive, as they are for soybeans and dryland sorghum; the sole use of this estimator could explain the positive results found by Goodwin *et al.* (2002). When using the FE estimator, an additional year of growing the crop decreases relative corn yields by almost 3 percentage points, while decreasing that of dryland wheat by about 1.3 percentage points. No learning effects from neighbors are found except in dryland corn, irrigated soybeans, and dryland wheat, where larger average county acres cause relative yields to decrease.

Our measure of overall land quality also yields mixed results. In general, OLS coefficient estimates suggest a greater share of operated acres used as cropland increases relative yields. Results are significant for the four crops, varying only the magnitude. And they are usually lower for equation (5.5) than for equation (5.4). For the latter, an additional 1

percentage point in this share increases relative yields by between 4 and 47 percentage points. But acknowledging the presence of unobserved effects renders these effects insignificant except for irrigated sorghum and for dryland sorghum. For the latter, a greater percentage of operated acres devoted to crops actually significantly decreases relative yields.

Finally, in terms of the financial characteristics of the farms, our results suggest the following. In general, if unobserved effects are not accounted for, wealth has a statistically significant positive effect on relative yields, although this effect is very small in magnitude. On the contrary, the debt to asset ratio has a negative effect on the relative yields of all crops and their practices except for irrigated corn, but this effect is rendered insignificant by our acknowledgment of unobserved effects. Indeed, except for irrigated sorghum, acknowledging the presence of unobserved effects renders both coefficients statistically insignificant. But this is the single crop/practice combination estimated using random effects, which implicitly assumes the unobserved effects are uncorrelated with the regressors.[56] When taking unobserved effects into account, government payments are found to have statistically significant positive effects on dryland corn, both practices of sorghum, and dryland wheat. For these crops, an additional $1,000 in government payments increases relative yields by between 0.04 and 0.1 percentage points. When using OLS, however, government payments have a significant negative effect on relative irrigated corn and wheat yields.

Overall, when using OLS, relative yields are significantly affected by farmers' wealth in seven out of eight cases, by farmers' debt to asset ratio in seven out of eight cases, and by farmers' government payment receipts in five out of eight cases. When using panel data methods, these numbers fall to one and zero for the first two coefficients, and to four for the third coefficient. These results suggest that government payments may play an important role in affecting relative yield performance. When we take into account unobserved effects, we find statistically significant positive effects for sorghum, dryland corn, and dryland wheat. In terms of joint significance, the partial F-tests suggest we reject the hypothesis that all three

[56] When estimated using FE, the coefficient on wealth is statistically insignificant, whereas that of the debt to asset ratio is significantly positive. The coefficient on government payments is still significantly positive and its magnitude unchanged. The partial F-test of joint significance has a p-value of 0.0014, suggesting these coefficient estimates are not equal to zero.

coefficients are zero for the different crops and their practices when using OLS, and for corn, sorghum, and dryland wheat when using panel data methods.

The finding that government payments affect yield performance motivates our next analysis. As explained in the previous chapters in this dissertation, decoupled payments may increase the liquidity or improve the collateral of the credit constrained farmer in a manner that allows investment in production to occur. This investment may be used to improve production methods rather than expand acreage, as assumed in Chapters 3 and 4. Our goal in the following application is to observe whether decoupled payments affect relative yield performance.

5.5. AMTA payments and relative yield performance

This section estimates the impact of AMTA payments on relative crop yields. Equation (5.5) is estimated for 1996 through 2001, the period of the FAIR Act, using AMTA payments instead of total government payments. Because information is required on the farms' historical acres and yields, a smaller set of farms is available for this application. In particular, we can only use the subset of farms that reported production in the years 1986 through 1988, since we base our estimation of the AMTA payments on these years' average acres and yields. We calculate of the amount of AMTA payments received by these farms using the methodology described in Chapter 3.

Our data contain a total of 7,187 observations. The highest number of observations in a year occurs in 1996 (1,307 observations) and the lowest number occurs in 2001 (1,056 observations). We can observe 882 farms over all the years in our sample; of these, we observe between 8 farms and 130 farms growing irrigated crops (the bounds correspond to sorghum and corn, respectively) and between 241 farms and 608 farms growing dryland crops (the bounds correspond to corn and wheat, respectively). Table 5.10 reports the summary statistics for the data used in our estimation.

