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Incentives and contract design: a case study of farmland lease contracts in US agriculture

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Incentives and contract design: A case study of farmland lease contracts in U.S. agriculture

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CHAPTER 1. GENERAL INTRODUCTION

Economists have given considerable attention to the effect of incentives facing agents on the performance of economic activities. Incentives can be controlled by utilizing institutions such as contracts, organizations, law and other social norms, and other mechanisms that either explicitly or implicitly affect incentives of people involved in the transaction. The major objective of this dissertation is to provide empirical evidence on how incentives actually affect contract design from the perspective of the principal-agent framework. Using a large data set on farmland lease contracts in modern U.S. agriculture, I present evidence on how risk, transaction costs, and incentives affect contract design. Moreover, I address the role of matching between the landlord and tenant attributes, landlord's participation in management decisions, and contractual externalities in contract design. These are topics that have received little attention in the empirical literature.

In the literature on farmland lease contracts, the design of contract principally means the choice between a cash rent contract and a cropshare contract. Under a typical cash rent contract, the tenant makes a fixed payment to the landlord, and the tenant takes all the realized output. Under a typical cropshare contract, on the other hand, the tenant and landlord share the realized output in accordance with the prior agreement. This kind of contract design can be observed in industries other than agriculture. An example is a royalty contract in franchising, in which the franchisee and franchiser share the realized sales or profit in accordance with a prior agreement. Therefore, farmland lease contracts are a great example that provides rich implications applicable to non-agricultural contracting and helps us better understand contract design and contract choice.

A substantial number of hypotheses have been suggested by economists to explain why cropshare contracts have prevailed over a very long time period and diverse stags of development. Among the most important hypotheses are the risk sharing hypothesis and the transaction cost hypothesis. Stiglitz (1974) uses a standard principal-agent model and shows that a cropshare contract achieves the second best welfare outcome when a trade-off exists between risk sharing and incentive provision. More recently, Allen and Lueck (1992, 1993, 1999) develop the transaction cost hypothesis, arguing that transaction costs explain contract design better than risk sharing. According to Allen and Lueck (1992, 1993, 1999), the major transaction costs in cropshare contracts are the cost of dividing output equally between the landlord and tenant, and the cost of maintaining land quality, e.g., fertility and low rates of soil erosion or degradation. Furthermore, using a data set from modern U.S. agriculture, Allen and Lueck (1992, 1993, 1999) conclude that transaction costs do indeed affect contract design, but risk factors do not have significant effects. In contrast to the findings by Allen and Lueck (1992, 1993, 1999), Ackerberg and Boticcini (2002) conclude that risk sharing affects contract design in Renaissance Tuscany, Italy. Ackerberg and Boticcini (2002) consider the case where the tenants are matched with landlords before they contract. Ackerberg and Boticcini (2002) conclude that the tenant's risk preference does not have a significant effect on contract choice, when possible endogenous matching is ignored. When the endogenous matching is taken into account, the tenant's risk preference does have a significant effect on contract choice. Ackerberg and Boticcini (2002), therefore, conclude that risk sharing actually affects contract design in the farmland lease contracts. Serfes (2005) develops a simple principal-agent model that formalizes the idea of endogenous matching suggested by Ackerberg and Boticcini (2002). According to Serfes (2005), when

endogenous matching of the tenant with the landlord is present, the trade-off between incentives and risk sharing does not always occur as implied in a standard principal-agent model. Serfes's result, therefore, is consistent with the argument by Ackerberg and Boticcini (2002). Furthermore, this may explain why empirical supports of the risk sharing hypothesis were not found in many of the past studies.

The goal of this dissertation is three-fold. First, I attempt to fill in holes existing in the empirical literature on farmland tenancy contract design by providing new evidence from a comprehensive and new data set—the 1999 Agricultural Economics and Land Ownership Survey (AELOS). As I described in the previous paragraph, scholars disagree on whether or not risk sharing really affects contract design. In this dissertation, I provide new and convincing evidence for the role of risk sharing in farmland lease contract design. Second, I address the role of transaction costs, landlord's participation in management decisions, and contractual externalities arise from the difficulty of landlords to act cooperatively in the design of farmland lease contracts with a given tenant. In the United States, tenants on average contract with four landlords during a production cycle, and I show that these factors also affect contract choice in U.S. agriculture. Although the past literature on farmland lease contracts has principally dealt with the design of monetary compensation schemes in contract design, I present new evidence in this dissertation that contract design is not just a matter of the design of monetary compensation scheme, but also involves more complicated problems that broadly affect incentives. Third, when it is possible, I attempt to formalize the discussion of the reasons why cropshare contracts are chosen over cash rental contracts. The objective of using formal models is not to pursue theoretical sophistications, but rather I use formal models to inform the choice of empirical models applied in this dissertation. A major

virtue of using formal models is that we often see clear-cut implications which lead directly to testable hypotheses. Also, specification of empirical models based on formal models helps us understand how assumptions affect predictions and to narrow the focus of our empirical analyses.

The rest of this dissertation consists of four chapters. Chapters 2 to 4 are independent papers that focus on different topics but approach the common goal stated above. Chapter 2, which is the paper that Wallace Huffman and I coauthored, presents the method and results of the empirical evaluations of the transaction cost hypothesis and the risk sharing hypothesis. Chapter 2 provides a comprehensive analysis of contract choice using AELOS, in terms of a range of issues addressed in the chapter. By virtue of rich information contained in the data set, we carry out comprehensive analyses of contract design using various variables on both landlord and tenant attributes. Specifically, we find evidence that supports both the transaction cost hypothesis and the risk sharing hypothesis. In particular, we emphasize results that support the risk sharing hypothesis. This is important because there has not been much empirical evidence for the risk sharing hypothesis. In addition, we take into account endogenous matching between the tenant and landlord, and present empirical evidence that endogenous matching indeed occurs, and is related to contract choice.

Chapter 3 is the paper that Brent Hueth and I coauthored. In this chapter, our interest is in the fact that the portion of cropshare contracts in all farmland lease contracts used in modern U.S. agriculture has decreased over the years, while the number of landlords per tenant has increased. We argue that, using a simple model, if contractual externalities exist among contracts, the likelihood of cropshare contracts will decrease as the number of contracts per tenant increases, due to non-cooperative strategic interaction of landlords.

Since it is more difficult for the landlords to elicit effort from a tenant if there exist contractual externalities as the number of landlords per tenant increases, the landlords need to offer higher-powered contracts in order to elicit efforts from the tenant. Using AELOS, we test the predictions derived from the model, and present empirical evidence that supports the model.

In chapter 4, I focus on the fact that the landlords are more likely to participate in management decisions under cropshare than under cash rent. Based on studies of double-sided moral hazard and royalty contracts mainly in franchising contracts, I develop a simple model of farmland lease contracts in which the landlord does not only decide contract design but also decides whether or not to participate in management decisions. Using AELOS, I test the predictions derived from the model, and find evidence that supports the model. Finally, chapter 5 provides the general conclusions of this dissertation.

CHAPTER 2. THE ROLE OF RISK, TRANSACTION COSTS, AND ENDOGENOUS MATCHING IN CONTRACT DESIGN: EVIDENCE FROM FARMLAND LEASE CONTRACTS IN U.S. AGRICULTURE

A paper submitted to *The American Journal of Agricultural Economics*

Keita Fukunaga and Wallace Huffman

Abstract

This article presents empirical evidence on the choice of farmland lease contracts, using data on landlord and tenant attributes in modern U.S. agriculture. Controlling for potential endogenous matching between crop type and landlord and tenant attributes, we find empirical supports for the transaction cost hypothesis and the risk sharing hypothesis. We also find that both landlord and tenant attributes, specifically their risk preferences and attributes that increase transaction costs significantly affect contract and crop choices. The results indicate that prior studies that omit landlord or tenant attributes cause inconsistent estimates of contract choice equation. Moreover, our results suggest that careful studies of matching and its role in the design of contract are needed for a better understanding of landlord-tenant contract choice.

Introduction

Contract choice in agricultural land tenancy has attracted many researchers over time. One of the biggest questions is why cropshare contracts prevail under diverse conditions in both developed and developing agriculture. While some scholars condemn cropshare as an inefficient system, others try to provide sound reasons why cropshare contracts are popular in many countries and regions under circumstances that seem to be very different. The hypotheses suggested are diverse. Singh (1989) argues that there are four major hypotheses that explain why cropshare exists: the risk sharing hypothesis, the incentive provision

hypothesis, the financial constraint hypothesis, and the screening hypothesis. Among these hypotheses, researchers have recently discussed whether evidence exists for the risk sharing hypothesis, which is based on the principal-agent models. The evidence is mixed. Using data from North America, Allen and Lueck (1992, 1993, 1999) find that the effects of the tenant's wealth, which is used as a proxy for the tenant's risk aversion, and variability in production on contract choice are not consistent with the risk sharing hypothesis. Ackerberg and Botticini (2002), on the other hand, find that the tenant's wealth has a significant and predicted effect on contract choice, once endogenous matching between crop type and the tenant is controlled.

Researchers face the problem of limited data when they attempt empirical evaluation of these hypotheses. In most prior empirical studies, information on tenant attributes is available, but little information on landlord attributes is available. Thus, in most of the past empirical studies, the set of regressors has been limited to tenant attributes. However, as Ackerberg and Botticini (2002) argue, this could cause bias and inconsistency in the estimated coefficients of the contract and crop equations.

In this article, we econometrically investigate the set of factors that explain the choice of farmland leasing contracts with an emphasis on testing the transaction cost hypothesis and the risk sharing hypothesis. In doing so, we go beyond existing empirical studies by using a new data set containing both tenant and landlord attributes and discuss how both landlord and tenant attributes affect contract choices in farmland leasing transactions. Using the information contained in our new data set, this article also sheds light on the mechanism of matching and its impact on contract choice. Specifically, we find that both landlord and tenant attributes affect contract choice and matching (i.e., endogenous crop

choice). Moreover, we find that the agents' risk preferences and transaction costs associated with contracts affect matching. The latter is a new empirical finding that has not been revealed in the past literature. Our empirical results indicate that the conventional empirical approach, in which either landlord or tenant attributes are included and endogenous matching is not controlled properly, could suffer from omitted variable bias. Furthermore, in order to explain our results, theoretical studies in which endogenous matching is jointly built into the design of contracts may be required.

In the following sections, we first present a brief review of the empirical literature. In the review, we define endogenous matching and explain how it could cause bias and inconsistency in the estimates in the existing literature, following the argument by Ackerberg and Botticini (2002). Then, we present our empirical model, the data, and our empirical results. The last section contains conclusions and also provides a discussion of the findings and suggestions for future research.

Literature Review

The risk sharing hypothesis underlying the landlord-tenant contract choice was first presented formally by Stiglitz (1974). It was derived from a principal-agent model, where a landlord (principal) designs a contract to maximize her expected profit (utility) under tenant participation and incentive constraints. If both the landlord and the tenant are risk neutral, at least the short-run production efficiency is achieved under a cash rent contract, while less-than-optimal production occurs under a cropshare contract. However, if the tenant is more risk averse than the landlord, cropshare, rather than cash rent, may be optimal.

Allen and Lueck (1992, 1993, 1999) argue that transaction costs involved in land tenancy contracting, rather than the trade-off between risk sharing and incentives, are the

major determinants of contract type. Transaction costs mainly consist of monitoring costs (the landlord monitors the tenant so that the tenant does not overuse the land or shirk on labor input, timely planting or harvesting) and the cost of dividing output fairly. Let us call this argument the transaction cost hypothesis. Allen and Lueck (1992, 1993, 1999) argue that the trade-off between incentives and risk sharing, emphasized in the typical principal-agent models, is not important and that the type of contract is chosen to minimize the transaction costs involved[1].

Allen and Lueck (1992, 1993, 1999) obtain interesting empirical results, using data on landlord-tenant contracts from South Dakota, Nebraska, Louisiana, and British Columbia (Canada). They conclude that if the landlord does not have to worry about the tenant's overuse of the land, then cash rent is more likely to be used. This is support for the transaction cost hypothesis. They also find that a higher variation in production does not increase the likelihood of a cropshare contract being chosen. Furthermore, they show that the wealth of the tenant does not affect contract choices or that the coefficient estimates have signs that are inconsistent with the prediction. These results contradict a common assumption of decreasing absolute risk aversion in the tenant's utility function. Based on these results, they conclude that transaction cost, rather than risk sharing, is important in contract choice.

Ackerberg and Botticini (2002) criticize the existing empirical literature, arguing that coefficient estimates in empirical models may be biased and inconsistent if they do not properly deal with endogenous matching. The authors consider the case in which risk preference of the tenant is an unobserved variable, and a landlord attribute (in their study, the type of crop) and the wealth level of the tenant are correlated with the unobserved risk

preference. If there is an unobservable variable that is correlated with a variable included in the regression, the coefficient estimate of the included variable will be biased and inconsistent. They resolve this problem by using an instrumental variable method and including a fixed effect for unobservable landlord attributes. They show that, after the treatment, the wealth level of the tenant has a significant effect that is insignificant when the problem of unobserved variables is ignored.

The argument and the results of Ackerberg and Botticini (2002) are very important because some previous empirical studies ignore this problem. Allen and Lueck (1992, 1993, 1999) do not include variables that represent the landlord's attributes except for crop type. Moss and Barry (2002) include crop type and information on whether or not the landlord is opportunistic, but information on other landlord attributes (most importantly, risk preference) is not included. In addition, Laffont and Matoussi (1995) and Bierlen, Parsch, and Dixon (1999) have not included landlords' attributes (except crop type) in the contract-choice equation either.

However, there are several studies that deal with the problem in different ways. Pudney, Galassi, and Mealli (1998) account for landlords' unobserved characteristics using a landlord-specific random effect. They find that the random effect has significant effects on the coefficient estimates, and that if it is omitted, significant biases are generated. They also find that when a random effect is included in the model, wealth has a significant effect on contract choice for some types of farms, and the sign is as the risk sharing hypothesis predicts. In another empirical study, Dubois (2002) considers the role of land fertility in the contract choice along with the effect of risk preference and transaction costs. Accounting for landlord unobservable characteristics by using landlord-specific random effects, he finds that

neither the pure risk sharing hypothesis nor the pure transaction cost hypothesis competes effectively with a combined model in his data. These techniques, however, do not provide us with any information on the effect of specific landlord attributes on contract choice. With better information on landlords, we can examine the role of risk in contract choice more precisely.

As far as we know, only Rainey et al. (2001) and Canjels (1998 [a], [b]) include both landlord and tenant attributes in the contract choice regressions. Using survey data of landlords who leased land in selected Arkansas districts, Rainey et al. (2001) study the relationship between the landlord's characteristics and the type of contract that is actually used by the landlord. First, they find that as the tenant's financial strength becomes greater, the contract is more likely to be cash rent. Second, as the value of the landlord's total land becomes greater, the contract is more likely to be cash rent. Third, as the number of years that the landlord has contracted with a particular tenant becomes longer, cash rent is more likely to be used. Finally, greater output variance makes the possibility of a cash rent contract greater. These results indicate that the landlords are, in fact, risk averse. Canjels (1998 [a], [b]) alone use the data set of the Agricultural Economics and Land Ownership Survey (AELOS) of the United States Department of Agriculture (USDA) to analyze contract choices between landlords and tenants in the United States. Using 1988 AELOS and other data sources, Canjels (1998 [a]) investigates the role of risk in contract choice. As a measure of risk, the author uses an estimate of county-level yield variability that is based on county-level weather variability. The author find that his measure of risk has a significant impact on contract choice, and the sign is consistent with the risk-sharing hypothesis: cropshare is more likely to be used in areas with higher production variability. This article offers an

opportunity to reevaluate the findings of these studies, and moreover, it provides new findings by using an extensive set of landlord and tenant attributes. Specifically, we will carry out joint tests on landlord attributes and tenant attributes, respectively, to see if these attributes jointly affect the contract choice.

Focusing on landlord-tenant matching, Ackerberg and Botticini (2002) find that less risk averse tenants are more likely to be matched with less risky crop production in Renaissance, Tuscany. Serfes (2005) argues that positive assortative matching, in which less risk averse agents are more likely to be matched with principals with less risky assets, is a sufficient condition for a negative correlation between risk and incentives. By including more independent variables in the right hand side of contract choice and crop choice equations than does Ackerberg and Botticini (2002), we provide a closer look at the mechanism of endogenous matching. As far as we know, this is the first study that comprehensively investigates the role of risk, transaction costs, and landlord-tenant matching in contract design.

Empirical Methods

Data and Estimation Procedure

We use data from the 1999 Agricultural Economics and Land Ownership Survey (AELOS) to evaluate the hypotheses discussed above. AELOS is a comprehensive data set consisting of tenant demographic information, economic attributes and household characteristics, and landlord demographic information and economic attributes. Survey questionnaires were first sent to producers/tenants all over the United States. They were asked to answer a set of questions and to provide the addresses and names of their landlords. Questionnaires were then sent to those listed landlords. This procedure makes it possible for us to identify a

tenant and a landlord for every contract in the data set. In the United States, where average farm size has been steadily increasing, a tenant usually has more than one landlord. Reflecting this fact, the information for a tenant may appear more than once in our data set, but in combination with the information for different landlords. In other words, in our data set, the sample unit is not an individual tenant or landlord, but a contract between a tenant and a landlord. After deleting unusable observations we had a total of 61,944 observations (contracts) in our data set.