Table 5.10. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Number of farms (per year)	7,188	1,198	98	1,056	1,307
Operated Acres, Total (1,000)	7,188	1.78	1.37	0.05	11.06
Share of Crops in Total Operated Acres	7,188	0.6778	0.2701	0.0034	1.0000
Wealth ($1,000)	7,188	520.66	518.84	-568.61	5,924.80
Total Liabilities ($1,000)	7,188	222.36	272.92	0.00	4,313.30
Debt to Asset Ratio	7,188	0.3328	0.3219	0.0000	9.2463
Government Payments ($1,000)	7,188	19.12	18.09	0.00	329.80
Net Farm Income ($1,000)	7,188	45.46	83.32	-563.70	1,555.62
Non Farm Income ($1,000)	7,188	16.76	23.06	-8.46	309.21
Seeds (per 1,000 crop acres) ($1,000)	7,188	0.06	0.71	-0.18	28.01
Chemical (per 1,000 crop acres) ($1,000)	7,188	0.31	3.60	-0.34	132.15
Machinery (per 1,000 crop acres) ($1,000)	7,188	133.15	193.15	0.00	12,730.45
Ownership Interest	7,188	0.6982	5.7050	-257.6805	134.6589
Diversification	7,139	0.5229	0.2025	0.0000	0.8392
Livestock Share of Sales	7,139	0.2676	0.3273	0.0000	1.0000
Normalized Yields,Irrigated Corn	1,140	98.31	18.78	0.00	182.34
Normalized Yields, Dryland Corn	977	101.66	40.15	0.00	384.13
Normalized Yields, Irrigated Sorghum	259	94.30	38.07	0.00	251.89
Normalized Yields, Dryland Sorghum	3,822	102.55	28.90	0.00	232.31
Normalized Yields, Irrigated Soybeans	594	104.98	25.34	9.41	209.09
Normalized Yields, Dryland Soybeans	2,220	100.70	36.77	0.00	382.63
Normalized Yields, Irrigated Wheat	482	96.49	40.32	0.00	393.48
Normalized Yields, Dryland Wheat	5,972	99.99	27.70	0.00	306.67
Acres, Irrigated Corn (1,000)	7,188	0.06	0.17	0.00	2.63
Acres, Dryland Corn (1,000)	7,188	0.08	0.17	0.00	1.64
Acres, Irrigated Sorghum (1,000)	7,188	0.01	0.05	0.00	2.66
Acres, Dryland Sorghum (1,000)	7,188	0.17	0.23	0.00	4.49
Acres, Irrigated Soybeans (1,000)	7,188	0.02	0.07	0.00	0.94
Acres, Dryland Soybeans (1,000)	7,188	0.18	0.31	0.00	3.57
Acres, Irrigated Wheat (1,000)	7,188	0.01	0.07	0.00	1.37
Acres, Dryland Wheat (1,000)	7,188	0.35	0.40	0.00	4.20
County Acreage, Irrigated Corn (1,000)	5,667	13.58	21.28	0.10	123.72
County Acreage, Dryland Corn (1,000)	6,101	6.62	8.39	0.17	57.15
County Acreage, Irrigated Sorghum (1,000)	4,948	2.45	3.29	0.10	18.46
County Acreage, Dryland Sorghum (1,000)	7,188	34.82	25.81	0.23	100.78
County Acreage, Irrigated Soybeans (1,000)	5,646	3.15	3.96	0.10	20.73
County Acreage, Dryland Soybeans (1,000)	6,626	26.63	24.72	0.10	100.88
County Acreage,Irrigated Wheat (1,000)	3,132	8.27	12.93	0.10	76.44
County Acreage, Dryland Wheat (1,000)	7,188	98.17	82.49	0.64	452.08
Years Produced, Irrigated Corn	7,188	0.94	1.56	0.00	4.00
Years Produced, Dryland Corn	7,188	1.61	1.68	0.00	4.00
Years Produced, Irrigated Sorghum	7,188	0.43	0.98	0.00	4.00
Years Produced, Dryland Sorghum	7,188	2.99	1.47	0.00	4.00
Years Produced, Irrigated Soybeans	7,188	0.60	1.21	0.00	4.00
Years Produced, Dryland Soybeans	7,188	2.32	1.77	0.00	4.00
Years Produced, Irrigated Wheat	7,188	0.51	1.13	0.00	4.00
Years Produced, Dryland Wheat	7,188	3.52	1.08	0.00	4.00
Mean other crops, Irrigated/Dryland Corn	7,188	0.9781	0.2544	0.0000	5.3481
Mean other crops, Irrigated/Dryland Sorghum	7,188	0.9736	0.2542	0.0000	5.3481
Mean other crops, Irrigated/Dryland Soybeans	7,188	0.9656	0.2050	0.0000	2.0792
Mean other crops, Irrigated/Dryland Wheat	7,188	0.9469	0.4156	0.0000	10.9809

As before, we subtract the amount of AMTA payments from farmers' wealth to avoid double counting. Because the remaining portion of payments is not subtracted from wealth, average wealth in this sample is greater than that of the previous application. Now, the average farmer has a wealth of about $520.66 thousand and $222.36 thousand in debt. In terms of normalized yields, those of irrigated corn, irrigated sorghum, dryland soybeans, and irrigated and dryland wheat are greater than in the previous sample, and those of dryland corn, dryland sorghum, and irrigated soybeans smaller than those in the previous sample.

Tables 5.11 through 5.18 report the results of estimating relative yield performance for the eight crop/practice combinations of corn, sorghum, soybeans and wheat. Again, each table contains the results for a given crop/practice combination. Tables 5.11 through 5.14 report the results for dryland corn, sorghum, soybeans, and wheat, and tables 5.15 through 5.18 report the result for the irrigated practice of those crops, respectively. Once more, we use OLS and panel data methods, FE or RE, and use specifications that vary in the dummy variables included. For each estimator, the first specification does not include any dummy variables, while the second includes year dummy variables. We again use a third specification when using OLS, which further includes county dummy variables.

As before, in each table, columns (1) through (3) contain the results from the OLS estimation. Column (1) contains the results when the specification does not contain dummy variables, column (2) contains those when year dummy variables are included, and column (3) contains the results when both year and county dummy variables. Columns (4) and (5) contain the results from the FE or RE estimators. Column (4) contains the results when no dummy variables are included in the specification and column (5) contains the results when year dummy variables are included. Again, the last row in each table reports the p-value associated with the partial F-test for the joint significance of the net worth of the farm, the debt to asset ratio, and the amount of government payments received. We again estimate the dryland crops and irrigated corn, soybeans, and wheat using FE and estimate irrigated sorghum using RE.[57]

[57] We again judged the appropriateness of the FE estimator by a series of Hausman tests. The results were similar to those in the previous section.

Table 5.11. Parameter estimates and summary statistics for dryland corn (AMTA payments)

	OLS			FE	
Corn, Dryland	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	2.1877 **	1.9829 ***	2.3487 **	1.8826	1.1104
	(1.086)	(1.13)	(1.137)	(1.883)	(1.817)
Chemical ($1000/crop acres)	0.0966	0.1146	0.1103	0.4021 *	0.4179 *
	(0.173)	(0.19)	(0.181)	(0.122)	(0.144)
Machinery ($1000/crop acres)	0.0602 *	0.0688 *	0.0490 **	0.0281	0.0461
	(0.022)	(0.022)	(0.023)	(0.076)	(0.075)
Operated acres	-0.0320	-0.4821	0.1990	-3.6352	-3.4264
	(1.313)	(1.302)	(1.559)	(4.419)	(4.285)
Acres of crop/practice	3.4094	7.1337	0.1143	-1.0359	5.0622
	(9.419)	(8.518)	(8.049)	(15.146)	(14.192)
Livestock share of sales	-0.8586	1.7375	-8.7294	-27.4536 ***	-23.6434 ***
	(5.956)	(5.905)	(6.578)	(14.65)	(14.042)
Diversification	0.2332	3.7149	6.0333	3.2997	4.5602
	(8.733)	(8.232)	(8.901)	(14.106)	(13.878)
Ownership interest	0.0742	0.0511	0.1170	-0.1329	-0.1495
	(0.159)	(0.161)	(0.231)	(0.304)	(0.343)
Mean other crops	1.8222	1.0954	4.2846	-33.1585 ***	-33.3123 ***
	(12.768)	(12.125)	(12.165)	(19.43)	(18.829)
Number of years	-0.3831	-0.6846	-1.4570	-6.2038 *	-3.3094
	(1.083)	(1.021)	(1.07)	(2.239)	(2.461)
Average county acres (1,000)	-0.2265	-0.0475	0.7078	0.7052	1.4299 ***
	(0.217)	(0.201)	(0.526)	(0.692)	(0.794)
Crops acres share of operated acres	10.0499	11.8364	13.5441	16.7385	24.5536
	(9.1)	(8.983)	(10.169)	(21.201)	(21.196)
Wealth ($1,000)	0.0052	0.0043	0.0036	0.0100	0.0106
	(0.003)	(0.003)	(0.003)	(0.014)	(0.013)
Debt to asset ratio	-0.7660	-1.5405	-0.6451	3.9430	1.2138
	(6.295)	(6.364)	(7.505)	(15.318)	(14.634)
AMTA payments ($1,000)	0.0911	0.1853 ***	0.1261	-0.3148	0.1001
	(0.098)	(0.098)	(0.106)	(0.286)	(0.498)
Constant	81.3478 *	75.8194 *	17.6592	139.4553 *	116.8287 *
	(19.235)	(18.153)	(18.053)	(34.348)	(35.123)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	913	913	913	913	913
R^2	0.0415	0.0741	0.1860	0.5012	0.5198
F-test	0.1783	0.0970	0.3503	0.5950	0.8306

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.12. Parameter estimates and summary statistics for dryland sorghum (AMTA payments)

	OLS			FE	
Soghum, Dryland	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-0.3558	-0.4525	-0.4462	0.6600	0.4502
	(0.594)	(0.623)	(0.624)	(0.66)	(0.705)
Chemical ($1000/crop acres)	-0.1001	-0.1004	-0.1485	0.1221	0.1398
	(0.133)	(0.123)	(0.109)	(0.145)	(0.139)
Machinery ($1000/crop acres)	0.0156 *	0.0193 *	0.0165 *	0.0018	0.0090
	(0.005)	(0.005)	(0.005)	(0.009)	(0.009)
Operated acres	-0.1444	-0.3210	0.2297	-0.0808	0.3380
	(0.493)	(0.484)	(0.464)	(1.417)	(1.403)
Acres of crop/practice	8.9598 *	7.4054 *	5.5481 **	-3.2570	-5.3570
	(2.42)	(2.35)	(2.341)	(4.291)	(4.376)
Livestock share of sales	-10.2388 *	-9.8606 *	-10.3719 *	-3.8188	-4.1487
	(1.925)	(1.932)	(1.9)	(4.075)	(4.016)
Diversification	13.4110 *	13.0022 *	10.0904 *	8.5964 ***	8.5184 ***
	(3.19)	(3.157)	(3.146)	(4.752)	(4.654)
Ownership interest	0.0509	0.0404	0.0620	0.0338	0.0143
	(0.057)	(0.054)	(0.051)	(0.064)	(0.06)
Mean other crops	-7.3964 **	-8.2516 **	-8.7309 **	-2.1077	-2.1952
	(3.482)	(3.519)	(3.572)	(4.814)	(4.727)
Number of years	2.2147 *	2.3766 *	0.9685	-0.0061	-0.5303
	(0.687)	(0.673)	(0.689)	(1.423)	(1.402)
Average county acres (1,000)	-0.0278	-0.0479 ***	0.1221	0.1775	0.2988 ***
	(0.026)	(0.025)	(0.164)	(0.159)	(0.177)
Crops acres share of operated acres	-1.0113	-2.8366	4.5469	-14.9804 ***	-12.6162 ***
	(2.864)	(2.795)	(2.91)	(7.813)	(7.596)
Wealth ($1,000)	0.0047 *	0.0046 *	0.0033 *	0.0012	0.0023
	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)
Debt to asset ratio	-7.2752 *	-7.5145 *	-8.7867 *	-3.1494	-4.4523
	(1.748)	(1.798)	(1.981)	(6.384)	(6.309)
AMTA payments ($1,000)	0.1406 *	0.2115 *	0.2611 *	-0.2456 **	0.0069
	(0.04)	(0.044)	(0.051)	(0.095)	(0.112)
Constant	92.3774 *	89.5568 *	102.4388 *	110.3005 *	104.7000 *
	(5.436)	(5.742)	(9.234)	(11.374)	(11.457)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	3,815	3,815	3,815	3,815	3,815
R^2	0.0784	0.0895	0.1553	0.5699	0.5770
F-test	0.0000	0.0000	0.0000	0.0745	0.8033

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.13. Parameter estimates and summary statistics for dryland soybeans (AMTA payments)

	OLS			FE	
Soybeans, Dryland	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-4.0562 *	-3.9150 *	-2.8513 ***	1.7488 *	-1.6129
	(1.384)	(1.375)	(1.665)	(-0.88)	(1.847)
Chemical ($1000/crop acres)	-0.5941 **	-0.5515 **	-0.6175 *	-0.5669 ***	-0.5594
	(0.228)	(0.213)	(0.212)	(0.341)	(0.348)
Machinery ($1000/crop acres)	0.0319 *	0.0359 *	0.0326 *	-0.0086	-0.0068
	(0.009)	(0.01)	(0.01)	(0.019)	(0.02)
Operated acres	1.1604	0.9008	0.7096	0.2108	0.2590
	(1.105)	(1.126)	(1.155)	(4.224)	(4.238)
Acres of crop/practice	-4.3811	-4.1286	-2.7948	-19.4016 ***	-19.5166 ***
	(3.565)	(3.444)	(3.788)	(11.3)	(10.92)
Livestock share of sales	-7.0114 **	-6.5218 ***	-6.1102 ***	-11.4777	-13.2663
	(3.525)	(3.569)	(3.629)	(8.73)	(9.253)
Diversification	-0.6044	-1.1813	-0.7061	-4.9858	-3.9358
	(6.154)	(6.029)	(6.181)	(13.089)	(13.589)
Ownership interest	-0.0482	-0.0374	-0.0346	-0.1090	-0.0976
	(0.167)	(0.171)	(0.18)	(0.253)	(0.249)
Mean other crops	-4.7856	-3.6027	-3.1469	-7.7509	-8.0388
	(5.674)	(5.839)	(5.66)	(8.906)	(8.718)
Number of years	3.0744 *	2.8162 *	2.2180 ***	-4.3206	-4.2190
	(1.049)	(1.02)	(1.144)	(2.682)	(2.823)
Average county acres (1,000)	0.0147	0.0376	-0.3852	-0.1172	-0.2298
	(0.052)	(0.052)	(0.644)	(0.43)	(0.844)
Crops acres share of operated acres	-3.1121	-4.7921	-4.8020	-19.9107	-17.7556
	(5.523)	(5.351)	(6.421)	(14.495)	(15.159)
Wealth ($1,000)	0.0073 *	0.0067 *	0.0059 *	0.0032	0.0054
	(0.002)	(0.002)	(0.002)	(0.01)	(0.01)
Debt to asset ratio	-2.2750	-2.5643	-3.0139	4.1156	3.0982
	(2.852)	(2.936)	(2.786)	(12.478)	(12.213)
AMTA payments ($1,000)	0.1860 **	0.2748 *	0.2835 *	0.0480	0.0519
	(0.073)	(0.073)	(0.076)	(0.261)	(0.331)
Constant	88.1444 *	84.0197 *	125.2456 **	147.5804 *	155.4306 *
	(8.633)	(11.11)	(50.107)	(23.279)	(36.151)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	2,214	2,214	2,214	2,214	2,214
R^2	0.0568	0.0727	0.1195	0.5491	0.5514
F-test	0.0000	0.0000	0.0000	0.9853	0.9541