We have to refine the data set further, however, for the following reasons. If a landlord contracts with more than one tenant and uses different types of contracts for her tenants, we cannot identify the type of each contract. In addition, there are observations with cash-cropshare contracts or other types of non-conventional contracts. We do not use a cash-cropshare contract as a category for the dependent variable, because they may be non-linear contracts. For example, if the landlord and the tenant use different types of contracts for different crops, the contract is reported as a cash-cropshare contract. Although this is a different practice from a linear combination of a cropshare contract and a cash rent contract (that is, a contract in which the payment consists of a share part and a fixed payment), we can not distinguish them in the data set. If we exclude these unusable observations, the total number of remaining usable observations is 44,515.

One way to deal with these problems is to simply delete all of the undesirable observations. However, a potential problem with this deletion is that it could generate selection biases in the coefficient estimates when the propensity for being deleted is correlated with some attributes that affect contract choice. To examine the effects of this possibly non-random selection, we adopt the method suggested by Van de Ven and Van

Praag (1981). We include the sample selection correction term similar to the inverse Mills ratio as a regressor in the equations of contract choice. We also employ maximum likelihood estimation suggested by Van de Ven and Van Praag (1981) that accounts for the possible selection problem. As we will show, the selection problem is not found to be severe in our data, as the qualitative results (specifically, the signs of coefficients) do not change across the different approaches, while some effects are observed on the magnitudes of the estimated coefficients[2].

Econometric Model

We include both landlord and tenant characteristics in our empirical model, so that we can hopefully mitigate the endogenous matching problem. An advantage of having a data set with more variables is that adding variables can reduce the probability of omitting variable bias.

A probit model is used for the empirical analysis of landlord-tenant contract choice. The dependent variable is a discrete choice between a cash rent contract and a cropshare contract: *cropshare* = 1 if cropshare is chosen, and *cropshare* = 0 if cash rent is chosen. We specify the model in the following way:

$$(1) \qquad cropshare_{ij}^{*} = \alpha' x_i + \beta' y_j + \gamma' z_{ij} - \varepsilon_{ij}$$

$cropshare_{ij}^{*}$ is a latent variable for contract type such that

$$(2) \qquad cropshare_{ij} = \begin{cases} 1, \text{ if } cropshare_{ij}^{*} > 0 \\ 0, \text{ if } cropshare_{ij}^{*} \le 0 \end{cases}.$$

x_i denotes the vector of tenant i's attributes; y_j denotes the vector of landlord j's attributes; and z_{ij} denotes the vector of other characteristics, such as the contracted acres, the total

market value of the land and buildings on the contracted land, and the market value of the tenant's dwellings on the contracted land, as well as a constant term[3]. The random disturbance term ε_{ij} is assumed to follow a standard normal distribution. A positive value for a coefficient means that an increase in the corresponding variable makes the choice of a cropshare contract more likely.

Predictions of the Signs of Coefficients

The short definitions of the variables to be used are summarized in table 1 along with the means and standard deviations. Note that, since we do not have the data for what crops are grown on the contracted land, we use farm type as a proxy for crop type. For example, if a tenant's farm is categorized as a grain-oilseed farm, then the contracted land is likely to be used for cash grain and/or oilseed production. If a tenant's farm is categorized as a cattle ranching or dairy farm, then the contracted land is likely to be used for pasturing or hay production.

Transaction Cost Factors

To proxy transaction cost, we use farm type dummies, the number of landlords that the tenant has; the number of acres of contracted land; the total value of the land; the value of farm buildings, and dwellings on the contracted land; the value of the tenant's dwelling on the contracted land; whether the landlord lives on the contracted land; whether the landlord lives close to the contracted land; and the average value of the Beale code for the area where the tenant resides.

In grain and/or oilseed crop production, we expect that cropshare contracts are more likely to be chosen because it is relatively easy for tenants and landlords to divide the output between them, and it is easy for landlords to market their share of output (Allen and Lueck

1993, 1999). Since easy access to marketing channels will lower the transaction costs arising from marketing output for the landlords, this will encourage the use of cropshare contracts. On the other hand, in vegetable and fruit production, where dividing output between landlords and tenants is more costly, and few markets exist for the output, we expect that cash rent contracts are more likely to be used.

As a proxy for landlord monitoring costs, we use a dummy variable indicating whether the landlord lives on the contracted land, and a dummy variable indicating whether the landlord lives close to the contracted land, given the landlord does not live on the land. Since landlords who live further away from their contracted land will have higher monitoring costs, the contract is more likely to be a cropshare in order to avoid overuse of the land (Allen and Lueck 1993, 1999). If this is the case, we expect positive coefficients for the dummy variables.

The Beale codes are used as an index that measures the importance of the contracted land as farmland. The Beale code measures the degree of urbaneness of the county, and these codes range from one to nine, with one indicating the most urbanized area and nine indicating the most rural area. If the farmland is located in a relatively urban county, then the future importance of the land for farming would be reduced, because the landlord would have greater opportunities to use the land for non-agricultural purposes. Thus, the landlord would be less concerned about current land-degrading agricultural production, and therefore, cash rent would more likely be optimal for the landlord. Thus, the expected sign for the Beale code would be positive. Since data on the Beale codes are not available for the years between 1993 and 2003, we used the average of the 1993 and 2003 values.

The number of contracted acres is another proxy for transaction costs. As the number of contracted acres increases, the importance of the landlord to the tenant would also increase. The cost of opportunistic actions would be higher for the tenant and the risk of overuse of land when a cash rent contract is used would be lower. The expected sign of the contracted acres would be negative. A similar explanation can be applied to the total value of the land, farm buildings, and dwellings on the contracted land, and the value of the tenant's dwelling on the contracted plot. As the total value of the assets on the contracted land increases, the potential damage from the tenant's opportunistic action is higher for the landlord, increasing the likelihood of a cropshare contract. As the value of the tenant's assets on the contracted land (e.g., the value of the tenant's dwellings) increases, then the land will be more important for the tenant. Hence, the landlord can choose the contract with stronger incentives. Therefore, increased value of assets on the contracted land increases the likelihood of cropsharing, and an increase in the value of the dwelling for the tenant on the contracted land increases the likelihood of cash renting.

According to Allen and Lueck (1992, 1993, 1999), the risk of overusing soils is one of the most important transaction costs. In order for us to capture the effect of this risk, we use county average erodibility index for the county where the tenant resides calculated from 1997 National Resources Inventory (NRI). The erodibility index proxies the sensitivity of land to soil overuse. Land in a county with greater value of erodibility index is more likely to be sensitive for land overuse. Since Allen and Lueck (1992, 1993, 1999) argue that a cropshare contract is more likely to be used on the land that is subject to greater risk of land overuse, we expect that a larger value for the erodibility index increases the likelihood of cropshare, from the perspectives of the transaction cost hypothesis.

Risk-Related Factors

We expect, from the risk sharing hypothesis, that as the tenant becomes wealthier he/she is less risk averse, so that the contract type is more likely to be cash rent. Also, for the same reason, we expect that the wealthier landlords are more likely to offer cropshare contracts. While the data on a tenant's total assets are available for us, the data on the landlord's total assets are not. We could use, instead, the total value of the landlord's farm assets and the total value of the agricultural land and buildings that the landlord owns. A potential problem with these proxies is that, while these variables will be correlated with the value of the landlord's total assets, they could be correlated to the landlord's farming experience and knowledge, and also to the landlord's commitment to farming. If this is true, we cannot be sure what these variables measure. Therefore, we need to interpret the estimated coefficients for these variables cautiously.

Using the USDA's county level annual yield data from 1990 to 1999, we create a county average weighted and standardized yield variability index. The county data contain the yields for corn, soybeans, hay, beans, and so forth. First, we calculate the standard deviations of yields for each crop in each county. Second, because different units of quantity are used for different crops in the data set, we divide the standard deviations by the respective mean values in order to make our yield variability index unit-free. Then, using the ten-year average share of the number of harvested acres for each crop in the ten-year average total harvested acres in the county as a weight, we sum up the standardized deviations and obtain a weighted and standardized yield variability index for each county.

Empirical Results

The Estimates and Interpretations

Table 2 presents the estimates for the basic model described above and the estimates for the basic model with a sample selection correction term[4]. In table 2, the results with multiple crop dummies and with a combined crop dummy (whether the tenant is a grain/oilseed or a tobacco/cotton farm) are shown. The results do not change much across all of the specifications, indicating that neither the data selection nor the exact specification of a crop dummy affects the coefficient estimates in the contract choice equation. The maximum likelihood estimation that takes into account the data selection problem using a model suggested by Van de Ven and Van Praag (1981) is presented in table 3. The results are similar to the basic models overall and the estimated bivariate correlation coefficient is low (0.08) and statistically insignificant, although there are some differences observed in the magnitude of estimated coefficients for some variables. These findings indicate that selection does not affect contract choice qualitatively in our data set. Because of the robustness of the results of the basic models to the selection problem, we disregard the selection problem in the following analyses. Thus, for the interpretations below, we refer to the second column in table 2.

All of the regional variables have negative and significant coefficient estimates. This result indicates that cash rent is more likely to be chosen in the Northeast, the Midwest, and the South regions than in the West region, other things equal. When the tenant farm is categorized as either a grain/oilseed farm, a cropshare contract is more likely to be chosen; and when the tenant farm is categorized as either a vegetable/fruit farm, a dairy farm or a farm that raises other animals, then cash rent is more likely to be chosen. This result

supports the transaction cost hypothesis, because in grain and oilseed production it is easy to divide the products between the tenant and the landlord, and for them to find markets for their output. When the contracted land is used for producing fruits or vegetables, landlords may prefer cash rent to cropshare, since landlords do not generally have ways to sell the received products when they cropshare. Thus, cash rent is more likely to be chosen. When the tenant farm is categorized as a dairy farm or a farm that raises other livestock, the contracted land is more likely to be used for pasture and hay production. Since for pasture and hay production it is more difficult to divide the products between the tenant and the landlord, and to find a market for these outputs, cash rent is more likely to be chosen. As such, the transaction cost hypothesis seems to explain the signs for the farm type dummies quite well.

The coefficient estimate for the number of landlords in the contract choice equation is negative, as expected from the transaction cost hypothesis. If the landlord lives on the contracted land, or if the landlord lives close to the contracted land, cash rent is more likely to be chosen. This can be because landlords living further away from the land have higher monitoring cost, and thus it may be more difficult to monitor the tenants to avoid overuse of the land. If that is true, this result is consistent with the transaction cost hypothesis. The Beale code has a significant coefficient estimate with the expected sign. When the land is located in a more rural area, the contract is more likely to be a cropshare contract, because the future importance of the land as farmland is greater and the landlord wants to prevent overuse of the land. As the value of the tenant's dwelling on the contracted land increases, cash rent is more likely to be chosen, but the effect is statistically insignificant. The tenant's total assets have a negative and significant coefficient estimate, offering support for the risk

sharing hypothesis. The total market value of land and buildings owned by the landlord has a negative coefficient estimate that contradicts the risk sharing hypothesis, while the value of the landlord's farm assets has a positive and significant coefficient estimate that is consistent with the risk sharing hypothesis. County-level crop yield variability index has a significant estimated coefficient with the expected sign: as the variability of crop yields increases, the likelihood of cropshare increases. This provides more support for the risk sharing hypothesis. As the total value of assets on the contracted land increases, cash rent is more likely to be used. We are not sure how this result can be explained.

In the basic models described above, we included the county-level crop yield variability index, along with farm type indicator variables (as proxies for crop types) to capture the effect of risk on contract choice. Since the yield variability index is constructed from county-level data on various crops grown in the county, some may worry that the yield variability effect of a specific crop grown on the contracted land may not be captured completely by the county-level yield variability index, but may be mixed into the farm type variable. In order to consider this potential problem more closely, we group the observations by each farm type, namely, grain or oilseed, tobacco or cotton, vegetable or fruit, beef, and dairy farms, and run the basic models for each group. This way, we have more homogeneous observations in each group, and thus, the county-level crop yield variability index will carry more accurate information on the effects of production variability that the tenant and the landlord face.

Table 4 summarizes these results. Except for "other crops" and dairy farms, the signs of the coefficients for yield variability are all positive, although, for vegetable-fruit, dairy, and beef farms, the coefficients for yield variability are insignificant. For grain-oilseed

farms, tobacco-cotton farms, and farms that raise other animals, we have significant and positive coefficients for yield variability, indicating that as the yield variability index increases, a cropshare contract is more likely to be chosen. For other crop farms, the sign is negative, indicating that a cash rent contract is more likely to be chosen. Finally, for other variables, the results are similar to those in table 2. Based on these results, we conclude that it is likely that yield variability increases the likelihood of a cropshare contract, and the effect holds robust for different types of farms. Overall, we find evidence for both the transaction cost hypothesis and the risk sharing hypothesis in landlord-tenant contract choice.

Should We Include Both Tenant and Landlord Attributes in the Equation?

An essential problem of endogenous matching raised by Ackerberg and Botticini (2002) is the omission of variables that are relevant and correlated to other variables that are included in the empirical model. Existing empirical studies, including Allen and Lueck (1992, 1993, 1999) and Moss and Barry (2002), test for tenant attributes affecting contract choice or landlord attributes affecting contract choice separately, and fail to include the attributes of both sides simultaneously due to limited availability of the data. Here, we test separate composite hypotheses that tenant attributes do not matter and that landlord attributes do not matter, and compare these estimates with and without restrictions, to see whether there is significant effect on the estimated coefficients.

Table 5 contains the estimation results of the models in which either landlord attributes or tenant attributes are excluded. The chi-square test statistics calculated from table 2 and table 5 are large enough to reject the hypotheses that tenant attributes do not matter and that landlord attributes do not matter. The fact that both the landlord and the tenant attributes jointly affect contract choice implies that omission of relevant variables in

analyses using other data sets could be problematic. Although there are no sizable effects of these restrictions on many of the estimated coefficients in table 5, this may be due to the large sample size of our data set, and bias that arises from omitting relevant variables could be substantial in other data sets with smaller sample size. In the following section, we investigate the possible endogeneity problem in contract choice. Since we know that both landlord and tenant attributes affect contract choice, if there is an endogenous variable included in the contract choice equation, which is likely correlated with landlord and tenant attributes, the problem of omitting relevant variables can be even worse.

Endogeneity Problem in Contract Choice

The analysis above overlooks any endogeneity problems in contract choice. In this section, we address the possible endogeneity problem, focusing on farm type dummies (as proxies for crop types) in contract choice that are likely to be endogenously determined. In Ackerberg and Botticini (2002), crop type is considered to be a landlord attribute and matching between crop type and the tenant's attributes is primarily analyzed, while the landlord's unobservable attributes are controlled using fixed effects. In this article, we explicitly allow both landlord and tenant attributes to affect crop choice, by including both attributes in the regression.

As Ackerberg and Botticini (2002) argue, some attributes such as risk preference are inherently unobservable. Although we can use proxies for them, the proxies may be poorly correlated with the true values of these variables. Thus, although we believe that having many variables will at least mitigate the endogenous matching problem, we admit that there is still a possibility that the effect of endogenous matching remains. Following Ackerberg and Botticini (2002) and Dubois (2002), we tackle this problem by explicitly considering endogenous matching of crop type and tenant attributes.

We develop a simultaneous probit model in which the type of contract and the type of tenant farm are endogenous. Consider the following model:

$$
\begin{aligned}
cropshare_{ij}^{*} &= a_1 \cdot crop\_type_{ij} + \alpha_1' x_{i1} + \beta_1' y_{j1} + \gamma_1' z_{ij1} - \varepsilon_{ij1} \\
crop\_type_{ij}^{*} &= \alpha_2' x_{i2} + \beta_2' y_{j2} + \gamma_2' z_{ij2} - \varepsilon_{ij2}
\end{aligned} \tag{3}
$$

where $crop\_type_{ij}^{*}$ is a latent variable for crop choice such that

$$
crop\_type_{ij} = \begin{cases} 1, \text{ if } crop\_type_{ij}^{*} > 0 \\ 0, \text{ if } crop\_type_{ij}^{*} \le 0 \end{cases} \tag{4}
$$

crop_type is an indicator variable and *crop_type* = 1 if the tenant's farm type is *grain_oil* or *tobacco_cotton*, and *crop_type* = 0 otherwise. The random disturbance terms $(\varepsilon_{ij1}, \varepsilon_{ij2})$ are assumed to follow a bivariate normal distribution with the mean (0,0). The specification follows Heckman (1976) and Lee (1981). Note that we include landlord attributes along with tenant attributes in the equation for crop choice. This accounts for possible endogenous matching between the landlord and crop type. Since at least one of the covariates in the model is continuous and varies great enough, the model is readily identified (Wilde, 2000).

The results are presented in table 6. The estimated value of the bivariate correlation of random disturbance ρ is -0.47 and significant, indicating that disturbance terms in the crop choice equation and contract choice equation are indeed correlated. However, the estimated coefficients of the contract choice equation do not differ from those of the basic models in terms of signs. Important variables such as the crop type, the tenant's total assets, the erodibility index, the yield variability index and the average value of the Beale code have signs consistent with the basic models. In terms of magnitude, however, some differences are sizable. For example, the estimated coefficient for the tenant's total assets becomes -0.0011, which is about two thirds of that in the basic model[5]. Although some differences are

found in the estimation results and there is evidence that crop choice is correlated with contract choice, the evidence for both the transaction cost hypothesis and the risk sharing hypothesis persists, even after examining potential endogeneity problems.