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.14. Parameter estimates and summary statistics for dryland wheat (AMTA payments)

	OLS			FE	
Wheat, Dryland	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-0.3793	-0.3764	-0.4295	0.5034 *	0.2045 *
	(0.452)	(0.452)	(0.479)	(0.42)	(0.39)
Chemical ($1000/crop acres)	-0.2691 *	-0.2661 *	-0.2284 *	0.0194	0.0261
	(0.073)	(0.072)	(0.077)	(0.077)	(0.076)
Machinery ($1000/crop acres)	0.0107 **	0.0106 **	0.0074 ***	-0.0026	-0.0009
	(0.005)	(0.005)	(0.004)	(0.008)	(0.008)
Operated acres	-0.4501	-0.4756	0.3947	-1.3594	-1.4212
	(0.514)	(0.503)	(0.498)	(1.173)	(1.178)
Acres of crop/practice	2.2706	2.2992	0.7752	-1.6798	-1.7049
	(1.817)	(1.8)	(1.613)	(3.276)	(3.279)
Livestock share of sales	-4.9648 *	-5.1342 *	-6.0336 *	-7.9869 **	-7.9465 **
	(1.628)	(1.621)	(1.621)	(3.616)	(3.618)
Diversification	11.3128 *	11.2150 *	5.7469 *	4.9533	4.6645
	(2.564)	(2.567)	(2.136)	(3.301)	(3.308)
Ownership interest	-0.0005	0.0014	-0.0160	-0.0454	-0.0429
	(0.038)	(0.036)	(0.034)	(0.042)	(0.043)
Mean other crops	3.4986 *	3.4459 *	3.4040 *	10.6357 *	10.6676 *
	(1.249)	(1.249)	(1.173)	(2.637)	(2.607)
Number of years	0.3044	0.4038	1.1213	-1.8095	-1.7151
	(0.915)	(0.913)	(0.922)	(1.409)	(1.435)
Average county acres (1,000)	-0.0108	-0.0109	-0.3015 *	-0.3045 *	-0.2910 **
	(0.008)	(0.008)	(0.099)	(0.096)	(0.113)
Crops acres share of operated acres	1.7878	1.6667	9.2317 *	4.8001	5.5330
	(2.865)	(2.849)	(2.628)	(5.857)	(5.817)
Wealth ($1,000)	0.0030 *	0.0030 *	0.0009	-0.0054	-0.0046
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)
Debt to asset ratio	-5.6216 *	-5.6112 *	-6.7466 *	5.1560	5.7589
	(1.307)	(1.296)	(1.372)	(4.996)	(4.975)
AMTA payments ($1,000)	0.0793 *	0.0786 *	0.1810 *	0.0582	0.1377
	(0.025)	(0.024)	(0.026)	(0.091)	(0.113)
Constant	87.7642 *	87.6880 *	101.7913 *	129.7574 *	125.1458 *
	(4.454)	(4.605)	(6.789)	(14.617)	(16.677)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	5,961	5,961	5,961	5,961	5,961
R^2	0.0361	0.0403	0.1310	0.4633	0.4660
F-test	0.0000	0.0000	0.0000	0.1606	0.1444

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.15. Parameter estimates and summary statistics for irrigated corn (AMTA payments)

	OLS			FE	
Corn, Irrigated	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-0.0323	-0.0831	0.2068	0.3235	0.0447
	(0.253)	(0.22)	(0.298)	(0.324)	(0.304)
Chemical ($1000/crop acres)	-0.0192	-0.0285	-0.0581 ***	0.0095	-0.0106
	(0.036)	(0.029)	(0.031)	(0.059)	(0.051)
Machinery ($1000/crop acres)	0.0078	0.0086	0.0127 **	-0.0153	-0.0175
	(0.005)	(0.006)	(0.006)	(0.013)	(0.013)
Operated acres	-0.0924	-0.0710	-0.5147	-1.6840	-1.5371
	(0.619)	(0.589)	(0.467)	(1.168)	(1.241)
Acres of crop/practice	5.0321 **	4.8570 **	2.3161	-7.1146 ***	-7.6135 ***
	(2.193)	(2.233)	(2.209)	(3.955)	(4.102)
Livestock share of sales	-16.0874 *	-15.5801 *	-16.4782 *	-4.2809	-2.7942
	(3.036)	(2.955)	(3.167)	(4.857)	(4.702)
Diversification	-2.9411	-2.8098	-1.6426	0.2460	-0.5867
	(3.464)	(3.419)	(3.009)	(4.702)	(4.717)
Ownership interest	0.6610 *	0.7199 *	0.4988 *	0.4550 *	0.5095 *
	(0.196)	(0.205)	(0.157)	(0.169)	(0.165)
Mean other crops	13.0435 *	12.7029 *	9.9697 **	1.2348	-1.6992
	(4.423)	(4.377)	(5.012)	(5.935)	(5.672)
Number of years	0.5266	0.4246	1.0675	-0.9592	-1.3722
	(1.001)	(0.986)	(1.067)	(2.018)	(1.901)
Average county acres (1,000)	-0.0924 *	-0.0954 *	-0.0810	-0.2840 **	-0.1465
	(0.028)	(0.028)	(0.158)	(0.127)	(0.189)
Crops acres share of operated acres	-6.7170 ***	-5.9859	0.4871	-3.0601	-4.3985
	(3.711)	(3.758)	(3.833)	(10.409)	(10.061)
Wealth ($1,000)	0.0037 *	0.0037 *	0.0058 *	0.0041	0.0020
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)
Debt to asset ratio	3.2712	3.3609	6.8855 *	9.2452	5.9380
	(2.459)	(2.468)	(2.559)	(9.038)	(8.168)
AMTA payments ($1,000)	0.0306	0.0308 ***	-0.0158	0.0400	-0.0438
	(0.019)	(0.018)	(0.026)	(0.06)	(0.054)
Constant	88.0928 *	84.8468 *	87.5522 *	113.9269 *	115.3677 *
	(7.085)	(7.473)	(21.285)	(15.976)	(16.428)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	1,120	1,120	1,120	1,120	1,120
R^2	0.0816	0.1046	0.2220	0.5224	0.5446
F-test	0.0059	0.0024	0.0007	0.6723	0.7635

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.16. Parameter estimates and summary statistics for irrigated sorghum (AMTA payments)

	OLS			RE	
Sorghum, Irrigated	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-13.3395 *	-12.4781 *	-13.0453 ***	3.9286 **	-7.3372 **
	(2.494)	(-4.41)	(7.582)	(3.929)	(3.446)
Chemical ($1000/crop acres)	-9.8641 **	-10.1328 *	-11.5119	-9.2098 **	-9.4929 *
	(4.034)	(3.622)	(8.812)	(4.176)	(3.601)
Machinery ($1000/crop acres)	-0.0518	-0.0556 ***	-0.0587	-0.0465	-0.0419
	(0.033)	(0.033)	(0.039)	(0.04)	(0.04)
Operated acres	0.2315	-0.3880	-0.5527	-0.6292	-1.3781
	(2.05)	(2.119)	(1.985)	(2.391)	(2.379)
Acres of crop/practice	37.9130	37.6334	47.6899	68.7277 *	66.0267 *
	(27.776)	(29.212)	(31.345)	(22.927)	(24.005)
Livestock share of sales	-27.2888 **	-26.7255 **	-10.1710	-16.2706	-15.5086
	(11.425)	(11.118)	(13.763)	(11.574)	(10.792)
Diversification	26.0650 ***	20.9915	8.3734	13.4662	9.2734
	(14.589)	(15.165)	(16.098)	(13.516)	(13.768)
Ownership interest	-0.1321	-0.1931	-0.7875	-0.6010	-0.7939 ***
	(0.384)	(0.41)	(0.635)	(0.412)	(0.424)
Mean other crops	14.4759	14.5487	-10.5624	8.2080	6.9858
	(16.452)	(17.42)	(19.174)	(13.97)	(14.825)
Number of years	-2.3653	-2.3657	1.2230	-2.1040	-2.4767
	(2.308)	(2.373)	(2.554)	(2.248)	(2.336)
Average county acres (1,000)	-0.9492 ***	-1.1057 **	-2.3117 ***	-0.6280	-1.1518
	(0.495)	(0.517)	(1.309)	(0.653)	(0.731)
Crops acres share of operated acres	23.9236	24.7948 ***	44.9564 **	22.2972	26.4122
	(14.844)	(14.069)	(20.3)	(19.471)	(19.095)
Wealth ($1,000)	0.0095 **	0.0104 **	0.0106 **	0.0080	0.0091 ***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Debt to asset ratio	-4.1642 ***	-4.3715 ***	-9.3855 *	-4.7418 **	-4.4326 **
	(2.419)	(2.474)	(2.379)	(2.052)	(2.144)
AMTA payments ($1,000)	-0.0134	0.0480	-0.0299	-0.0279	0.1098
	(0.103)	(0.1)	(0.123)	(0.12)	(0.12)
Constant	61.5414 **	56.7670 **	85.6870 ***	72.6008 *	77.9464 *
	(25.673)	(26.703)	(50.42)	(25.209)	(25.692)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	259	259	259	259	259
R^2	0.1573	0.1732	0.4136	0.1356	0.1509
F-test	0.0136	0.0131	0.0001	0.0425	0.0373

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.17. Parameter estimates and summary statistics for irrigated soybeans (AMTA payments)

	OLS			FE	
Soybeans, Irrigated	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-0.8704	-0.8037	-1.1333	0.9730	-0.5175
	(0.659)	(0.572)	(0.756)	(0.973)	(0.95)
Chemical ($1000/crop acres)	0.0332	0.0074	-0.0218	0.0606	0.0797
	(0.061)	(0.053)	(0.051)	(0.079)	(0.079)
Machinery ($1000/crop acres)	-0.0094	-0.0043	-0.0035	-0.0181	-0.0017
	(0.007)	(0.006)	(0.006)	(0.037)	(0.037)
Operated acres	-0.0819	-0.3937	-0.3431	1.7272	3.4469
	(1.097)	(1.011)	(1.227)	(2.692)	(2.895)
Acres of crop/practice	-0.9538	0.6310	-4.0373	-28.8434 ***	-23.7802
	(8.474)	(8.228)	(8.879)	(17.04)	(16.952)
Livestock share of sales	-10.5979	-11.6460	-2.7323	-5.5829	-7.0434
	(7.743)	(7.457)	(7.12)	(11.339)	(11.469)
Diversification	-3.7053	-2.3698	-4.5776	-21.2448	-17.4756
	(11.518)	(10.113)	(8.757)	(17.346)	(15.831)
Ownership interest	0.4829	0.5332 ***	0.8524 **	0.6666	0.5628
	(0.335)	(0.275)	(0.341)	(0.502)	(0.537)
Mean other crops	-15.8825	-11.6706	-16.6862	3.4322	5.0118
	(12.791)	(12.706)	(13.44)	(18.393)	(18.412)
Number of years	1.0377	0.6000	1.1732	2.2184	3.0726
	(1.009)	(0.877)	(0.982)	(2.263)	(2.13)
Average county acres (1,000)	-0.7755 **	-0.6762 **	-2.4003 **	-3.9352 *	-2.6451 ***
	(0.301)	(0.302)	(1.077)	(1.102)	(1.339)
Crops acres share of operated acres	3.0117	-1.8035	3.1287	17.4629	21.1137
	(8.964)	(9.473)	(11.384)	(24.773)	(24.621)
Wealth ($1,000)	0.0053 **	0.0054 *	0.0057 *	-0.0017	0.0012
	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)
Debt to asset ratio	-2.8997 **	-2.7247 **	-2.4707	0.3826	5.8906
	(1.408)	(1.342)	(1.687)	(12.35)	(11.471)
AMTA payments ($1,000)	0.0731	0.1033 **	0.0461	-0.1045	-0.2382
	(0.049)	(0.049)	(0.05)	(0.177)	(0.269)
Constant	120.9384 *	120.9299 *	98.0812 *	130.8872 *	109.7423 *
	(17.415)	(16.376)	(25.026)	(30.772)	(35.779)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	579	579	579	579	579
R^2	0.0669	0.1035	0.2685	0.5651	0.5751
F-test	0.0000	0.0000	0.0006	0.9227	0.8119