We can derive some information on the mechanism of endogenous matching as well as the impact of the mechanism on contract choice from our results. In the crop choice equation, it is shown that a tenant who has a larger share of owned land is less likely to be a grain or oilseed farmer, or a tobacco or cotton farmer. This probably reflects the trend that a field crop farmer rents land in order to expand his operation and to enjoy economies of scale. Wealthier (and thus less risk averse) tenants are less likely to be grain or oilseed farmers or tobacco or cotton farmers. Tenants who have a high debt-asset ratio are less likely to be grain, or oilseed farmers or tobacco or cotton farmers. An increase in yield variability decreases the likelihood of the farm type being grain or oilseed farms, or tobacco or cotton farms. When the farm is located in a more rural area, as indicated by the Beale code, it is more likely to be a grain or oilseed farm, or a tobacco or cotton farm. Moreover, some landlord attributes affect crop choice. If the landlord does not live on the farm or does not live within five miles from the contracted land, the tenant farm type being grain or oilseed, or tobacco or cotton is more likely. Landlords who have a high debt-asset ratio are less likely to be involved in grain or oilseed, or tobacco or cotton production.

Ackerberg and Botticini (2002) presented evidence that tenants who have less wealth (and a higher degree of risk aversion) are more likely to be matched with landlords who have high-risk assets (in their case, grapevine cultivation, which they argue is more risky than grain production), using data from Renaissance, Tuscany. Serfes (2005) shows that positive assortative matching (PAM), in which agents who are more risk averse are

matched with principals with many assets, is a sufficient condition for a negative relationship between risk and incentives. Serfes (2005) argues that the finding of Ackerberg and Botticini (2002) is consistent with the theoretical predictions. In our empirical results, we find evidence that tenants who are more risk averse are more likely to be grain or oilseed farmers, or tobacco or cotton farmers, although we do not have priori information that grain or oilseed, or tobacco or cotton production is less risky than other agricultural production. That is, we are not sure which type of matching, PAM or negative assortative matching (NAM), if any, is occurring. However, these results indicate that factors affecting contract choice, especially the agents' risk preferences and transaction costs among other things, also affect crop choice.

Furthermore, this result indicates that the matching may be in fact three-sided. That is, landlords and tenants are respectively matched with crop type (Ackerberg and Botticini, 2002 and Serfes, 2005 deal with two-sided matching in which landlords are matched with tenants). These implications regarding the mechanism of matching are interesting, although they need further investigation and are beyond the scope of this article. However, they still deserve a few more comments. Crop choice is a complicated decision in modern U.S. agriculture. First of all, the profitability of a crop is obviously an important determinant, and production uncertainty and output and input price uncertainty should be important, too. Since farmers may have repeated trial-and-error attempts in order to match a crop to the local environmental conditions, such as weather and soil type, environmental conditions as well as the history of the development of local agriculture may matter. Government farm programs can provide some counter-risk supports to producers and landlords. A future task is to take these factors into account in the matching model and to carefully evaluate the role of risk and the agents' risk preferences in matching.

Conclusions

We have examined the empirical evidence for the major hypotheses on contract choice in land tenancy contracts in U.S. agriculture, using a data set of both tenant and landlord attributes. We find evidence for the risk sharing hypothesis, which has tended to be rejected in past literature. Furthermore, our results support the hypothesis that both tenant and landlord attributes affect contract choice and crop choice, although endogenous matching does not significantly affect contract choice in our data. The findings that both landlord and tenant attributes affect contract choice and crop choice, and that the choices are indeed correlated imply that empirical analysis including only tenant attributes (or landlord attributes) in the empirical model, without properly treating the endogeneity problem, may generate misleading estimates. In developed agriculture like modern U.S. agriculture, in which landlord and tenant characteristics are likely to be heterogeneous, the failure to control for endogeneity could be problematic.

As an extension of this research, it may be fruitful and interesting to explore more carefully how and why endogenous matching occurs and if it affects contract choice. Our results indicate that risk, risk preference, and transaction costs affect not only the farmland lease type, but also the type of crop being produced on the contracted land. Further development of both theoretical and empirical studies is needed in order to carefully evaluate this issue. If this relationship is true, the mechanism of farmland leasing should be understood as the conjuncture of contract choice and crop choice. This is important since a similar mechanism can be observed broadly in other industries: tasks are commonly allocated among employees based on the employer's evaluation of employees' skills and risk preferences, among other factors, and it is possible that contract choice is related to this task

allocation. Further investigation of the mechanism of endogenous matching, built into the mechanism of farmland lease contract choice, therefore, may provide new perspectives and better understandings of contracting practices.

Endnotes

[1] However, Dubois (2002) shows that the choice between cash rent and cropshare can be explained even without assuming risk averse agents, using a multi-task principal-agent framework. Lack of evidence for risk sharing does not necessarily mean that the principal-agent approach is invalid. Furthermore, there have been several principal-agent models developed to explain how a positive relationship between risk and the agent's risk preference could arise. As examples of such models, see Prendergast (2002) and Serfes (2005). Serfes (2005) explains how a positive relationship between risk and risk preference can appear if the matching between the principal and agent happens before they contract. As such, a question of interest that we investigate in the present article is whether risk plays a role in determining contract type, rather than whether the principal-agent framework is valid or not.

[2] There is, however, another potential problem in our data set. We have the data on tenants and landlords who actually contract, but do not have data on other potential tenants and landlords who failed to complete a contract. Since the decision on contract choice is conditional upon the choice between lease-in and lease-out, estimating only the contract choice equation may result in estimation biases -a well known selection problem. Dubois (2002) and Pandey (2004) explicitly deal with the selection problem and find no significant effects on the results. Although we note that there remains an unsolved selection problem, we do not have the data to resolve it.

[3] One could ask whether the use of simple linear proxies for inherently unobservable parameters of interest is a valid approach. This is an important question, but has been

ignored in the literature. In Appendix 1, we briefly discuss this issue using a simple model. The main point is that we need a strong assumption for the procedure to be valid. However, in this article, we assume the traditional procedure works well, for analytical simplicity purposes.

[4] The estimation results for selection equations from which we derived the selection correction term are presented in Appendix 2.

[5] Interestingly, this result contradicts Ackerberg and Botticini (2002) in which the coefficient estimate for the tenant's wealth becomes greater (in the absolute value) after the endogenous matching is controlled.

Table 1. Variable Definitions and Sample Summary Statistics

Variables	Definitions	Mean	S.D.	Min	Max
Dependent variables					
cropshare	=1 if contract is cropshare, =0 if contract is cash rent	0.20	0.40	0	1
Independent variables					
Regions					
NE	=1 if location of tenant's farm is Northwest region	0.12	0.33	0	1
MW	=1 if location of tenant's farm is Midwest region	0.37	0.48	0	1
SR	=1 if location of tenant's farm is South region	0.35	0.48	0	1
WR	=1 if location of tenant's farm is West region	0.16	0.36	0	1
Tenant's farm type					
grain_oil	=1 if type of tenant's farm is grain and/or oilseed production	0.39	0.49	0	1
tobacco_cotton	=1 if type of tenant's farm is tobacco and/or cotton production	0.12	0.33	0	1
vegetable_fruit	=1 if type of tenant's farm is vegetable and/or fruit production	0.08	0.27	0	1
other_crop	=1 if type of tenant's farm is other crop production	0.08	0.29	0	1
beef	=1 if type of tenant's farm is beef cattle ranching and farming	0.10	0.30	0	1
dairy	=1 if type of tenant's farm is dairy	0.15	0.36	0	1
other_animal	=1 if type of tenant's farm is producing other animals	0.17	0.37	0	1
crop_type	=1 if grain_oil=1 or tobacco_cotton=1	0.52	0.50	0	1
Other tenant's attributes					
t_age	age of tenant	51.65	12.09	18	96
t_gender	=1 if tenant is male	0.98	0.12	0	1
t_white	=1 if race of tenant is white	0.98	0.14	0	1
ind_farm	=1 if type of tenant's farm is individual farm	0.63	0.48	0	1
n_family_members	number of family members living in tenant's household	3.17	1.52	1	20
t_n_landlords	number of landlords whom tenant contract with	13.35	19.83	1	171
t_total_income_net	tenant's net total income ($1,000)	206.05	795.27	-16,881.52	55,087.09
t_farm_share	=1 if share of farm income in tenant's household is greater than 75%	0.50	0.50	0	1
t_total_assets	value of farm and nonfarm assets in tenant's household ($100,000)	23.86	67.53	0.00	5528.50
t_share_owned	share of number of acres of land owned by tenant (%)	29.64	26.64	0.00	99.90
t_dwelling_value	market value of tenant's dwellings on contracted land ($100,000)	0.08	0.31	0.00	9.63
t_debt_free	=1 if tenant has no debt	0.12	0.33	0	1
t_da_50	=1 if tenant's farm debt-asset ratio is greater than 50%	0.13	0.34	0	1

Table 1. (Continued)

Landlord's attributes					
l_age	age of landlord	65.09	14.47	2	100
l_white	=1 if race of landlord is white	0.94	0.23	0	1
l_n_tenants	number of tenants whom landlord contracts with	1.36	2.82	1	170
l_ope_99	=1 if landlord operated farm or ranch in 1999	0.11	0.32	0	1
l_liv_on_farm	=1 if landlord lives on contracted land	0.13	0.34	0	1
l_liv_close	=1 if *l_liv_on_farm* =0 and landlord resides within 5 miles of contracted land	0.42	0.49	0	1
l_farm_income	=1 if landlord's net farm income is greater than $25,000	0.06	0.23	0	1
l_farm_share	=1 if share of gross farm income in landlord household is 76% or more	0.08	0.27	0	1
l_farm_assets	market value of all farm assets owned by landlord ($100,000)	2.83	9.68	0.00	584.33
l_total_value	market value of all lands and buildings owned by landlord ($100,000)	5.50	137.79	-11.93	4818.55
l_acres_owned	number of acres owned by landlord (100 acres)	5.32	34.55	0.01	2552.08
l_debt_free	=1 if landlord has no debt	0.86	0.35	0	1
l_da_50	=1 if landlord's farm debt-asset ratio is greater than 50%	0.05	0.21	0	1
total_value	market value of land and buildings on contracted land ($100,000)	2.76	9.55	0.00	584.33
Other factors					
variability	standardized and weighted production variability for county of tenant's residence	0.26	0.10	0.01	1.29
average_beale	average of Beale code in 1993 and 2003 forcounty of tenant's residence	4.74	2.48	0.50	9.00
contracted_acres	number of acres of contracted land (100 acres)	2.17	10.91	0.01	880.00
erodibility	erodibility index for county of tenant's residence	2.68	2.72	0.00	29.14

Table 2. Basic Models –Maximum Likelihood Estimation of Probit Model of Contract Choice (Probability that Cropshare is Chosen), N = 44,515

	With Selection Term	Without Selection Term	With Selection Term	Without Selection Term
Regressors	-Loglikelihood = 18572.23	-Loglikelihood = 18573.12	-Loglikelihood = 18724.70	-Loglikelihood = 18830.50
Intercept	-4.7794***	-4.0460***	-4.7962***	-2.9371***
NER	-1.4002***	-1.2606***	-1.6202***	-1.3514***
MWR	-0.5707***	-0.5024***	-0.6990***	-0.5250***
SR	-0.4634***	-0.3806***	-0.6224***	-0.4830***
grain_oil	0.2783***	0.3097***		
tobacco_cotton	0.0807	-0.0075		
vegetable_fruit	-0.1833**	-0.2823***		
beef	-0.1467*	-0.0454		
dairy	-0.6305***	-0.7333***		
other_animal	-0.2735***	-0.3118***		
crop_type			0.5063***	0.5658***
t_age	0.0010	0.0002	0.0016**	0.0003
t_gender	-0.1404	0.0112	0.3030***	0.0311
t_white	0.2515***	0.2403***	0.2032***	0.1876***
ind_farm	0.0077	0.0198	-0.0174	0.0190
n_family_members	-0.0006	-0.0012	-0.0021	-0.0083
t_n_landlords	-0.0100***	-0.0100***	-0.0095***	-0.0095***
t_total_income_net	<0.0001**	<0.0001**	<0.0001	<0.0001***
t_farm_share	0.0753***	0.0625***	0.0846***	0.0353**
t_total_asset	-0.0017***	-0.0019***	-0.0013***	-0.0018***
t_share_owned	-0.0034***	-0.0047***	-0.0025***	-0.0054***
t_dwelling_value	0.0092	-0.0136	0.0266	-0.0271
t_debt_free	0.0458*	0.0656***	0.0251	0.0770***
t_da_50	-0.0561**	-0.0407**	-0.0666***	-0.0398*
l_age	0.0038***	0.0038***	0.0037***	0.0039***
l_white	-0.0563	0.1522***	-0.2987***	0.1508***
l_ope_99	0.0331	0.0380	0.0223	0.0328
l_liv_on_farm	-0.0549	-0.0985***	-0.0059	-0.1115***
l_liv_close	-0.1857***	-0.1880***	-0.1797***	-0.1978***
l_farm_income	0.1462***	0.1760***	0.1217***	0.1830***
l_farm_share	0.0004	0.0069	-0.0042	0.0113
l_farm_assets	0.0327***	0.0387***	0.0229***	0.0356***
l_total_value	-0.0015***	-0.0013***	-0.0018***	-0.0013***
l_acres_owned	0.0005	0.0006	0.0003	0.0006
l_debt_free	-0.0316	0.0006	-0.0683***	0.0004
l_da_50	-0.0746	-0.0463	-0.1041**	-0.0514
total_value	-0.0349***	-0.0414***	-0.0242***	-0.0377***
variability	0.3583***	0.3505***	0.3852***	0.3289***
average_beale	0.0274***	0.0318***	0.0198***	0.0350***
contracted_acres	0.0013	0.0002	-0.0016	0.0002
erodibility	0.0745***	0.0777***	0.0691***	0.0759***
Selection Correction Term	0.9156	-	1.8834***	-

Note: Three asterisks indicate the coefficient estimate is significant at the 1% level. Two asterisks indicate the coefficient estimate is significant at the 5% level. One asterisk indicates the coefficient estimate is significant at the 10% level.

Table 3. MLE Probit of Contract Choice with Selection, N = 61,944

	Cropshare Chosen	Being Selected
	-Loglikelihood = 54959	
Regressors	Estimates	
Intercept	-1.8079***	0.6479***
NER	-1.3537***	-0.2373***
MWR	-0.5435***	-0.1690***
SR	-0.5074***	-0.1473***
crop_type	0.5477***	-0.0720***
t_age	0.0007	0.0021**
t_gender	0.2457	0.2983***
t_white	0.3423***	0.1033*
ind_farm	-0.0112	-0.0360***
n_family_members	-0.0076	0.0010***
t_n_landlords	-0.0084***	-0.0016
t_total_income_net	<0.0001*	<0.0001**
t_farm_share	0.0357	0.0573***
t_total_asset	-0.0045***	0.0009***
t_share_owned	-0.0048**	0.0032***
t_dwelling_value	-0.0218	0.0660***
t_debt_free	0.0707	-0.0507***
t_da_50	-0.0449**	-0.0201**
l_age	0.0041***	0.0002
l_white	0.1479	-0.5255***
l_ope_99	0.0449*	-0.0041
l_liv_on_farm	-0.1291	0.1185***
l_liv_close	-0.2045***	0.0311**
l_farm_income	0.2006***	-0.0531**
l_farm_share	0.0202	-0.0068
l_farm_assets	0.0364***	-0.0185
l_total_value	-0.0015***	-0.0004*
l_acres_owned	0.0006	-0.0004**
l_debt_free	-0.0123	-0.0884***
l_da_50	-0.0700	-0.0306
total_value	-0.0384***	0.0141*
variability	0.4040***	0.1002
average_beale	0.0329***	-0.0148***
contracted_acres	0.0003	0.0018*
erodibility	0.0757***	-0.0078***
Correlation in Disturbance	0.07670	

Table 4. Basic Model for Each Farm Type –MLE of Probit Model of Contract Choice (Probability that Cropshare Is Chosen)

	Grain-Oilseeds	Tobacco-Cotton	Vegetable-Fruit	Other Crops
	N = 17,485	N = 5,514	N = 3,591	N = 3,779
Regressors	-Loglikelihood = 9230.43	-Loglikelihood = 2115.65	-Loglikelihood = 985.47	-Loglikelihood = 1528.07
Intercept	-3.6894***	-5.3759	-4.1200***	-4.0456***
NER	-1.9645***	-6.0348	-1.1378***	-2.5642***
MWR	-0.8169***	1.5380***	-1.0065***	-0.2461***
SR	-0.6572***	-0.0781	-0.6422***	0.0100
t_age	0.0052***	-0.0051**	0.0051*	-0.0013
t_gender	0.0046	0.3168**	0.0029	0.3908
t_white	0.2544**	0.2615	0.3997***	0.0934
ind_farm	-0.0097	-0.0703	0.0110	0.0108
n_family_members	-0.0194**	0.0121	-0.0326	0.0328*
t_n_landlords	-0.0220***	-0.0156***	-0.0212***	0.0198***
t_total_income_net	<0.0001	0.0002**	<0.0001	0.0001
t_farm_share	0.0448**	0.0883*	0.0193	0.1640***
t_total_asset	-0.0051***	-0.0109***	<0.0001	-0.0103***
t_share_owned	-0.0056***	-0.0045***	-0.0039***	-0.0059***
t_dwelling_value	0.0056	0.0745	-0.0367	0.0339
t_debt_free	0.1598***	0.0125	-0.0466	-0.2490***
t_da_50	-0.0048	0.0442	-0.3100***	-0.4002***
l_age	0.0054***	-0.0020	0.0046**	0.0013
l_white	0.0846	0.3296***	0.0842	0.3489***
l_ope_99	0.0091	0.1016	-0.0723	-0.0396
l_liv_on_farm	-0.1347***	-0.1462**	0.0467	0.0052
l_liv_close	-0.2279***	-0.1344***	-0.0952	-0.1050*
l_farm_income	0.1924***	0.0567	0.1878*	0.3714***
l_farm_share	-0.0216	0.0768	-0.0704	0.0427
l_farm_assets	0.1781***	-0.0055	-0.1540**	0.0273
l_total_value	-0.0029**	-0.0074**	-0.0050	-0.0025
l_acres_owned	0.0026	0.0189***	-0.0119	0.0014
l_debt_free	0.0626*	-0.0865	-0.1216	-0.1222
l_da_50	-0.0386	-0.0057	0.0256	-0.1578
total_value	-0.1793***	-0.0113	0.1655**	-0.0246
variability	0.4615***	0.9336***	0.0160	-0.9269***
average_beale	0.0236***	-0.0217*	0.0435**	0.0474***
contracted_acres	-0.0022	0.0217	0.0189	-0.0001
erodibility	0.0549***	0.1829***	0.0220	0.0667***

Table 4. (Continued)

	Beef	Dairy	Other Animals
	N = 4,322	N = 6,641	N = 7,505
Regressors	-Loglikelihood = 1587.58	-Loglikelihood = 914.42	-Loglikelihood = 2692.71
Intercept	-1.4716***	-3.3743***	-1.7513***
NER	-0.5607**	-0.9764***	-0.4626***
MWR	0.2104**	-0.3675***	0.0651
SR	-0.1126**	-0.3768***	-0.2687***
t_age	-0.0050**	-0.0089***	-0.0035**
t_gender	0.5236**	0.0203	0.4634***
t_white	0.6580**	0.1944	0.4437**
ind_farm	0.1797***	0.0515	0.0502
n_family_members	-0.0097	0.0507***	-0.0113
t_n_landlords	-0.0006	0.0063	-0.0058***
t_total_income_net	<0.0001	-0.0005***	<0.0001
t_farm_share	0.0473	-0.0291	0.0330
t_total_asset	-0.0015	-0.0090***	-0.0037***
t_share_owned	0.0003	0.0020	-0.0006
t_dwelling_value	0.0676	-0.0815	0.0405
t_debt_free	-0.0686	-0.3631**	-0.0272
t_da_50	0.2210***	-0.3820***	0.1225**
l_age	0.0013	0.0030	0.0025*
l_white	-0.1657	0.2451	-0.0103
l_ope_99	0.1563**	0.1194	0.1635***
l_liv_on_farm	0.0355	0.0333	-0.0413
l_liv_close	-0.1082*	-0.2520***	-0.961**
l_farm_income	0.2786***	0.1164	0.1118
l_farm_share	-0.1815*	0.0025	-0.0158
l_farm_assets	0.0075	0.0466**	0.0365*
l_total_value	-0.0013	-0.0073	-0.0015
l_acres_owned	0.0003	0.0147	0.0006
l_debt_free	0.1306	-0.0978	0.0229
l_da_50	-0.1360	0.0523	-0.0497
total_value	-0.0060	-0.0437	-0.0348*
variability	0.3132	-0.4180	0.7469***
average_beale	0.0117	0.0183	0.0130
contracted_acres	<0.0001	-0.0135	0.0008
erodibility	0.1009***	0.0060	0.0615***

Table 5. Specification Test of Contract Choice Equation (Probability that Cropshare Is Chosen), N = 44,515

	No Tenant Effects	No Landlord Effects
Regressors	-Loglikelihood = 18919.36	-Loglikelihood = 18713.34
Intercept	-4.3012***	-3.9085***
NER	-1.2923***	-1.3207***
MWR	-0.4953***	-0.5264***
SR	-0.3719***	-0.4033***
grain_oil	0.3442***	0.3240***
tobacco_cotton	-0.0112	0.0198
vegetable_fruit	-0.3402***	-0.2919***
beef	-0.0413	-0.0263
dairy	-0.7221***	-0.7517***
other_animal	-0.3017***	-0.3090***
t_age		0.0005
t_gender		0.0192
t_white		0.2725***
ind_farm		0.0186
n_family_members		-0.0012
t_n_landlords		-0.0109***
t_total_income_net		<0.0001***
t_farm_share		0.0664***
t_total_asset		-0.0018***
t_share_owned		-0.0049***
t_dwelling_value		-0.0035
t_debt_free		0.0642***
t_da_50		-0.0378*
l_age	0.0043***	
l_white	0.1683***	
l_ope_99	0.0426*	
l_liv_on_farm	-0.1043***	
l_liv_close	-0.1969***	
l_farm_income	0.1994***	
l_farm_share	0.0249	
l_farm_assets	0.0391***	
l_total_value	-0.0014***	
l_acres_owned	0.0007	
l_debt_free	-0.0166	
l_da_50	-0.0582	
total_value	-0.0406***	
variability	0.3842***	0.4497***
average_beale	0.0407***	0.0361***
contracted_acres	0.0006	<0.0001
erodibility	0.0820***	0.0796***

Table 6. MLE of Simultaneous Probit Model of Contract Choice and Tenant's Farm Type (Probability that Cropshare Is Chosen and that the Tenant's Farm Type Is Grain, Oilseed, Tobacco, or Cotton), N = 44,515

	cropshare = 1	*crop_type* = 1
	-Loglikelihood = 44966	
Regressors	Estimates	
Intercept	-1.3781***	-0.7588***
NER	-1.2148***	-0.2835***
MWR	-0.6766***	0.7022***
SR	-0.5973***	0.5659***
crop_type	1.2811***	
t_age	-0.0004	-0.0001
t_gender	-0.0768	0.2849***
t_white	0.0960	0.3617***
ind_farm	-0.0050	0.0552***
n_family_members	0.0058	-0.0682***
t_n_landlords	-0.0116***	0.0117***
t_total_income_net	<0.0001	-0.0001***
t_farm_share	0.0196	0.0549***
t_total_asset	-0.0011***	-0.0063***
t_share_owned	-0.0024***	-0.0096***
t_dwelling_value	-0.0224	-0.0342
t_debt_free	0.0779***	-0.0566***
t_da_50	0.0180	-0.2612***
l_age	0.0027***	0.0022***
l_white	0.1262***	-0.0634**
l_ope_99	0.0490**	-0.1099***
l_liv_on_farm	-0.0741***	-0.1458***
l_liv_close	-0.1484***	-0.1702***
l_farm_income	0.1874***	0.0725**
l_farm_share	-0.0118	0.1009***
l_farm_assets	0.0320***	0.0096
l_total_value	-0.0013***	-0.0003
l_acres_owned	0.0005	0.0006
l_debt_free	-0.0123	0.0020
l_da_50	-0.0326	-0.1170***
total_value	-0.0345***	-0.0097
variability	0.4685***	-0.4330***
average_beale	0.0193***	0.0405***
contracted_acres	0.0010	-0.0037***
erodibility	0.0566***	0.0577***
Correlation in Disturbance	-0.4669***	

Appendix 1. Empirical Specification of the Choice between Cash Rent and Cropshare

In the past literature, formal discussion on empirical specification of the choice between cash rent and cropshare has been absent. Specifically, although it has been informally argued that risk and the tenant's risk aversion increases the likelihood of cropshare while the landlord's risk aversion decreases the likelihood of cropshare, none has derived the argument directly from formal models. In this appendix, we explicitly derive the condition such that cropshare becomes more likely and show that risk and the tenant's risk aversion indeed increases the likelihood of cropshare while the landlord's risk aversion decreases the likelihood of cropshare. We adopt a simple model of contract choice. The similar models are used to explain the choice between cash rent and cropshare in the past literature (e.g., see Allen and Lueck, 1999 and Huffman and Just, 2004).

Suppose that the output function is given by

(A1.1) $$y = L + \delta$$

where L is the tenant's effort level and δ is an unobservable disturbance factor that follows a normal distribution, $N(0,\sigma^2)$. The landlord utilizes a linear contract denoted as $w = \alpha y + \beta$. The landlord and the tenant are either risk neutral or risk averse, and the Arrow-Pratt risk aversion coefficients are denoted by r_l for the landlord and r_t for the tenant, respectively. The tenant's private cost of effort is given by $\frac{1}{2}kL^2$. k stands for the effort cost sensitivity of the tenant. The reservation utility of the tenant is denoted as U_0. Let the tenant's utility function be U. U is a concave, monotonic increasing function. The tenant's problem is

$$\max_L \left\{ E[U(\alpha(L+\delta)+\beta-kL^2/2)] \right\}.$$

Using the second order Taylor approximation,

$$\begin{aligned} E[U(\alpha(L+\delta)+\beta-kL^2/2)] &= U(E[I]) + E[U'(E[I])\cdot\alpha\delta] + \frac{1}{2}E[U''(E[I])\cdot\alpha^2\delta^2] \\ &= U(E[I]) + \frac{1}{2}U''(E[I])\cdot\alpha^2\sigma^2 \end{aligned} \quad \text{(A1.2)}$$

where $E(I)$ is the tenant's expected income, $E(I) = \alpha L + \beta - kL^2/2$.

The tenant's problem can be alternatively written as

$$\max_L \{U(CE)\}$$

where *CE* stands for the certainty equivalent for the tenant's uncertain income. By using the risk premium, *RP*, *CE* is defined as $CE = E(I) - RP$.

Since U is a monotonic increasing function, the tenant's problem is equivalent to

$$\max_L \{CE\}.$$

Now, using the first order Taylor approximation,

$$E[U(I)] = U(CE) = U(E[I] - RP) = U(E[I]) - U'(E[I])\cdot RP \quad \text{(A1.3)}$$

Therefore, from (A1.2) and (A1.3), $RP = -\frac{1}{2}\frac{U''(E[I])}{U'(E[I])}\alpha^2\sigma^2 = -\frac{1}{2}r_t\alpha^2\sigma^2$. Thus, the tenant's problem becomes

$$\max_L \{E[I] - RP\} = \max_L \left\{ \alpha L + \beta - \frac{1}{2}k(L)^2 - \frac{1}{2}\alpha^2 r_t \sigma^2 \right\}.$$

Similarly, the landlord's certainty equivalent is given by $(1-\alpha)L - \beta - \frac{1}{2}r_l(1-\alpha)^2\sigma^2$.

Under these settings, the landlord's problem becomes

$$\max_{\alpha}\left\{(1-\alpha)L^{*}-\beta-\frac{1}{2}(1-\alpha)^{2}r_{l}\sigma^{2}\right\}$$

s.t.

$$L^{*}=\arg\max_{L}\left\{\alpha L+\beta-\frac{1}{2}k(L)^{2}-\frac{1}{2}\alpha^{2}r_{t}\sigma^{2}\right\}$$

$$\alpha L^{*}+\beta-\frac{1}{2}k(L^{*})^{2}-\frac{1}{2}\alpha^{2}r_{t}\sigma^{2}\geq U_{0}$$

The first constraint is the tenant's incentive constraint, and the second constraint is the tenant's participation constraint.

From the incentive constraint, $L^{*}=\alpha/k$. Because of β, the participation constraint holds with equality (whenever the participation holds with inequality, the landlord can reduce the fixed payment so that she is better off). Thus, $\beta=U_{0}-\alpha L^{*}+\frac{1}{2}k(L^{*})^{2}+\frac{1}{2}\alpha^{2}r_{t}\sigma^{2}$.

Plugging these into the landlord's objective function, the landlord's problem becomes

$$\max_{\alpha}\left\{\frac{\alpha}{k}-\frac{1}{2}k\left(\frac{\alpha}{k}\right)^{2}-\frac{1}{2}\alpha^{2}r_{t}\sigma^{2}-\frac{1}{2}(1-\alpha)^{2}r_{l}\sigma^{2}-U_{0}\right\}$$

Solving this problem, one obtains

(A1.4) $$\alpha^{*}=\frac{1+kr_{l}\sigma^{2}}{1+k(r_{l}+r_{t})\sigma^{2}}$$

Because α^{*} is not equal to unity unless $\sigma^{2}=0$ or $r_{t}=0$, the optimal contract is in general cropshare. Let the total welfare that the landlord maximizes with the optimal contract be represented by π_{CS}, where the subscript *CS* denotes cropshare. Now, suppose that the landlord obtains gains from saving transaction costs when she uses a cash rent contract instead of the optimal cropshare contract. Let *B* denote the total additional benefits under

cash rent. Then, the total welfare when the landlord uses cash rent instead of the optimal cropshare contract denoted by π_C is

(A1.5) $$\pi_C = \frac{1}{2}\cdot\frac{1}{k} - \frac{1}{2}r_t\sigma^2 + B$$

It is optimal for the landlord to use a cropshare contract if and only if

(A1.6) $$\pi_{CS} - \pi_C = \frac{kr_t^2\sigma^4}{2}\cdot\frac{1}{1+k(r_l+r_t)\sigma^2} - B > 0$$

Through straight-forward calculations, one can show that $\pi_{CS} - \pi_C$ is monotonically increasing in σ^2 and in r_t, and monotonically decreasing in r_l and in B. This is the result that the past literature on contract choice has implicitly relied on in order to derive testable hypotheses on the effects of risk and transaction costs on contract choice. Most past studies use very simple linear proxies for the parameters. An implicit assumption that is necessary to justify such empirical analyses is that (A1.6), which is a nonlinear function of the parameters, can be approximated as a linear function of the parameters, so that replacing the parameters with linear proxies should not cause serious specification errors. This is apparently a strong assumption, and needs to be carefully evaluated. Fukunaga and Hueth (2006) provide some empirical tests on this matter and find evidence for nonlinearity, while they find no qualitative effects of the use of linear approximation and linear proxies on the contract choice equation, using the 1999 AELOS.

Appendix 2. MLE of Probit Model of Selection (Probability that the Observation Is Selected), N = 61,944

Regressors	-Loglikelihood = 35878.43	-Loglikelihood = 36116.04
Intercept	-0.0204	-0.3705***
NER	-0.3174***	-0.2483***
MWR	-0.1570***	-0.1817***
SR	-0.1895***	-0.1604***
grain_oil	-0.0668***	
tobacco_cotton	0.1678***	
vegetable_fruit	0.2556***	
beef	-0.2234***	
dairy	0.2520***	
other_animal	0.0862***	
crop_type		-0.0767***
t_age	0.0018***	0.0013***
t_gender	0.2723***	0.2786***
t_white	0.0219	0.0190
ind_farm	-0.0247**	-0.0427***
n_family_members	0.0014	0.0063*
t_n_landlords	-0.0001	-0.0002
t_total_income_net	<0.0001*	<0.0001***
t_farm_share	0.0271**	0.0558***
t_total_asset	0.0007***	0.0009***
t_share_owned	0.0028***	0.0032***
t_dwelling_value	0.0544***	0.0588***
t_debt_free	-0.0429**	-0.0543***
t_da_50	-0.0323**	-0.0241
l_age	-0.0001	-0.0002
l_white	-0.5462***	-0.5571***
l_ope_99	-0.0098	-0.0107
l_liv_on_farm	0.0995***	0.1130***
l_liv_close	0.0054	0.0245**
l_farm_income	-0.0701***	-0.0621**
l_farm_share	-0.0157	-0.0179
l_farm_assets	-0.0141**	-0.0139**
l_total_value	-0.0005**	0.0004*
l_acres_owned	-0.0004	-0.0004
l_debt_free	-0.0718***	-0.0543***
l_da_50	-0.0637**	-0.0560*
total_value	0.0150**	0.0151**
variability	0.0225	0.0390
average_beale	-0.0103***	-0.0151***
contracted_acres	0.0035***	0.0018**
erodibility	-0.0074***	-0.0080***

Appendix 3. MLE of Probit Model of Selection (Probability that Cropshare Is Chosen), the State of Iowa, N = 1,212

Regressors	-Loglikelihood = 492.52
Intercept	-9.7360
grain_oil	-0.4530
vegetable_fruit	-6.6150
beef	-0.2497
dairy	-0.8937**
other_animal	-0.6683*
t_age	0.0090*
t_gender	-0.0810
ind_farm	-0.3910***
n_family_members	-0.0240
t_n_landlords	-0.0449***
t_total_income_net	-0.0005
t_farm_share	-0.0287
t_total_asset	-0.0170**
t_share_owned	-0.0011
t_dwelling_value	0.2442
t_debt_free	0.0782
t_da_50	-0.2866*
l_age	0.0090**
l_white	-0.2118
l_ope_99	0.3100*
l_liv_on_farm	-0.1306
l_liv_close	-0.1620
l_farm_income	0.1597
l_farm_share	0.1960
l_farm_assets	1.0919***
l_total_value	0.0311
l_acres_owned	-0.0380
l_debt_free	-0.0890
l_da_50	-0.0692
total_value	-1.1753***
variability	-1.7868
average_beale	0.0643**
contracted_acres	0.1456**
erodibility	-0.0393***

CHAPTER 3. CONTRACTUAL EXTERNALITIES AND CONTRACT DESIGN: EVIDENCE FROM FARMLAND LEASE CONTRACTS IN U.S. AGRICULTURE

A paper to be submitted to a journal in the field

Keita Fukunaga and Brent Hueth

Abstract

This article uses cross sectional data on the characteristics of landlords and tenants in U.S. agricultural markets to study the effect of multilateral contracting on contract choice. We find evidence that tenants who rent from a relatively large number of landlords are more likely to use cash-rent, rather than crop-share, rental leases. We interpret this finding in the context of a contract-design model with multitasking. When a tenant's labor effort is allocated across multiple plots of land, one landlord's contract may influence the marginal cost of effort for the tenant operating under another's. We show how our empirical findings are consistent with this sort of contractual externality, but only when the contracts of each tenant-landlord pair are determined in isolation. If contracts are chosen cooperatively across all pairs, a reverse prediction holds. Our results therefore support the hypothesis that some institutional or transaction friction limits the communication and redistribution needed to achieve a cooperative (and Pareto-efficient) outcome.