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Table 5.18. Parameter estimates and summary statistics for irrigated wheat (AMTA payments)

	OLS			FE	
Wheat, Irrigated	(1)	(2)	(3)	(4)	(5)
Seed ($1000/crop acres)	-4.0856	-4.2021	-4.5396	3.0132	2.7296
	(2.607)	(2.799)	(3.116)	(3.013)	(3.33)
Chemical ($1000/crop acres)	-0.1963	-0.1067	0.1573	1.5363	0.9424
	(2.157)	(2.254)	(2.554)	(6.139)	(5.996)
Machinery ($1000/crop acres)	0.0641 **	0.0645 *	0.0630 *	0.0442	0.0542
	(0.025)	(0.024)	(0.023)	(0.039)	(0.046)
Operated acres	2.2062	2.2117	1.4240	-7.4485	-6.4972
	(1.521)	(1.543)	(2.101)	(5.702)	(5.729)
Acres of crop/practice	8.1368	8.6491	6.1162	27.2727	27.9406
	(10.804)	(10.944)	(13.401)	(28.7)	(28.932)
Livestock share of sales	-14.5151	-14.7284	-16.0063	-7.3122	-13.8850
	(11.268)	(11.488)	(11.914)	(24.919)	(24.719)
Diversification	2.9776	3.8127	1.5873	-10.8380	-10.8018
	(9.782)	(9.819)	(11.167)	(13.255)	(13.847)
Ownership interest	0.7242 ***	0.7909 ***	0.6387 ***	0.4259 **	0.4961 **
	(0.397)	(0.423)	(0.386)	(0.181)	(0.221)
Mean other crops	11.1124	11.5543	12.5479	23.2695	26.9010 ***
	(9.599)	(9.787)	(9.438)	(14.292)	(13.915)
Number of years	-3.7371 ***	-3.9048 ***	-3.4524	2.5840	2.9818
	(2.178)	(2.115)	(2.429)	(5.487)	(5.756)
Average county acres (1,000)	-0.2365 **	-0.2387 ***	0.2296	0.4765	-0.4215
	(0.119)	(0.126)	(1.038)	(0.836)	(1.041)
Crops acres share of operated acres	18.7895	18.8484	6.1637	-56.5866	-41.9128
	(13.178)	(13.455)	(15.343)	(35.405)	(36.642)
Wealth ($1,000)	0.0049	0.0050	0.0054	-0.0070	-0.0060
	(0.004)	(0.004)	(0.004)	(0.014)	(0.015)
Debt to asset ratio	-1.2981	-1.1213	5.0572	2.1702	1.0745
	(2.305)	(2.512)	(7.446)	(19.824)	(20.49)
AMTA payments ($1,000)	0.0148	0.0162	0.0505	0.2986 **	0.4297 **
	(0.056)	(0.06)	(0.07)	(0.144)	(0.176)
Constant	68.8334 *	65.3258 *	5.4939	109.0183 **	96.4052 ***
	(19.474)	(19.865)	(74.953)	(48.902)	(51.903)
Year dummies	No	Yes	Yes	No	No
County dummies	No	No	Yes	No	-
Year - County dummies	No	No	No	No	Yes
N	482	482	482	482	482
R^2	0.0792	0.0843	0.1902	0.5555	0.5629
F-test	0.4328	0.4422	0.4671	0.2336	0.1013

Notes: Robust standard errors reported in parentheses. Single, double and triple asterisks indicate significance at the α= 0.01, 0.05 and 0.10 levels, respectively. F-test is the p-value associated with the partial F-test of joint significance of wealth, debt to asset ratio, and government payments.

Our results suggest AMTA payments distort relative crop yields. When using OLS, a statistically significant positive effect is found in five out of eight cases: irrigated and dryland corn, dryland sorghum, irrigated soybeans, and dryland wheat. When panel data methods are used, these effects are only significant for dryland sorghum, where this effect is actually negative, and for irrigated wheat, where the effect is positive. The magnitude of these effects is crop and practice specific. When using OLS, an additional $1,000 in AMTA payments increases relative crop yields by 0.03 percentage points in the case of irrigated corn, by 0.18 percentage points in the case of dryland corn, and by between 0.10 and 0.28 percentage points in the case of dryland sorghum and soybeans. For dryland wheat, these values vary between 0.08 and 0.18 percentage points. When using FE, an additional $1,000 in AMTA payments decreases dryland sorghum yields by 0.25 percentage points, although this effect is no longer significant when year dummy variables are included in the estimating equation; irrigated wheat yields are increased by between 0.30 to 0.43 percentage points.

As before, the effects of the other regressors on relative yields are crop and practice specific. Again, both size, number of acres devoted to the crop/practice, and share of livestock sales have a negative impact on relative yields. And although the coefficient estimates are never statistically significant for the first variable for either estimator, those on the number of acres devoted to the crop/practice in question are significantly positive in two out of eight cases under OLS (irrigated corn and dryland sorghum) and significantly negative in three out of eight cases under FE (irrigated corn and both practices of soybeans). Those on the livestock share of sales are significantly negative in five cases under OLS (dryland sorghum, soybeans, and wheat, and irrigated corn and sorghum) and two cases under panel FE (dryland corn and wheat). Diversification overall has a positive effect on relative yields, although some coefficient estimates are negative (but statistically insignificant). The estimate for the Herfindahl index coefficient is significant in three cases under OLS (irrigated sorghum and dryland sorghum and wheat) and in one case under panel data methods (dryland sorghum). Ownership interest raises relative crop yields for irrigated corn and wheat under both estimators and for irrigated soybeans under OLS, while decreasing relative irrigated sorghum yields under RE. In terms of experience, a better performance in other crops raises

relative dryland wheat yields under both estimators, irrigated wheat under FE, and irrigated corn yields under OLS, while decreasing those of dryland sorghum under OLS and dryland corn under FE. The effect of more years growing the crop is also not clear: a statistically significant positive effect is found for dryland sorghum and soybeans under OLS, but a negative effect is found for irrigated wheat under OLS and dryland corn under FE. Having more acres in the county devoted to growing the crop/practice in question tends to lower relative yields, as we find a significantly negative effect in six out of eight cases using OLS (irrigated corn, sorghum, soybeans and wheat, and dryland sorghum and wheat) and in three our of eight cases when using FE (irrigated corn, soybeans, and wheat). But a statistically significant positive effect for dryland corn and sorghum is found when using FE.