Introduction

Empirical study of contract choice has focused principally on bilateral arrangements, even when potentially there are multilateral effects. For example, a franchisor may design contracts with some of its franchisees to encourage cooperation, or at least to limit opportunities for market competition among the relevant set of franchisees. Alternatively, the terms offered by a construction firm to a given client may depend in part on the firm's

current portfolio of projects and contract terms with other clients. In each case, technological and market interdependencies create contractual externalities across a group of bilateral contracts, and possibly provide good reason for explicit or implicit multilateral contracting where antitrust or other legal restrictions allow. Although a number of authors have studied contractual externalities of this sort at a theoretical level, there is little complementary empirical evidence of their importance.

In this article, we study land-lease contracts in U.S. agricultural markets where a typical farmer tenant contracts with 4 or more landlords. For the most part, contract design in this context is a simple binary choice between a cash-rent and crop-share land lease for each tenant-landlord pair. Although contracts are bilateral, there are clear multilateral effects that result from a given pair's choice. A given tenant has finite labor and capital resources to allocate across multiple plots of land. As a result, one landlord's decision to present his or her tenant with more highly powered incentives---for example, by choosing a cash-rent rather than share-rent lease---indirectly increases the opportunity cost for the tenant of allocating resources to the plots of other landlords. It is natural to hypothesize that, absent a cooperative multilateral contract, competition among landlords will lead to "excessive" cash-rent contracting. Heuristically, each landlord, knowing that his or tenant faces strong incentives from another landlord, must him or herself offer relatively strong incentives. Conversely, if contracts are negotiated cooperatively among all the affected parties, we should expect more share-rent contracting among tenants who contract with multiple landlords. For a given total capacity of labor and capital, a tenant producing for multiple landlords must spread his or her production resources across more land. Efficient contract design in this context dictates that incentives to produce on any one plot of land be less

intense than for a tenant who produces for a single landlord.

We test this hypothesis using data on a cross section of 44,870 contracts covering 12,212 tenants. We find strong evidence that tenants with multiple landlords are indeed more likely to use a cash rent contract than tenants with a single landlord. Cooperation could be implemented implicitly with an appropriate set of bilateral ex ante transfers between each tenant-landlord pair. Unlike the settings considered by Bernheim and Whinston (1986), there is no institutional restriction (anti-trust) on cooperation among the relevant parties. Even when landlords are the relevant decision making party, there is nothing to stop the farmer from communicating with all landlords and implementing the transfers needed to achieve a cooperative outcome. Our evidence suggests that this does not happen: there appear to be significant transactional costs to coordinating contract choice.

In what follows, we briefly summarize related work. We then present a simple model that we use to motivate our empirics. In the subsequent sections we present our data, empirical methodology, and discussion of results. The final section concludes.

Related Literature and Institutional Setting

Typically, there are a finite number of discrete contract forms that account for the majority of economic transactions in any given industrial sector. One widely adopted approach to learning about the underlying forces that affect contract design is to study the choices that contracting parties make among these discrete alternatives, or to study the choice of specific provisions within a given form. In most cases, this means estimation of a descriptive qualitative choice model using the characteristics of the contracting parties and the economic environment in which they operate as explanatory variables. Although this approach plays down fundamental issues involving the origins of a given discrete set of contract forms, it

does offer a convenient and tractable paradigm for empirical investigation of contracts. For recent surveys of empirical contract economics that discuss results from this and a broader set of approaches, see Masten and Saussier (2002), and Chiappori and Salanie (2003). Our contribution in the context of this line of work is to consider the effect of "common agency" on contract choice.

In a seminal treatment of the topic, Berhneim and Whinston (1986) define common agency as a situation where, "the action chosen by a particular individual (the agent) affects not just one, but several other parties (the principals), whose preferences for the various possible actions typically conflict." Viewing common agency as one form of multilateral contracting, it can be distinguished from team production and other forms of multilateral relationships by noting that a single party takes a productive action(s) that affects the payoffs of many others. At least one important question arises in this context that distinguishes common agency from bilateral contracting: can the affected parties (the principals) cooperate in designing an aggregate incentive scheme for the agent? As noted by Bernheim and Whinston (1986), if the answer is "yes," then common agency does not introduce any further frictions beyond the informational problems that may exist between a single principal and the agent. Whether or not cooperation is possible is an empirical question that depends on the potential observability and enforceability of an aggregate incentive scheme (or of individual bilateral contracts that implement a given aggregate scheme), and on the existence of legislative restrictions on the communication and coordination of principals (e.g., anti-trust restrictions).

For a general class of moral-hazard problems, Bernheim and Whinston (1986) show that a lack of cooperation among principals introduces inefficiencies beyond those that would

result from moral hazard alone. Dixit (1996) develops a more explicit set of results in an extended version of the Holmstrom and Milgrom (1987) linear contracting environment. Among his results, he shows that when an agent produces a separate output for each principal, and when effort allocated to the production of each output is substitutable, then a non-cooperative equilibrium among principals will result in incentives that are too highly powered, relative to a second-best contract that is cooperatively designed by the principals. In effect, a lack of cooperation leads to a "third-best" outcome where there is over provision of incentives that results from each principal competing for the agent's effort. In such a setting, there are potential Pareto gains from cooperation. Morevover, it is possible to implement a cooperative contract without direct communication among the principals. The agent, in negotiating bilateral contracts, can coordinate actions and make (implicit) transfers across principals to achieve a second-best outcome.

We study contracts in a setting where common agency is frequent, but not universal. U.S. farmers typically own some land, and rent additional land from multiple non-farming land owners. Moreover, there are no legal restrictions on communication across landlords. Such a setting presents an opportunity to observe empirically the effect of common agency on contract design. We do so by studying differences between the contracting decisions of farmers who produce for a single landlord and those who produce for multiple landlords[1]. As noted in our introduction, there are essentially two discrete contracts used to rent land for farm production in the United States. Either farmers and landowners negotiate an ex ante rental price for use of their land, with the farmer bearing all production and price risk and paying entirely for non-land farm inputs ("cash rent"), or they agree to a proportional sharing of realized production and input costs ("share rent")[2]. U.S. tax law treats these two contracts

differently because share-rent contracts typically have provisions that grant land owners a degree of managerial authority and say in production decisions. As a result, land owners with a share rental agreement are considered "materially engaged in production." Landlords who meet these criteria[3] must pay self-employment taxes, and cannot collect social-security retirement benefits. This distinction provides a reason for landlords and farmer tenants to choose a cash-rental arrangement, even when there may be substantial benefits from sharing production and price risk via a share-rental agreement. In our contract choice model below, we assume that a share contract is an optimally designed linear contract that may be dominated by a cash-rental agreement provided "private benefits" (resulting from the right to collect social security payments and benefit from self-employment tax exemption, and possibly other unobservables) to the landlord are sufficiently high.

The theoretical arguments above suggest potential gains from coordinating contract choices among multiple landowners who share a common farmer tenant. Below, we adapt the analysis in Dixit (1996) to show that when such coordination occurs, tenants who produce for multiple landlords should, *ceteris paribus*, be more likely than a tenant who produces for a single landlord to use a share-rent contract. Similarly, the likelihood of any given farmer-tenant pair choosing a share-rent contract should increase with the total number of landlords who contract with the given farmer. The experiment we have in mind is observation of two identical tenants. One happens to be close to a single non-farming landowner with an acre of land, and another is close to two or more non-farming landowners, each with an acre of land. As an observer, what expectation should we hold about the relative likelihoods of the three pairs' contract choices? Holding everything else equal, the tenant with two landlords has more land to work, and it is second-best efficient for incentives

to be lower powered on each individual acre. One way this can be accomplished is by using share-rent leases. Absent cooperation, exactly the reverse prediction holds: for the tenant with two landlords, each landlord must offer relatively high powered incentives to ensure that the tenant work his land effectively. In this case, a landlord who might otherwise prefer a share-rent arrangement, will instead choose a cash-rent arrangement.

This intuition suggests a very clear test of whether tenants and landlords are able to achieve second-best (cooperative) outcomes in choosing their land-rental agreements, or whether instead competition among landlords leads to too much cash-rental leasing. Finding that tenants who have multiple landlords are more likely to use a share-rent lease supports the cooperation hypothesis. In what follows, we develop our theoretical arguments more formally, and test this hypothesis.

Theory

The model discussed here is adopted from Itoh (2003) and was originally developed by Dixit (1996). We develop the model further so that we can explicitly discuss the conditions under which cash rent is more preferred. With the simple model, it can be shown that an increase in the number of landlords increases the likelihood of cash rent in the presence of contractual externalities, that there are structural differences in the contract choice equations between bilateral contracting and multilateral contracting, and that the contract choice equations is in general nonlinear in parameters. Formal modeling with more general settings remains to be our future task, although we believe that the same results are likely to hold.

We consider the following three regimes: in regime 1, there are n landlords and each of them contracts with a tenant; in regime 2, there are n landlords, contracting with the same tenant

and choosing contract cooperatively; in regime 3, there are n landlords contracting with the same tenant and choosing contract non-cooperatively.

Regime 1 One-on-one contract

In regime 1, a tenant contracts with only one landlord. This is the standard principal-agent model that Holmstrom and Milgrom (1987) presented. The production function is given by

$$y = L + \delta \tag{1}$$

where L is the tenant's effort level provided for the landlord, and δ is an unobservable disturbance factor that follows a normal distribution, $N(0,\sigma^2)$. Furthermore, it is assumed that the landlords are risk neutral while the tenant is risk averse (constant absolute risk averse, CARA is also assumed), and the Arrow-Pratt risk aversion coefficient is denoted by r. The effort cost function is given by $kL^2/2$, where k stands for the effort cost sensitivity of the tenant. The expression of the optimal output share for the tenant is (for the derivation, see Appendix 1 of Fukunaga and Huffman, 2006)

$$\alpha^* = \frac{1}{1+rk\sigma^2}. \tag{2}$$

Regime 2 n landlords and one tenant, and the landlords act cooperatively

Now, let us consider the case in which $n(\geq 2)$ landlords contract with the same tenant. Here, we consider the case in which the landlords behave cooperatively. The tenant allocates his efforts to n landlords' plots of land. Namely, the tenant makes effort L_j for landlord j. The production function is given by equation (1), but now we assume that $y = (y_1, \cdots y_n)_{1\times n}$ and

$L = (L_1, \cdots, L_n)_{1\times n}$. The disturbance vector δ follows a multi-variate normal distribution,

$$N(0,\Omega), \text{ where } \Omega = \begin{pmatrix} \sigma_1^2 & 0 & \cdots & 0 \\ 0 & \ddots & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \sigma_n^2 \end{pmatrix}.$$

Landlord j receives revenue 1 per unit of output. She does not receive any benefit from the output produced in the transaction with other landlords. Landlord j utilizes a linear contract denoted as $w_j = \alpha_j y' + \beta_j$, where $\alpha_j = (\alpha_j^1, \cdots, \alpha_j^n)_{1\times n}$ and $\beta_j = (\beta_j^1, \cdots, \beta_j^n)_{1\times n}$. It is assumed that individual landlords cannot use contracts that directly affect incentives for the tenant's effort for other landlords. That is, the ith factors of the vectors α_j and β_j, α_j^i and β_j^i are zero for all $i \neq j$. We assume this because contracts that directly affect incentives for other landlords seem very unusual in U.S. agriculture. Difficulty in observing the output for other landlords may explain the absence of such contracts. Let the tenant's private cost function be

$$C(L) = \frac{1}{2} LCL', \text{ where } C_{n\times n} = \begin{pmatrix} k & ks & \cdots & ks \\ ks & k & & ks \\ \vdots & & \ddots & \vdots \\ ks & ks & \cdots & k \end{pmatrix}. \quad k > 0 \text{ and } 0 \leq s < 1. \quad k \text{ stands for the effort}$$

cost sensitivity of the tenant. The parameter s can be interpreted as the degree of the externalities of efforts: when $s = 0$, there is no externality between the tenant's efforts, while when s is greater than 0, externality exists and the efforts have substitution effects. That is, when s is greater than 0, greater efforts for one landlord increase the marginal cost of the efforts for other landlords. The reservation utility of the tenant is denoted as U_0.

The tenant maximizes the certainty equivalent given by

(3) $$\alpha L' + \sum_{j=1}^{n} \beta_j - C(L) - \frac{1}{2} r \alpha \Omega \alpha'$$

where $\alpha = \sum_{j=1}^{n} \alpha_j$. Solving the first order condition with respect to L, one obtains

(4) $$L = \alpha C^{-1}$$

This is the incentive compatibility condition for the tenant (we assume that the first order approach is valid in this problem). Since the participation constraint for the tenant holds with equality, using the incentive compatibility constraint, one obtains

(5) $$\sum_{j=1}^{n} \beta_j = U_0 - \frac{1}{2} \alpha (C^{-1} - r\Omega) \alpha'$$

The cooperating landlords' problem is

$$\max_{\alpha} \left\{ (i - \alpha) L' - \sum_{j=1}^{n} \beta_j \right\}$$

with the tenant incentive constraint (4) and participation constraint (5), where $i = (1, \cdots, 1)_{1 \times n}$.

Substituting L and $\sum_{j=1}^{n} \beta_j$ using equations (4) and (5), the problem becomes

$$\max_{\alpha} \left\{ (i - \alpha) C^{-1} \alpha + \frac{1}{2} \alpha (C^{-1} - r\Omega) \alpha' - U_0 \right\} = \max_{\alpha} \left\{ i C^{-1} \alpha' - \frac{1}{2} \alpha (C^{-1} + r\Omega) \alpha' - U_0 \right\}.$$

The first order condition is

(6) $$i C^{-1} = \alpha (C^{-1} + r\Omega).$$

Or, multiplying both sides by C,

(7) $$i = \alpha (I + r\Omega C)$$

where I is n-dimensional identify matrix. Note that ΩC is a positive definite matrix. Thus, when s is greater than zero, the arguments in the matrix become greater, and as a result, the

shares for the tenant, α, becomes smaller than in regime 1. To see this, assume that $\sigma_j^2 = \sigma^2$ for all j. Then, equation (7) reduces to

$$(8) \qquad \alpha_i(1+r\sigma_i^2 k) + rks\sum_{j\neq i}^{n}\alpha_j\sigma_j^2 = \alpha^{**}(1+r\sigma^2 k) + \alpha^{**}(n-1)rks\sigma^2 = 1, \text{ for all } i.$$

Solving this for α^{**},

$$(9) \qquad \alpha^{**} = \frac{1}{1+r\sigma^2 k(1+s(n-1))}.$$

When s is greater than zero and n is greater than 1, $\alpha^{**} < \alpha^{*}$. Moreover, equation (9) shows that α^{**} is decreasing in n. This gives us the first proposition:

Proposition 1. *Suppose that substituting effects exist among the tenant's efforts for different landlords, and that the landlords cooperatively choose contract type. Then, the optimal share of output for the tenant becomes smaller, as the number of landlords increases.*

When the landlords cooperatively choose contract type, an increase in the number of landlords adds more risk to the transaction. Since the tenant is assumed to be risk averse while the landlords are assumed to be risk neutral, the increase in risk lowers the optimal output share for the tenant.

Regime 3 n landlords and one tenant, and the landlords act non-cooperatively

Now, suppose that there are n landlords contracting with one tenant, and the production function and the cost function are the same as in regime 2. The difference is that now the landlords do not cooperate and independently choose contract type. Define the aggregated incentives over all the landlords except landlord j: $A_j = \sum_{i\neq j}^{n}\alpha_i, B_j = \sum_{i\neq j}^{n}\beta_i$. Recognizing that

the tenant's effort is given by equation (4), the tenant's certainty equivalent as in equation (3) is given by

$$\frac{1}{2}(A_j+\alpha_j)(C^{-1}-r\Omega)(A_j+\alpha_j)'+B_j+\beta_j. \tag{10}$$

Without landlord j, the tenant's certainty equivalent is

$$\frac{1}{2}A_j(C^{-1}-r\Omega)A_j'+B_j. \tag{11}$$

Therefore, the addition to the tenant's surplus when the tenant contracts with landlord j is

$$A_j(C^{-1}-r\Omega)\alpha_j'+\frac{1}{2}\alpha_j(C^{-1}-r\Omega)\alpha_j'+\beta_j. \tag{12}$$

Landlord j's expected surplus is

$$(i-\alpha_j)C^{-1}(A_j+\alpha_j)'-\beta_j. \tag{13}$$

Landlord j maximizes the total surplus arising from the bilateral relationship treating A_j as given:

$$\max_{\alpha_j}\left\{iC^{-1}(A_j+\alpha_j)'-rA_j\Omega\alpha_j'-\frac{1}{2}\alpha_j(C^{-1}+r\Omega)\alpha_j'\right\}$$

Recognizing the assumption that α_j^i and β_j^i are zero for all $i\neq j$, this problem reduces to

$$\max_{\alpha_j^j}\left\{C_{jj}^{-1}\alpha_j^j-\frac{1}{2}(C_{jj}^{-1}+r\Omega_{jj})(\alpha_j^j)^2\right\}$$

Solving this problem, one obtains

$$\alpha_j^{j***}=\frac{1}{1+r\sigma_j^2\dfrac{k+(n-2)ks-(n-1)ks^2}{1+(n-2)s}} \tag{14}$$

From equation (14), we obtain the following propositions.

Proposition 2. *Suppose that substituting effects exist among the tenant's efforts for different landlords, and that contractual externalities exist and the landlords non-cooperatively determines the contract terms. Then, the optimal share of output for the tenant is greater than in regime 1 or regime2.*

Proof. Since we know that $\alpha^{**} < \alpha^{*}$ from proposition 1, it suffices show that α_j^{j***} is greater than α^{*}. We show that the denominator in α_j^{j***} is smaller than that in α^{*}. One can readily show that, in the denominator, $\frac{k+(n-2)ks-(n-1)ks^2}{1+(n-2)s} < k$, which completes the proof.

Q.E.D.

Proposition 3. *Suppose that substituting effects exist among the tenant's efforts for different landlords, and that contractual externalities exist and the landlords non-cooperatively determines the contract terms. Then, the optimal share of output for the tenant becomes greater, as the number of landlords increases.*

Proof. We show that α_j^{j***} is increasing in n.

$$\alpha_j^{j***}|_n - \alpha_j^{j***}|_{n-1}$$

$$= \frac{1}{1+\frac{kr(1-s)(1+(n-1)s)\sigma_j^2}{1+(n-2)s}} \cdot \frac{1}{1+\frac{kr(1-s)(1+(n-2)s)\sigma_j^2}{1+(n-3)s}} \cdot \frac{kr\sigma_j^2(1-s)s^2}{(1+(n-3)s)(1+(n-2)s)}$$

$$> 0, \text{ for } n \geq 3$$

Also, one can readily show $\alpha_j^{j***}|_2 - \alpha^{*} > 0$. These complete the proof. *Q.E.D.*

Proposition 2 states that, when the landlords non-cooperatively choose contract type, contracts with higher incentives are more likely to be chosen. A lack of coordination between the landlords leads to inefficient competition between them, because each of them

tries to elicit the tenant's effort using higher powered incentive contracts. Proposition 3 states that the power of incentives provided by the optimal contracts becomes even stronger as the number of landlords increases, given that there are such contractual externalities between the landlords.

These results seem consistent with the hypothesis that a cash rent contract is more likely as the tenant contracts with more landlords, because cash rent provides stronger incentives to the tenant than cropshare. However, because the optimal contract represented by $(\alpha_j^{j***}, \beta_j^{j***})$ is not generally a cash rent contract (actually, it is the optimal *cropshare* contract, as long as $0 < \alpha_j^{j***} < 1$), we need more formal discussion in order to clarify the implications of propositions 2 and 3 and derive testable predictions based on the propositions. In the following, we attempt to derive a testable prediction based explicitly on the formal model.

For that purpose, we use the social welfares in regime 1 and regime 3. The social welfare is the sum of the landlords' welfare and the tenants' welfare. In regime 1, there are n landlords and n tenants and each of them independently contracts. The social welfare in regime 1 becomes

$$
\begin{aligned}
W_1 &= \sum_{j=1}^{n} \left\{ \left((1-\alpha_j^*)L_j^* - \beta_j^* \right) + \left(\alpha_j^* L_j^* + \beta_j^* - \frac{1}{2}k(L_j^*)^2 - \frac{1}{2}r(\alpha_j^*)^2\sigma_j^2 \right) \right\} \\
&= \sum_{j=1}^{n} \left(L_j^* - \frac{1}{2}k(L_j^*)^2 - \frac{1}{2}r(\alpha_j^*)^2\sigma_j^2 \right) \qquad (15) \\
&= \sum_{j=1}^{n} \frac{1}{2} \frac{1}{k(1+kr\sigma_j^2)}
\end{aligned}
$$

In the right hand side of the first row, the principal j's welfare appears in the first parentheses, and the tenant j's welfare appears in the second parentheses. Since the payments are income

transfers between the landlords and the tenants, the contractual terms do not directly appear in the social welfare function, although, of course, they still play the central role in determining the social welfare by affecting the tenant's effort level.

Similarly, in regime 3, the social welfare when the landlords non-cooperatively contract with one tenant is given by

$$W_3 = \sum_{j=1}^{n}\left((1-\alpha_j^{j***})L_j^{***} - \beta_j^{j***}\right) + \sum_{j=1}^{n}\left(\alpha_j^{j***}L_j^{***} + \beta_j^{j***} - \frac{1}{2}r(\alpha_j^{j***})^2\sigma_j^2\right) - \sum_{i}^{n}\sum_{j\neq i}^{n}\left(\frac{1}{2}k(L_i^{***})^2 + ksL_i^{***}L_j^{***}\right) + (n-1)U_0 \tag{16}$$

The first summation represents the sum of the landlords' welfares while the rest terms represent the tenant's welfare. The second term represents the welfare for the tenant who contracts with n landlords in regime 3. The last term represents the sum of reservation utilities of the $n-1$ tenants who are out of leasing in regime 3.

Now, in regime 1, suppose that the landlords choose cash rent contracts. The optimal effort level under cash rent is $1/k$. In addition, suppose that there is an external source of gain for the landlords when they use cash rent. Examples of such an external source of gain are savings in self-employment tax, full receipt of social security benefits, potential savings in estate tax, etc. Denote such an external benefit under cash rent by θ_j. Then, the social welfare when the landlords use cash rent contracts in regime 1 becomes

$$W_1^C = \sum_{j=1}^{n}\left(\frac{1}{k} - \frac{1}{2}k(\frac{1}{k})^2 - \frac{1}{2}r(1)^2\sigma_j^2 + \theta_j\right) = \frac{n}{2k} + \sum_{j=1}^{n}\left(-\frac{1}{2}r\sigma_j^2 + \theta_j\right) \tag{17}$$

Similarly to the above, suppose that the landlords choose cash rent contracts in regime 3. The optimal effort level is now $1/k(1+(n-1)s)$. The social welfare under cash rent contracts becomes

$$W_3^C = \sum_{j=1}^{n}\left(\frac{1}{k(1+(n-1)s)} - \frac{1}{2}r(1)^2\sigma_j^2 + \theta_j\right) - \frac{1}{2}(L^{***}|_{\alpha=1})C(L^{***}|_{\alpha=1})' + (n-1)U_0$$
$$= \frac{n}{2k(1+(n-1)s)} + \sum_{j=1}^{n}\left(-\frac{1}{2}r\sigma_j^2 + \theta_j\right) + (n-1)U_0 \tag{18}$$

where $L^{***}|_{\alpha=1} = \left(\frac{1}{k(1+(n-1)s)}, \cdots, \frac{1}{k(1+(n-1)s)}\right)_{1\times n}$.

Then, it is optimal to choose cash rent if and only if

$$W_1^C > W_1, \text{ in regime 1} \tag{19}$$

$$W_3^C > W_3, \text{ in regime 3} \tag{20}$$

This reduces to

$$\sum_{j=1}^{n}\theta_j + \frac{n}{2k} - \frac{r}{2}\sum_{j=1}^{n}\sigma_j^2 - \sum_{j=1}^{n}\frac{1}{2}\frac{1}{k(1+kr\sigma_j^2)} > 0, \text{ in regime 1} \tag{21}$$

$$\sum_{j=1}^{n}\theta_j + \frac{n}{2k(1+(n-1)s)} - \frac{r}{2}\sum_{j=1}^{n}\sigma_j^2 - \sum_{j=1}^{n}\left(L_j^{***} - \frac{1}{2}r(\alpha_j^{j***})^2\sigma_j^2\right)$$
$$+\frac{1}{2}L^{***}CL^{***\prime} > 0, \text{ in regime 3} \tag{22}$$

Based on the condition, the following propositions are derived. Define $\Theta = \sum_{j=1}^{n}\theta_j$. Then,

Proposition 4. *For sufficiently large value of s, the lowest value of* Θ *that satisfies the condition (22) is smaller than the counterpart for the condition (21).*

Proof. We show that, for sufficiently great value of s, the LHS of inequality (21) except for the Θ term is greater than the LHS of inequality (22) except for the Θ term so that

inequality (22) can hold with a smaller value of Θ. To show this, we note that the LHS of inequality (22) becomes identical with the LHS of inequality (21) when $s=0$. Therefore, it suffices to show that the LHS of inequality (22) becomes greater than the LHS of inequality of (21) for $s>\underline{s}$, where $\underline{s}$ is some sufficiently great value. Define $\Delta W_3 = W_3^C - W_3$. Using the envelop theorem,

$$\begin{aligned}
\frac{\partial \Delta W_3}{\partial s} &= \frac{\partial W_3}{\partial \alpha}\cdot\frac{\partial \alpha}{\partial s} + \frac{\partial W_3}{\partial s}\Big|_{\alpha=\alpha^*} - \frac{\partial W_3}{\partial s}\Big|_{\alpha=1} \\
&= \frac{\partial W_3}{\partial s}\Big|_{\alpha=\alpha^*} - \frac{\partial W_3}{\partial s}\Big|_{\alpha=1} \\
&= \frac{1}{2}\frac{\partial\left(\frac{1}{k(1-s)(1+ns)}\right)}{\partial s} - \alpha\frac{\partial\left(\frac{1}{k(1-s)(1+ns)}\right)}{\partial s} + \frac{1}{2}\alpha^2\frac{\partial\left(\frac{1}{k(1-s)(1+ns)}\right)}{\partial s} \\
&= \frac{1}{2}\frac{\partial\left(\frac{1}{k(1-s)(1+ns)}\right)}{\partial s}(\alpha-1)^2
\end{aligned}$$

Thus, the sign of $\frac{\partial \Delta W_3}{\partial s}$ is the same as that of $\frac{\partial\left(\frac{1}{k(1-s)(1+ns)}\right)}{\partial s}$. The sign is positive when $s>\frac{1}{2}-\frac{1}{2n}$ and negative otherwise. The graphs of $W_3^C - W_3$ in cases of $n=2,3,4,5,6$ are shown in figure 1. Figure 1 shows that the value of $W_3^C - W_3$ becomes greater than $W_1^C - W_1$ for some sufficiently great value of s. Although the specific parameter values are used in the figure, the shapes and the qualitative properties are robust to other parameter values. *Q.E.D.*

Proposition 4 implies that, when the substituting effects between the tenant's efforts are sufficiently large, the domain of Θ such that cash rent is more preferred is narrower in regime 1 than in regime 3, meaning that the likelihood of cash rent contracts is greater as the shift from regime 1 to regime 3 occurs.

The next proposition claims that an increase in the number of landlords in regime 3 increases the likelihood of cash rent.

Proposition 5. *The lowest value of* Θ *per contract that satisfies the condition that cash rent contracts are more likely in regime 3 becomes smaller as the number of landlords, n, increases.*

Proof. A calculation shows that the value of the LHS of the condition (22) except for the Θ term and the risk term is increasing in n and the rate of decrease is decreasing (see figure 2). This implies that the smallest value of Θ per contract that satisfies the condition becomes smaller as n increases. This completes the proof. *Q.E.D.*

Because cash rent is sub-optimal from the perspective of incentives and risk-sharing, the inefficiency when cash rent is used becomes greater as the number of landlords increases. Proposition 3 above implies that the marginal increase in the loss becomes less as the number of landlords increases, because the optimal share for the tenant becomes closer to unity, and thus smaller increase in Θ is needed so that cash rent becomes more likely.

Now, using the analysis above, we state the predictions that we test in the empirical analysis. First, from proposition 4, we have the following prediction:

Prediction 1. *Cash rent becomes more likely when the tenant contracts with multiple landlords, compared to the case in which the tenant contracts with only one landlord.*

Proposition 5 leads us to the next prediction:

Prediction 2. *Cash rent becomes more likely as the number of landlords per tenant increases, given that the tenant contracts with multiple landlords.*

Finally, from equations (21) and (22), we obtain prediction 3:

Prediction 3. *The coefficients of the equation of contract choice when the tenant contracts with one landlord are not the same as those when the tenant contracts with multiple landlords.*

Data

The 1999 AELOS is a comprehensive data set consisting of tenants' demographic information, economic attributes and household characteristics, and landlords' demographic information and economic attributes. Survey questionnaires were first sent to producers/tenants all over the United States. They were asked to answer certain questions and to provide the addresses and names of their landlords. Then questionnaires were sent to those listed landlords. This procedure makes it possible for us to identify a tenant and a landlord for every contract in the data set. In the United States, a tenant usually has more than one landlord. Reflecting this fact, the information for a tenant may appear more than once in our data set but in combination with the information for different landlords. In other words, in our data set, the sample unit of the data is not an individual tenant or landlord, but a contract between a tenant and a landlord. After deleting unusable observations and refining the data set, we have a total of 44,870 observations (contracts) in the data set[4]. The number of tenants in the data set is 12,212 and the average number of landlords per tenant is 4.94 (the standard deviation is 6.71).

Empirical Methods and Results

Our empirical analysis is comprised of three phases. In the first phase, we observe the correlation between the number of landlords and the proportion of cash rent. This provides us with preliminary evidence for the correlation between the number of landlords and the likelihood of cash rent. In the second phase, we carry out simple regression analyses to

examine the causal relationship between the number of landlords and the likelihood of cash rent. In the third phase, we evaluate the potential endogeneity of the number of landlords in the contract choice equation, and see if this endogeneity problem affects our conclusions.

First, we provide preliminary evidence that an increase in the number of landlords is positively correlated with the likelihood of cash rent. Table 1 shows the percentage of cropshare by the tenant farm type and the number of landlords. When we compare the proportions of cropshare between bilateral contracting and multilateral contracting (upper half of table 1), we find that the proportion of cropshare is greater under bilateral contracting than under multilateral contracting, except for beef farms and farms raising other livestock. For beef farms and farms raising other livestock, the proportion of cropshare is greater under multilateral contracting, although the difference is not statistically significant. When we compare the proportions of cropshare between the tenants with more than one and less than five landlords and those with equal to or more than five landlords (lower half of table 1), we find that the proportion of cropshare is smaller and the proportion of cash rent is greater as the number of landlords is greater, except for beef farms. These results are generally consistent with the hypothesis that contractual externalities exist and competition among landlords results in greater likelihood of cash rent.

Although this descriptive analysis shows that an increase in the number of landlords is positively correlated with the likelihood of cash rent, this does not necessarily suggest the causal relationship that an increase in the number of landlords increases the likelihood of cash rent. If there is a variable that is correlated with both the number of landlords and the likelihood of cash rent, then the positive correlation found above is not a causal but a pseudo

relationship. In order for us to evaluate the true relationship between the number of landlords and contract design, we use regression analysis.

We specify the econometric model as follows. Consider the contract between tenant *i* and his *j*th landlord, landlord *ij*. We denote the type of contract between tenant *i* and landlord *ij* by c_{ij}, where $c_{ij} = 1$ when the contract is cropshare, and $c_{ij} = 0$ when the contract is cash rent. The landlord-tenant party obtains the social welfare W_{ij}^1 from the transaction when the party chooses cropshare, while the party obtains W_{ij}^0 from the transaction when the party chooses cash rent. In addition, suppose that there are exogenous net benefits when the landlord-tenant pair chooses a cash rent contract. Such benefits include, for example, savings in self-employment tax and receipt of full amount of social security payments. If landlords "materially participate" in production, the income from the transaction is subject to self-employment tax. Since landlords technically participate in management under cropshare and are considered to materially participate in production, landlords potentially have motivations to use cash rent. In addition, prior to 2000, landlords age 65 and older on social security retirement were required to count material participation income or other earned income toward the maximum amount of income that they may earn before social security retirement benefits are reduced. The income from cash rent is generally unearned income and thus is not counted toward the maximum amount of income that they may earn before social security retirement benefits are reduced. This may also motivate landlords to use cash rent. On the other hand, landlords have to materially participate in farming for at least five years before death to be eligible for estate tax reduction. This may motivate landlords to use cropshare. Denote the net benefits of cash rent for landlord *ij* described above by θ_{ij}. We assume that

θ_{ij} is observed by the landlord-tenant party but cannot be observed by econometricians. We assume that, from the perspectives of econometricians, θ_{ij} is a random variable that follows a standard normal distribution. The landlord-tenant party chooses cash rent if and only if

(23) $$W_{ij}^1 < W_{ij}^0 + \theta_{ij}$$

From the perspective of econometricians, the probability that the party chooses cash rent is $1-\Phi(W_{ij}^1 - W_{ij}^0)$, and the probability that the party chooses cropshare is $\Phi(W_{ij}^1 - W_{ij}^0)$, where Φ stands for the c.d.f. for standard normal distribution. In the past literature, it has been implicitly assumed that the difference in the social welfare, $W_{ij}^1 - W_{ij}^0$, can be approximated by a linear function of proxies for risk preference, risk, transaction costs, and other factors. However, in general, $W_{ij}^1 - W_{ij}^0$ is not a linear function of these variables. Therefore, we include nonlinear terms constructed from our proxies in the contract choice equation, and examine if there is evidence for nonlinearity. Our econometric model can be written as

(24) $$c_{ij}^* = X_{ij}\beta - \theta_{ij}$$

where c_{ij}^* is a latent variable such that $c_{ij} = 1$ when $c_{ij}^* > 0$ and $c_{ij} = 0$ when $c_{ij}^* \le 0$, X_{ij} is a vector of regressors, and β is a vector of coefficients. $X_{ij}\beta$ is our approximation of $W_{ij}^1 - W_{ij}^0$. Therefore, positive coefficient estimates mean that an increase in the variable increases the probability that cropshare is chosen, while negative coefficient estimates mean that an increase in the variable decreases the probability that cropshare is chosen. The proxies include a tenant farm type dummy variable, the number of landlords[5], tenant total assets, a dummy variable that indicates whether the landlord lives on the contracted land, landlord assets on the contracted land, county-level crop yield variability[6], and county-level

erodibility index[7] among others. The definitions and descriptive statistics of these variables are given in table 2.