In terms of the other two variables that pertain to the financial characteristics of the farms, wealth is found to have a statistically significant positive effect on relative crop yields only when using OLS, where it raises relative yields of irrigated corn, sorghum, and soybeans, and dryland sorghum, soybeans, and wheat. But, as before, the magnitude of this effect is very small. The debt to asset ratio is also found to significantly affect relative yields when using OLS, lowering those of irrigated sorghum and soybeans, and those of dryland sorghum and wheat, while increasing those of irrigated corn. But when unobserved effects are taken into account, a single statistically significant negative effect is found for irrigated soybeans. When taken together, the three variables included in the set of financial characteristics of the farms, net worth, debt to asset ratio, and government payments receipts, seem to be relevant in terms of explaining relative yield performance in six out of eight cases when using OLS (irrigated corn, sorghum and soybeans, and dryland sorghum, soybeans, and wheat), and in two out of eight cases when using panel data methods (irrigated and dryland sorghum).

5.6. Conclusions

The question of which specific farm characteristics affect crop yields has been largely

ignored by the economics literature. Yet, one would expect yields to be higher for farmers who are more skilled, who have a better knowledge of farming, or who have access to better technology or seeds. The goal of this section was to observe whether specific farm characteristics could explain relative crop yield performance. A variety of farm characteristics were treated as regressors in the econometric model of farm yields, including the financial characteristics of the farms, such as their wealth, debt to asset ratio, and the amount of government payments they received. As in Goodwin *et al.* (2002), we found that larger farms had lower relative yields, as did farms that had a greater share of sales coming from livestock. Wealthier farms also showed a tendency to have higher relative yields, as did farms with greater government payments receipts; these effects were mainly found when using OLS methods.

We took the analysis one step further and investigated whether decoupled payments under the form of AMTA payments could explain differing yield performances. Our results suggest this is the case. When using OLS, AMTA payments are found to have statistically significant positive effects on both practices of corn and soybeans, dryland sorghum, and irrigated wheat; when using FE a statistically significant positive effect is found on dryland sorghum, whereas a negative effect is found on irrigated wheat. This finding has potentially important implications for agricultural trade policy, as the sole motivation for the distribution of these payments is that they do not distort production. While there is a large existing literature on the effects of AMTA payments on acreage, land prices, and labor choices, there are no existing studies on whether AMTA payments enhance yield performance. Our results seem to suggest there is the potential for decoupled payments to boost relative yields, thereby giving an unfair advantage to their recipients. This is likely to become an issue in upcoming WTO discussions over the distortionary effects of decoupled payments.

Chapter 6

Conclusion

In the late nineties, the rising costs of maintaining income support programs together with recent commitments to limit trade-distorting subsidies motivated the U.S. and the European Union to take a more market-oriented approach to agricultural policy. This approach involved "decoupling" government payments from current levels of production, prices, or resource use. In theory, decoupling removes the connection between the level of support and current market conditions, allowing farmers to make market-based decisions about which commodities to produce, how much to produce, or whether to produce at all. As such, these payments were expected to not distort production or trade patterns. In the U.S., decoupled payments were introduced by the FAIR Act. While expected to be phased-out over the duration of the bill, the payments were continued by the following bill, the Farm Security Act of 2002.

The extent to which the 2002 Farm Bill reversed the tendency toward freer agricultural market depends largely on how the non-distortionary nature of decoupled payments is judged. If decoupling was seen as a major step in the direction of a more market-oriented and internationally integrated U.S. agriculture, the 2002 Farm Bill was a major step backwards. But a consensus about the non-distortionary nature of decoupled payments never appeared in the first place, as the literature has been prolific in finding potential "coupling" mechanisms of decoupled payments. Thus, the extent to which the FAIR Act changed U.S. farm policy continues to be debated. This debate is fostered by the amount of *ad hoc* support

and continuation of AMTA payments in the 2002 Farm Bill, as well as the base and yield updates it allowed. This problem of time consistency that seems to characterize agricultural policy, as farmers adjust current acreage given their expectations of future base revisions, further suggests theory and practice are not in accord.

Along with the potential for environmental consequences if the payments do affect crop production decisions, it is important to understand whether decoupled payments affect crop production for the following two reasons (Adams *et al.* 2001). First, if the payments increase crop production, and therefore decrease prices and returns, they fall short of meeting one of their main goals, which is to increase farm household income. Second, because agricultural policies have non negligible international spillovers, a causal relationship between decoupled payments and crop production would undermine the economic rationale of the WTO's green box category of domestic support.

The overall goal of this dissertation was to revisit the production effects of decoupled payments. Using both estimation and simulation methods, we analyzed their effects upon farmers' acreage decisions in the presence of credit constraints and their effects upon yield performance. Special attention was given to the role credit constraints may play as a "coupling" mechanism because of their potential positive impact on farmers' liquidity or collateral. The idea is that, for a credit-constrained farmer, the additional funds received increase their liquidity or their ability to borrow at lower costs. This, in turn, allows the farmer to make additional investments in production. In addition, because the greatest effect of decoupled payments seems to be on land values, the collateral of the farmers improves if they own land. Our main results can be summarized in terms of three sets of results: acreage and consumption effects, policy simulation analysis, and yield effects. We discuss each of these results next and then move on to point out the caveats from our research and suggest directions for future research.

(A) Estimation results: acreage and consumption effects

We extended previous research that estimated the acreage effects of decoupled payments by using farm-level panel data from the KFMA. This allowed us to overcome one of the major

limitations of previous studies that estimated these effects, as they typically used cross-sectional farm-level survey data from ARMS. Our ability to observe the same farms over time allowed us to take into account unobserved sources of heterogeneity that could cause OLS to be biased and inconsistent. So, we estimated total (owned and rented) crop, owned crop, pasture, and corn, sorghum, soybeans, and wheat acreage equations. Our goal was two-fold. First, we wanted to observe whether decoupled payments mattered for the farmers' acreage decisions. Second, we wanted to observe whether the magnitude of these effects depended on the degree to which the farmers were constrained by credit. Our hypothesis was that more highly leveraged farmers would have greater difficulty in accessing credit, so payments should play a greater role in their investment decisions. The possibility of simultaneity in the acreage and borrowing decisions was taken into account by using GMM methods and lagged leverage values.