The most important variable that we are interested in is, of course, the number of total landlords that the tenant contracts with, denoted by N_i. However, this variable may be subject to a problem of measurement error, because the true variable we want to use is the number of other competing landlords for a specific landlord, denoted by N_{ij}^*, and N_i is not always an exact measurement of N_{ij}^*, as we explain below. Consider the following two cases. In the first case, suppose that all the existing contracts are renegotiated simultaneously, along with new contracts, if any. In this case, N_i minus one is equal to N_{ij}^* for all j, and therefore, N_i can be used as an exact measurement of N_{ij}^*. In the second case, suppose that the existing contracts are not renegotiated once the landlord-tenant pairs set the contracts. In this case, N_{ij}^* depends on the order of the participation of landlord ij. N_{ij}^* is greater for a landlord who enters the transaction with the tenant at a later time. N_i is not an exact measurement of N_{ij}^*, and we do not have an exact measure of N_{ij}^*, since the data on the order of landlord participation are not available in our data set. Note, however, that N_i is positively correlated with N_{ij}^* even in the latter case. Because of the positive correlation, the use of N_i instead of N_{ij}^* should still consistently capture the effect of the true variable, at least qualitatively.

In addition to the number of landlords, we define, for each landlord, the share of the acres contracted by the tenant with other landlords in the total acres contracted by the tenant. This variable is another measurement of contractual externalities. We predict that as the share of total acres contracted with other landlords becomes greater, the landlord is more

likely to use a cash rent, because the landlord inclines to use a high powered contract in order to elicit tenant's effort.

Table 3 shows the summary of the effects of the number of landlords in the contract choice equation. In the first column, the coefficient estimate for the number of landlords is -0.0084 and it is statistically significant, which implies that an increase in the number of landlords decreases the likelihood of cropshare. In the second column where *l_peer_effect* is included, both *t_n_landlords* and *l_peer_effect* have negative and significant coefficient estimates. An increase in the number of landlords and an increase in the share of acres contracted with other landlords increase the likelihood of cash rent. This result, therefore, is consistent with the hypothesis that contractual externalities exist, and they affect contract choice in a way that principals choose contracts with stronger incentives than those in the absence of contractual externalities.

Next, we examine whether there exist structural differences between bilateral and multilateral contracting. In order to test the structural differences, we carry out the Chow-type test (Greene, 2000). The data set is divided into two categories, depending on whether a tenant has only one landlord (regime 1) or multiple landlords (regime 2). Evidence that the estimated coefficients in the contract choice equations across the two regimes are not identical indicates that there exist contractual externalities in the transaction, and the externalities affect contract choice. The test rejects the hypothesis that all the coefficient estimates are identical across the two regimes[8]. Thus, we conclude that there exist structural differences in the contract choice equations between bilateral contracting and multilateral contracting, and this provides further evidence for the hypothesis that contractual externalities affect contract choice.

The simple probit analysis above does not consider the possibility that the number of landlords is endogenous in the contract choice equation. If this is true, the estimates shown in table 3 may be biased. There is a reason that we have to worry about this problem. Since bigger farmers tend to have more landlords, and bigger farmers may be less risk averse, the size of farm may affect both the number of landlords and contract choice simultaneously. Without considering this potential endogeneity problem, the coefficient estimates of the contract equation may suffer from bias. In order to consider the endogeneity problem, we take two different approaches. First, using a linear probability model, we estimate a simultaneous model of contract choice and the number of landlords. We first estimate the equation of the number of landlords, and use the predicted value to replace the number of landlords included in the contract choice equation. In the equation of the number of landlords, we include the value of the tenant's farm machineries in addition to all the variables included in the contract choice equation. This variable is excluded from the contract choice equation so that we can identify the contract choice equation. Farmers who own more farm machineries are likely to be bigger farmers, and thus are likely to contract with more landlords in order to cultivate more acres and enjoy the economies of scale. On the other hand, there is no obvious reason that the value of farm machineries directly affects contract choice, provided that the tenant's attributes are controlled by the tenant's total assets and other variables in the contract choice equation. Specifically, the tenant's risk preference is controlled by the tenant's total assets. The result is reported in table 4. Overall, the qualitative results look very similar across the four specifications. The signs of the coefficient estimate for the number of landlords and for the predicted value of the number of landlords are negative whether or not *l_peer_effect* is included. The result indicates that our

prediction that contractual externalities affect contract choice is supported even after the possible endogeneity of the number of landlords is controlled. The coefficient estimates for *l_peer_effect* have negative signs in the third and fourth columns in table 4, which provides another support for our prediction. As the share of acres contracted with other landlords becomes greater, a cash rent contract becomes more likely.

As an alternative specification, we estimate a bivariate probit model in which contract type and regime (bilateral or multilateral contracting) are simultaneously determined. By explicitly allowing the correlation between the contract choice and the regime selection, we can simultaneously assess the effect of the potential endogeneity problem. In the bivariate probit model, we allow the coefficients of the contract choice equations in regime 1 (bilateral contracting) and regime 2 (multilateral contracting) to differ, because we find that the coefficients are not identical in the analysis above. Table 5 shows the results. We find that the estimated correlation in the disturbance terms has a negative sign, which implies that the tendency of multilateral contracting is negatively correlated with the likelihood of cropshare, and the effect is statistically significant. This provides evidence that the regime selection and contract choice are correlated. Moreover, the coefficient estimate for the number of landlords in the contract choice equation in multilateral contracting is negative and significant, indicating that an increase in the number of landlords decreases the likelihood of cropshare under multilateral contracting. These findings are consistent with those in table 3. Therefore, we conclude that the negative effect of the number of landlords on the likelihood of cropshare is robust to the possible endogeneity problem in contract choice.

Conclusions

Although multilateral contracting is one of the important characteristics in some areas, it has received little attention in the empirical literature to date. In this article, we carry out a case study using a data set from farmland lease contracts in U.S. agriculture. Farmer tenants often have more than one landlord, and multilateral contracting appears in farmland leasing in modern U.S. agriculture. We argue that cash rent becomes more likely as the number of landlords increases, provided that multi-tasking for different landlords is more costly for the tenant, and contractual externalities exist and coordination between landlords is absent. In the presence of contractual externalities, there are more landlords who provide greater incentives to the tenant in order to elicit greater effort from the tenant. We find that the number of landlords per tenant indeed increases the likelihood of cash rent contracts, and the result is robust to endogenous regime selection between bilateral and multilateral contracting. Also, we find that the structure of contract choice equation under bilateral contracting is different from that under multilateral contracting, which provides another evidence for the effect of contractual externalities on the design of farmland lease contracts.

Although we find some supporting evidence for the effect of contractual externalities on contract design, the results do not necessarily insist the incentive hypothesis against alternative hypotheses. Especially, the result that and increase in the number of landlords increases the likelihood of cash rent is also consistent with the transaction cost hypothesis. The transaction cost hypothesis argues that, as the number of landlords increases, a tenant faces higher transaction costs under cropshare, because more record keeping, more reporting, more communications with the landlords, and greater coordination between the landlords are required. Transaction costs under cash rent are generally small because no

reporting is required and the landlord's participation in management is rare. Because of these reasons, the likelihood of cropshare presumably decreases as the number of landlords increases.

To distinguish the effect of contractual externalities from the effect of transaction costs is an interesting task for future research. Having variables that are correlated with the transaction costs but not with contractual externalities in the regression analysis would be useful for this purpose. Such variables may include the average transaction costs spent by the tenant. Empirical evidence that the average transaction costs are increasing in the number of landlords would also support the transaction cost hypothesis. Variables that are correlated with inter-landlords relationship can be used to further test the incentive hypothesis. For example, if the residences of landlords are further away from each other, then it may be more difficult for them to cooperate, and thus contractual externalities may be greater. If this is true, then the average distance from each landlord would increase the likelihood of cash rent. To our knowledge, there are only a couple of empirical studies, including this article, that evaluate the effect of multilateral contracting on contract design. Further empirical and theoretical analyses would be therefore necessary for better understanding the effect of multilateral contracting on contract design.

Endnotes

[1] Of course, properly controlling for unobservable characteristics of farmers and landlords that influence both contract choice, and the decision to contract with multiple landlords, will be crucial in making valid inferences. This is formally analogous to "endogenous matching" as in Ackerberg and Botticini (2002), but where here there are potentially multiple matches. For our purposes, the total number of such matches represents a potentially endogenous variable in a contract choice equation.

[2] Further discussion of land-rental arrangements for U.S. farmland is provided by Allen and Lueck (1992, 1993).

[3] Formally, a landlord is materially engaged if he or she: "pays for at least half the direct cost of producing the crop; furnish at least half the tools, equipment, and livestock used in producing the crop; consults with the tenant; inspects the production activities periodically; regularly and frequently takes an important part in making management decisions substantially contributing to or affecting the success of the enterprise; works 100 hours or more spread over a period of five weeks or more in activities connected with crop production; or does things that, considered in their total effect, show that he or she is materially and significantly involved in the production of the farm commodities." (Hardin, 2004; Harrison, 2004).

[4] We need to refine the data set in order to use it for analyzing contract choice. In particular, non-random data selection problem may affect the estimation of the contract choice equation. Fukunaga and Huffman (2006) find that, however, the selection problem does not affect

qualitative estimation result of the contract choice equation in the data set. See Fukunaga and Huffman (2006), pages 6-8 for the detailed discussion on the data refinement.

[5] In table 2, the mean of the number of landlords that the tenant contracts with is 13.27, which is much bigger than 4.94, which is the number of landlords per tenant in the population of tenants. Note that our interest is the population of contracts, not the tenants. In the data set that we use for the following empirical analyses, tenants who have more landlords appear more often and thus the number of landlords is inflated. Provided that all the landlords reported by the tenants had responded to the questionnaire, the following relationship holds: $13.27 = \sum N_i^2 / \sum N_i$.

[6] The county-level yield variability is constructed as follows. Using the USDA's county-level annual yield data from 1990 to 1999, we create a county average weighted and standardized yield variability index. The county data contain the yields for corn, soybeans, hay, beans, and so forth. First, we calculate the standard deviations of yields for each crop in each county. Second, because different units of quantity are used for different crops in the data set, we divide the standard deviations by the respective mean values in order to make our yield variability index unit-free. Then, using the ten-year average share of the number of harvested acres for each crop in the ten-year average total harvested acres in the county as a weight, we sum up the standardized deviations and obtain a weighted and standardized yield variability index for each county.

[7] The erodibility index proxies the sensitivity of land to soil overuse. The county-level average erodibility index is calculated from the 1997 National Resources Inventory (NRI), using a weight variable included in the data set. Although the weight variable is designed to

provide an unbiased estimate for state-level erodibility index and thus our calculation does not provide an unbiased estimate for the county-level erodibility index, we believe that the index still provides us with an indicator of county-level erodibility index that is good enough for our analysis. For the detailed discussion on the weight, see United States Department of Agriculture (2001), pages 44-49.

[8] The chi-squared statistics is 88.23, which is great enough to reject the null hypothesis at the 1% significance level.

Table 1. The Percentage of Cropshare by Tenant Farm Type and the Number of Landlords, N = 44,870

Tenant Farm Type	Single Landlord	Multiple Landlords	Difference
Grain-Oilseed	0.36	0.31	0.05*
Tobacco-Cotton	0.34	0.2	0.14*
Vegetable-Friut	0.18	0.09	0.09*
Beef	0.12	0.14	-0.02
Dairy	0.08	0.03	0.05*
Other Livestock	0.12	0.13	-0.01

Note: An asterisk indicates the difference is significant at the 1% level.

Table 2. Symbols, Definitions of Variables and Summary Statistics

Variables	Definitions	Mean	S.D.	Min	Max
Dependent variables					
cropshare	=1 if contract is cropshare, =0 if contract is cash rent	0.20	0.40	0	1
regime	=1 if tenant has more than one landlord, =0 otherwise	0.92	0.27	0	1
Independent variables					
Regions					
NER	=1 if location of tenant's farm is Northwest region	0.12	0.33	0	1
MWR	=1 if location of tenant's farm is Midwest region	0.37	0.48	0	1
SR	=1 if location of tenant's farm is South region	0.35	0.48	0	1
WR	=1 if location of tenant's farm is West region	0.16	0.36	0	1
Tenant's farm type					
crop_type	=1 if tenant farm type is grain, oilseed, tobacco, or cotton	0.52	0.50	0	1
Other tenant's attributes					
t_age	age of tenant	51.63	12.11	18	96
t_total_asset	value of farm and nonfarm assets in tenant's household ($100,000)	23.80	67.42	0.00	5528.50
t_n_landlords	number of landlords whom tenant contract with	13.27	19.78	1	171
t_machinery	value of farm machinery owned by tenant ($100,000)	3.43	5.20	0.00	150.00
Landlord's attributes					
l_age	age of landlord	65.09	14.47	2	100
l_liv_on_farm	=1 if landlord lives on contracted land	0.13	0.34	0	1
l_total_value	market value of all lands and buildings owned by landlord ($100,000)	5.52	34.63	-11.93	4818.55
l_peer_effect	share of acres contracted by tenant with other landlords (%)	72.00	32.24	0.00	99.99
Other factors					
variability	standardized and weighted production variability for county of tenant's residence	0.26	0.10	0.00	1.29
erodibility	erodibility index for county of tenant's residence	2.68	2.72	0.00	29.14

Table 3. Maximum Likelihood Estimation of Probit Model of Contract Choice (Probability that Cropshare Is Chosen), N = 44,870

	Without *l_peer_effect*	With *l_peer_effect*
Intercept	-3.0643***	-2.8730***
t_n_landlords	-0.0084***	-0.0061***
l_peer_effect	-	-0.0024***
NER	-1.4763***	-1.4620***
MWR	-0.5420***	-0.5308***
SR	-0.4956***	-0.4835***
crop_type	0.6393***	0.6576***
t_age	-0.0015**	-0.0017**
t_total_asset	-0.0032***	-0.0031***
l_age	0.0044***	0.0041***
l_total_value	-0.0004	-0.0007**
l_liv_on_farm	-0.0180	-0.0236
variability	0.6080***	0.6114***
erodibility	0.0817***	0.0816***

Note: Three asterisks indicate the estimate is significant at the 1% level. Two asterisks indicate the estimate is significant at the 5% level. One asterisk indicates the estimate is significant at the 10% level.

Table 4. Two-Stage Least Squares Estimates of a Model of Contract Choice and the Number of Landlords per Tenant (Only Contract Choice Equations are Reported), N = 44,870

	Without *l_peer_effect*		With *l_peer_effect*	
	OLS	2SLS	OLS	2SLS
Intercept	0.1000***	0.0962***	0.1481***	0.1558***
t_n_landlords	-0.0015***	-	-0.0011***	-
t_n_landlords_predicted	-	-0.0011***	-	-0.0005***
NER	-0.2518***	-0.2557***	-0.2450***	-0.2485***
MWR	-0.1570***	-0.1576***	-0.1525***	-0.1521***
SR	-0.1422***	-0.1438***	-0.1370***	-0.1378***
crop_type	0.1663***	0.1640***	0.1718***	0.1702***
t_age	-0.0004**	-0.0004**	-0.0004**	-0.0004**
t_total_asset	-0.0002***	-0.0002***	-0.0002***	-0.0002***
l_age	0.0011***	0.0012***	0.0011***	0.0011***
l_total_value	-0.0001*	-0.0001*	-0.0001**	-0.0001*
l_liv_on_farm	-0.0084	-0.0089*	-0.0101*	-0.0113**
l_peer_effect	-	-	-0.0007***	-0.0009***
variability	0.1956***	0.1989***	0.1930***	0.1967***
erodibility	0.0273***	0.0275***	0.0269***	0.0272***

Note: *t_machinery* is excluded from the contract choice equations to identify the equations. Linear probability model is used for the contract choice equations. The result of the ordinary least squares estimate of the number of landlords is reported in Appendix.