While in general we found smaller marginal acreage effects when controlling for unobserved effects, we nonetheless found significant distortionary effects of PFC and MLA payments during the years of the FAIR Act. For total acres, a $1,000 increase in AMTA payments increased total acres by about 4 to 6 acres, implying an elasticity of about 0.06. This elasticity was somewhat smaller for owned acres, where AMTA payments did not play such a significant role. We further found that these payments had significant positive acreage effects for the crops whose acreage increased over the FAIR Act period (corn and soybeans) but not for those whose acreage decreased over the period (sorghum and wheat). For a farm with the average level of debt, the AMTA payments elasticities of corn acres was about 0.06, and that of soybeans was about 0.12, higher than those found in the total crop acres equation. These are also greater than those found by Goodwin and Mishra (2006), which varied between 0.025 and 0.035. We did not find strong evidence to support our second hypothesis, that decoupled payments mattered more for the more leveraged farmers.

Given survey data findings of farmers' determination to allocate payments to farm uses and our own significant acreage effects of AMTA payments, we further estimated the MPC AMTA payments during the period. Our goal was to investigate whether farm payments were indeed being used to support household consumption. Our statistically

insignificant coefficient estimates on AMTA payments served to strengthen our suspicion that decoupled payments are being used to invest in the farm.

(B) Policy simulation

In an effort to assess the importance of the potential collateral enhancing effect of decoupling payments, we used simulation methods in an expected utility maximization framework to characterize a credit-constrained farmer who must make acreage and borrowing decisions in the presence of uncertain yields and prices. Our use of several different cost, price, yields and risk aversion scenarios, along with different degrees of liquidity and allowable debt allowed us to characterize farmers with different cost structures, preferences, and financial states.

While we found that tighter limits on payments such as those proposed in the Grassley/Dorgan Rural American Preservation Act of 2005 (S. 385) would not impact production for the typical Kansas farmer, decoupled payments mattered for the credit-constrained farmer. They enhanced the farmer's collateral and slackened the credit constraint. As a result, additional borrowing took place and more acres were added to production. Using farm-level data we observed that, for the average Kansas farmer, doubling the amount of DP would increase planted acres by between 1.5 percent and 5.7 percent, depending on the liquidity level and percentage debt allowed.

Our result, while pointing to distortionary effects on acres from decoupled payments, is likely to underestimate the total acreage effects of these payments, as we abstracted from liquidity effects. Furthermore, the wealth function did not reflect the value of the farmer's endowment of land, which is likely to change as a result of the policy. However, this additional indirect effect on collateral is not expected to be as immediate as that of the payments themselves.

(C) Estimation results: yield effects

Decoupled payments need not affect farmers' decisions solely at the extensive margin. They may also affect how resources are used at the intensive margin, leading to different application rates of inputs such as pesticides, fertilizer or water. Farmers may choose to

invest the additional financial resources into better production methods, such as improved technology or other inputs, thereby increasing productivity. There is very little work published in the economics literature on the determinants of crop yield performance. Except for Goodwin and Mishra (2006), no other studies analyze the individual characteristics of farms and farmers that may lead some farms to have greater productivity than others.

Our analysis of the farm-level determinants of relative yield performance helped fill this gap. We used the KFMA data for 1994 through 2006 to estimate the impact on yields of several different farm characteristics, including size, experience, and diversification over farm enterprises. Other potentially interesting characteristics included the financial characteristics and the amount of government payments received. We found that both diversification over different enterprises and government payments significantly increase relative yields, whereas farm size and a greater share of sales coming from livestock had the opposite effect. We extended this analysis to the years of the FAIR Act to investigate the effects of AMTA payments on relative yields. This allowed us to observe the impact of AMTA payments on the intensive margin. While crop and practice specific, our overall results suggested that AMTA payments have the potential to affect crop yield performance. For example, for dryland sorghum, the second most important crop in Kansas, we found that an additional $1,000 in AMTA payments may increase relative yields by between 0.14 and 0.26 percentage points. These figures varied between 0.19 and 0.28 percentage points for dryland soybeans, the third most import crop in the state. This could be perceived as an unfair advantage given to farmers in future WTO discussions over the green-box categorization of decoupled payments.

(D) Caveats and future research

While the analysis improves on earlier studies by conditioning on unobserved characteristics of specific farms, there is an important caveat. The KFMA data only report the total government payments each farm receives. This total includes a variety of payments, ranging from PFC and MLA payments to Conservation Reserve Program payments. Therefore, we had to estimate the amount of AMTA payments received by these farms over the period of

the FAIR Act. Our methodology to retrieve these payments, while based on actual historical yields and acres, is unable to account for the fact that the farms in our sample may have added or subtracted base acres over the period of the Act. So, it is possible that we are missing relevant changes in the amount of AMTA payments received by these farms. This implies our AMTA payments variable is measured with error.[58] Hence, the study of the production effects of AMTA payments would benefit from a more complete set of data, where the actual amount of decoupled payments received by the farms are observed.

Future research on the production effects of decoupled payments will benefit from data that, in addition to including the actual payments received, also contain more specific information on the location of the farm. We only had access to the county where the farms in our sample were located. This additional information would allow us to incorporate spatial dynamics into our estimating framework.

It is generally believed that due to weather patterns, soil characteristics or other geographic factors, agricultural yields are positively correlated across space. Conceptually and empirically, positive spatial autocorrelation is the two-dimensional equivalent of redundancy, meaning that yields measured at nearby locations tend to be similar, and tend to be more similar than yields separated by larger distances.[59] Because standard econometric techniques often fail in the presence of spatial dependence, recognizing spatial dependence and accounting for it is important. If the observations are spatially clustered in some way, the unadjusted OLS standard errors on parameter estimates will be biased downward, conveying a false sense of precision. A further complication with spatial dependence is that it may not be independent of the relative positioning of locations on a map. DiRienzo (2001) found

[58] If the measurement error is uncorrelated the unobserved explanatory variable, pooled OLS is biased and inconsistent. In particular, if the true coefficient is positive, the estimated coefficient underestimates its value. But the inconsistency in OLS will be small if the variance of the true regressor is large relative to that in the measurement error (Wooldridge 2008). In the presence of unobserved effects, the FE transformation is believed to exacerbate measurement error bias (Wooldridge 2002). This bias increases with the autocorrelation in the unobserved variable relative to that in the measurement error.

[59] Formally, spatial autocorrelation is a weaker form of spatial dependence. Spatial dependence encompasses two types of spatial effects, spatial autocorrelation, which is the coincidence of value similarity with locational similarity, and spatial heterogeneity, which is, in a regression context, structural instability in the form on non-constant error variances (heteroscedasticity) or model coefficients (Anselin, 1999).

evidence that, for Iowa and North Carolina corn data, the rate of spatial correlation decay depended both on direction and on the distance that separated the counties. In addition, the extent of the spatial dependence may itself be state-dependent, with yields tending to be more highly correlated in extreme weather (Ozaki *et al.* 2006).

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