Table 5. MLE of Bivariate Probit Model of Contract and Regime Choices (Only Contract Choice Equations are Reported), N = 44,870

	Cropshare Chosen (Without *l_peer_effect*)		Cropshare Chosen (With *l_peer_effect*)	
	Bilateral Contracting	**Multilateral Contracting**	**Bilateral Contracting**	**Multilateral Contracting**
	-Log Likelihood=30361		-Log Likelihood=30256	
Intercept	-1.7578***	-0.9600***	-1.7586***	-0.6523***
t_n_landlords	-	-0.0079***	-	-0.0046***
NER	-0.8506***	-1.5814***	-0.8492***	-1.5387***
MWR	-0.2498***	-0.6366***	-0.2523***	-0.6210***
SR	-0.1595	-0.6117***	-0.1633**	-0.5870***
crop_type	0.4264***	0.5299***	0.4021***	0.5415***
t_age	0.0023	-0.0015**	0.0021	-0.0016**
t_total_asset	-0.0068***	-0.0075***	-0.0070***	-0.0071***
l_age	0.0013	0.0046***	0.0012	0.0042***
l_liv_on_farm	0.0164	0.0104	0.0167	0.0004
l_total_value	0.0002	-0.0002	0.0002	-0.0009*
l_peer_effect	-	-	-	-0.0044***
variability	-0.3025	0.9113***	-0.3023	0.9240***
erodibility	0.0637***	0.0806***	0.0630***	0.0798***
Correlation in Disturbance	-0.4546***		-0.4841***	

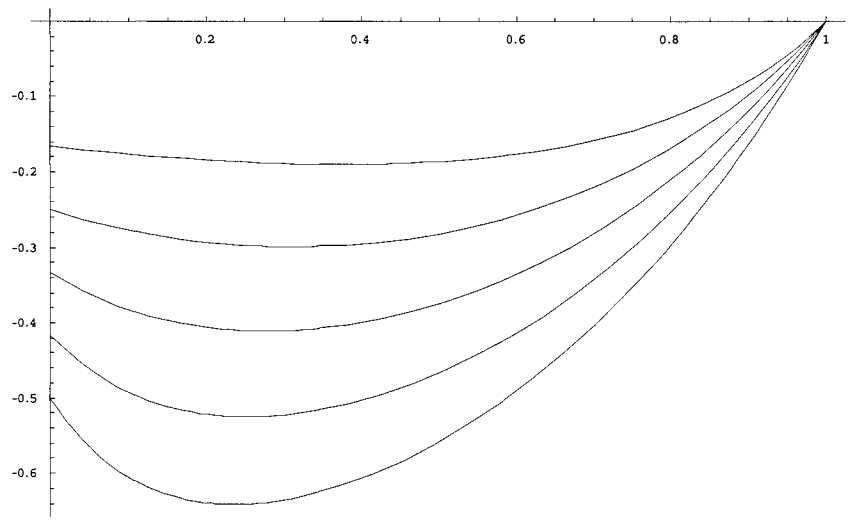

Figure 1. $W_3^C - W_3$ **as a function of** s **for** $n = 2,3,4,5,6$ $((\sigma_j^2, k, r) = (0.5,1,1))$

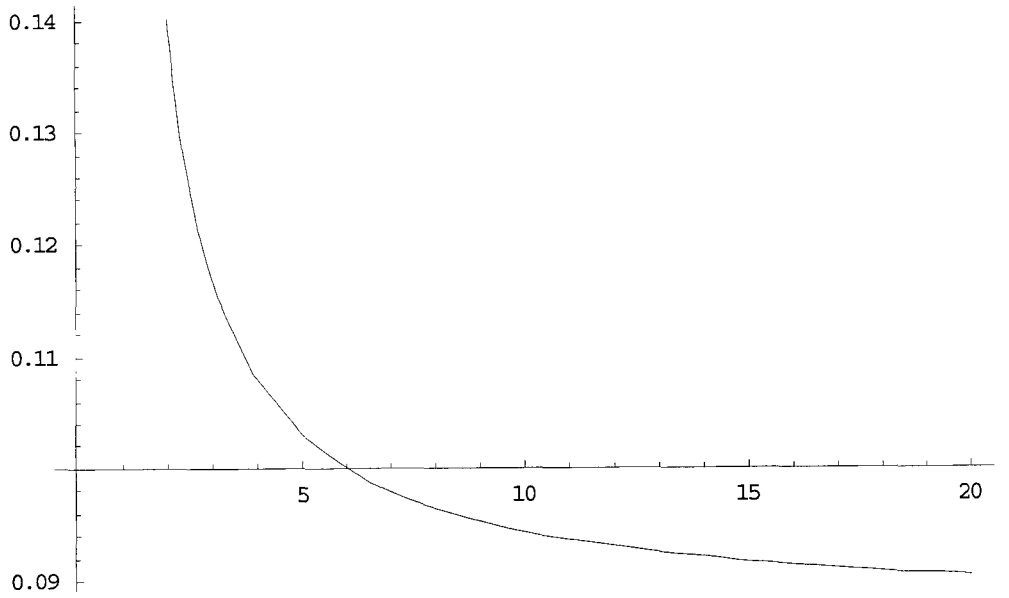

Figure 2. $W_3 - W_3^C$ **as a function of** n**:** $((\sigma_j^2, k, r, s) = (1,1,1,0.9))$

Appendix. Ordinary Least Squares Estimate of Equation Explaining the Number of Landlords per Tenant, N = 44,870

	Without *l_peer_effect*	With *l_peer_effect*
Intercept	5.6168***	-5.0466***
NER	10.2533***	7.9108***
MWR	1.6066***	0.4913**
SR	4.5782***	3.0524***
crop_type	5.2647***	3.6531***
t_age	0.0457***	0.0500***
t_total_asset	0.0138***	0.0146***
t_machinery	1.6580***	1.4333***
l_age	-0.0563***	-0.0344***
l_total_value	-0.0095***	<0.0001
l_liv_on_farm	1.2673***	1.5377***
l_peer_effect	-	0.1548***
variability	-7.5886***	-6.4235***
erodibility	-0.5152***	-0.4056***

CHAPTER 4. DOUBLE-SIDED MORAL HAZARD AND CONTRACT DESIGN: EVIDENCE FROM FARMLAND LEASE CONTRACTS IN U.S. AGRICULTURE

A paper to be submitted to a journal in the field

Keita Fukunaga

Abstract

I develop a simple model of the double-sided moral hazard that explains the relationship between contract and landlord participation decisions in farmland leasing contracts. Based on the predictions from the model, I empirically evaluate the double-sided moral hazard hypothesis, using the 1999 Agricultural Economics and Land Ownership Survey. I find some supporting empirical evidence for the hypothesis, while I find there are other factors, in addition to the costs and benefits of landlord participation, that affect the two decisions. Most importantly, there is evidence that contract choice and landlord participation are correlated decisions, which implies that contract design is not just a matter of designing a monetary compensation scheme.

Introduction

Empirical literature on contract design has mainly focused on monetary compensation schemes. In practice, however, contracts are comprised of various terms, including a monetary compensation scheme, allocation of decision rights, restrictions on agent actions, and termination terms. In recent years, a growing empirical literature focuses on the interactive roles of these contractual terms. Many studies find that contractual terms are indeed used interactively to modify incentives faced by agents. In this article, I study farmland lease contracts in U.S. agriculture from the perspective of the double-sided moral hazard hypothesis developed by Eswaran and Kotwal (1985) and Bhattacharyya and

Lafontaine (1995), and provide new evidence for the interaction between the monetary compensation scheme and the principal's participation in management decisions. In modern U.S. agriculture, landlords participate in management decisions more often when they use cropshare contracts than when they use cash rent contracts (Brown and Atkinson, 1981; also see table 1). Why is this so? Brown and Atkinson (1981), who first report the link between landlord participation in decision making and the choice of farmland lease contract type, argue that this is because tenants who have less entrepreneurial ability are more likely to use cropshare than those who have more entrepreneurial ability. Landlords are, thus, more likely to complement entrepreneurial inputs through participating in decision making under cropshare. A landlord whom I asked the same question provided a different perspective, however. He said that there is no reason for the landlord to participate in decision making under a cash rent contract, because the payment to the landlord does not change anyway. More precisely, the landlord has no incentive to participate in production decisions under a cash rent contract, because such an effort is not rewarded, at least in the short term, in which the payments to the landlord do not generally depend on the realized outcome. If this is true, the decisions on landlord participation and contract type should be endogenous. Specifically, focusing on the possible double-sided moral hazard problem as stated above, one would argue that if both the landlord and tenant participate in production, then cropshare would be optimal (Bhattacharyya and Lafontaine, 1995), and that if the landlord does not participate in production and the tenant makes decisions solely, then cash rent would be optimal.

In this article, I test this hypothesis using a data set of farmland lease contracts in U.S. agriculture, which consists of 44,515 contracts covering 12,212 tenants, and find some evidence for the double-sided moral hazard hypothesis. In doing so, I adopt a simple model

of double-sided moral hazard, in which landlord participation and contract choice are endogenized decisions, and fit an empirical version of the model. In this way, I clarify the motivation for the empirical evaluation of the interaction between landlord participation and contract decisions.

The rest of this paper proceeds as follows. The next section presents a review of related literature. Then, I briefly discuss the relationship between landlord participation in production and contract choice. Following that, I develop a simple model that explains the relationship between landlord participation and contract choice, and state testable predictions derived from the model. Then, I carry out an empirical examination of the predictions and present evidence on factors that affect landlord decisions and contract choices. In the last section, I provide discussions of the results and suggestions for future research.

Related Literature

There are a number of empirical studies on contract design in franchising. Most of this literature discusses how moral hazard, risk, and capital constraint, among other factors, affect the propensity of franchising in various industries. The main interest of the literature has been in determinants of the monetary compensation scheme. According to Lafontaine and Slade (2001), who provide a comprehensive survey of the empirical literature on contract design in franchising, the main interests include the role of the trade-off between risk sharing and incentives in contracting (Lafontaine, 1992), the relationship between the importance of the agent effort and the contract type (Norton, 1988; Lafontaine, 1992; Shepard, 1993; Slade, 1996), and the relationship between monitoring cost and contract type (Lafontaine, 1992; Scott, 1995). Lafontaine (1992) finds that the propensity of franchising increases as the importance of the franchisee's effort increases, while the propensity of owner-operation

increases as the importance of franchisor effort increases. Based on empirical results that are consistent with the prediction from the principal-agent model of double-sided moral hazard, Lafontaine (1992) argues that the double-sided moral hazard hypothesis explains the empirical findings better than the pure risk sharing and the capital constraint hypotheses.

Although the monetary compensation scheme has been the main focus of the literature, contracts in practice have very complicated aspects, with both formally specified terms and unspecified but informally agreed upon terms between the principal and agent. These formal contract terms and informal agreements are possibly interactively used to control incentives optimally. Some of the recent literature has begun to investigate various incentive devices involved in contract design other than the monetary compensation scheme and interactions among the devices. Kaplan and Stromberg (2003), using data from venture capital contracts, study the allocation of decision rights. They find that higher incentives are provided to the agent under the monetary compensation scheme when greater control is given to the principal. Thus, they conclude that the high-powered monetary compensation scheme and principal control are complementary. Using the data from automobile sales contracts, Arrunada, Garicano, and Vazquez (2001) find that the monetary compensation scheme and the allocation of decision rights in various areas are correlated. Specifically, they find that more monitoring intensity covaries with stronger incentives, which they argue is consistent with what the agency theory predicts. Brickley (1999), using the data from franchising, finds that restrictions on passive ownership, area development plans, and mandatory advertising expenditures specified in franchising contracts are most likely when there are significant externalities among the units within the franchising system, and that the contract terms are complements.

Unlike the allocation of decision rights and restrictions on the agent's activities in franchising contracts, landlord participation in agricultural production is not, in general, formalized in farmland lease contracts. Similarly, eviction terms are not formally specified in many farmland lease contracts, but evidence exists that they affect contract choices in West Bengal, India (Benerjee, Gertler, and Ghatak, 2002). Moreover, Ackerberg and Botticini (2002) find that pre-contract matching between the landlord and tenant is correlated with the choice of the monetary compensation scheme in Renaissance Tuscany, Italy[1]. Using a simple agency model with principal-agent matching, Serfes (2005) shows that such a matching mechanism between principals and agents can work as a sort of risk allocation mechanism and, as a result, affects monetary compensation schemes in contracts between principals and agents. These studies indicate that focusing solely on the monetary compensation mechanism in contracts may be misleading, and that it is important to analyze it together with other aspects of contract design.

There have been several studies focusing on the role of the principal's participation in decision making in farmland lease contract choices from a different, but related, perspective. Rao (1971) argues that cropshare is a tenant's first step up an agricultural ladder, and that as the tenant acquires entrepreneurial abilities, he then becomes a cash rent tenant, and finally, becomes an owner-operator. Hallagan (1978) argues that tenants with greater entrepreneurial ability are more likely to choose cash rent, while tenants with less entrepreneurial ability are more likely to choose cropshare. Thus, Hallagan (1978) suggests that contract choice can be used as a selection mechanism when tenants are endowed with different abilities. Using data on 314 farmers in the United States, Brown and Atkinson (1981) observe the unconditional correlation between the number of decisions made by the

tenant and the contract type, and find that more decisions are made by the tenant under cash rent than under cropshare. Based on this result, Brown and Atkinson (1981) agree that managerial ability plays an important role in determining contract type, as Rao (1971) and Hallagan (1978) argue. However, Brown and Atkinson (1981) simply observe the correlation between the number of decisions that the tenant makes and the contract type, and thus, the true conditional relationship between the number of decisions and the contract type is not revealed. Furthermore, they do not provide evidence on the determinants of tenant decisions and contract choice.

Formalizing the idea of Rao (1971), Eswaran and Kotwal (1985) consider a model in which agricultural production requires managerial and labor inputs, and the landlord and tenant can jointly provide these inputs. The authors assume that a cash rent contract is chosen when the tenant provides both managerial and labor inputs, a wage contract is chosen when the landlord provides both inputs, and a cropshare contract is chosen when the landlord provides managerial inputs and the tenant provides labor inputs. Considering the three cases, Eswaran and Kotwal (1985) find that a cropshare contract is likely to be chosen when the landlord's endowment of managerial ability is relatively large compared to the tenant's endowment, but a cash rent contract becomes more likely as the difference becomes smaller. A limitation of the Eswaran and Kotwal model is that the link between the contract type and who provides what inputs is fixed by assumption, and thus, their model does not explain why a cropshare contract emerges when the landlord provides managerial inputs and the tenant provides labor inputs. Partially filling this void, Bhattacharyya and Lafontaine (1995) show that, when the production function requires inputs from both the principal and agent, a cropshare contract is the optimal choice, even if both the principal and agent are risk neutral.

The assumption that the production function requires inputs from both the principal and agent is reasonable in Bhattacharyya and Lafontaine (1995), because their interest is in franchising in the non-agricultural sector, where inputs from both the principal and the agent are crucial in many cases: the principals are often responsible for advertising and brand image strategy, while the agents are responsible for daily store management. In farmland tenancy, however, this assumption may be unreasonable, since either the landlord or tenant can be fully responsible for all of the tasks such as crop choice, timing of seeding and harvesting, fertilizer choice, etc. In fact, tenants are fully responsible for production under cash rent in many cases, as table 1 shows. In order for us to fully discuss the relationship between contract choice and landlord participation in farmland tenancy, it is necessary to extend the Bhattacharyya and Lafontaine model (1995) in a way that makes landlord participation endogenous, where the landlord not only chooses contract type, but also decides whether he/she provides inputs (most likely, managerial input).

Contract Choice and Landlord Participation in Modern U.S. Agriculture

In modern U.S. agriculture, two major reasons seem to exist for landlords wanting to participate in decision making, even though landlord participation may not be as crucial as in franchising. One of the reasons is maximizing current production, as in Eswaran and Kotwal (1985) and Bhattacharyya and Lafontaine (1995). The landlord may have better information on the contracted land and local natural conditions than the tenant, and thus, the landlord may be able to improve current production by participating in managerial decisions. The other reason is for maintaining land quality. From the perspective of the transaction cost hypothesis, maintaining land quality is an important issue for landlords when they delegate farming to the tenants (Allen and Lueck, 1992, 1993, 1999; Dubois, 2002). Dubois (2002),

formalizing this argument in a dynamic principal-agent model, shows that a cropshare contract is optimal in the case where the landlord cannot monitor the tenant's actions. In reality, however, the landlord may be able to influence tenant action by some amount of monitoring and/or participating in decision making, and such landlord action may affect contract choice. Specifically, if the risk of land degradation is substantial, then the landlord would be more likely to participate in production decisions so as to avoid land overuse.

There have been substantial discussions over time on the reasons that cropshare contracts have prevailed in agriculture in various locations and stages of development. Among the major hypotheses, risk sharing between the landlord and tenant (Stiglitz, 1974), transaction costs (Allen and Lueck, 1992, 1993, 1999; Dubois, 2002), and double-sided moral hazard (Eswaran and Kotwal, 1985; Bhattacharyya and Lafontaine, 1995, on royalty contracts in franchising) are well-known. However, there have been few empirical studies that shed light on the relationship between landlord participation in management and contract choice. To my knowledge, Brown and Atkinson (1981) is an only exception that discusses the link between landlord participation and contract choice. Provided that the landlord can affect tenant actions not only by choosing contract type but also by participating in management, focusing only on contract choice could generate misleading results in the empirical analysis of contract choice.

Model

In order to evaluate the link between landlord participation and contract choice, I consider a simple model of double-sided moral hazard in which the landlord not only chooses the contract type, but decides whether or not he/she will participate in production. In the model, I follow the same spirit as in Eswaran and Kotwal (1985) and Bhattacharyya and Lafontaine

(1995), arguing that the current production function has two arguments: landlord input and tenant input. Using the model, I state the condition under which the landlord decides to participate in management, and show that a cropshare contract is chosen when the landlord participates in management, while a cash rent contract is chosen when the landlord does not participate in management. Although I do not explicitly deal with maintenance of land quality in the model, I present some evidence of the role of this matter in the landlord participation decision in the empirical analysis.

In the following, I develop a modified version of the Bhattacharyya and Lafontaine model (1995). The production function f has two arguments, the landlord's effort, L, and the tenant's effort, l. Namely, production y is given by $y = f(L,l) + \varepsilon$, where ε represents an unobservable disturbance factor in production. The usual properties of the production function (that is, increasing in both inputs, and concavity) are assumed. The landlord cannot observe the tenant's effort, and the tenant cannot observe the landlord's effort. The landlord and the tenant are both assumed to be risk neutral, and their private cost functions are given by $V(L)$ and $U(l)$, respectively. V and U are both increasing in their arguments and convex. We restrict our interest to a linear contract, $\alpha y + \beta$, where α stands for the share of output for the tenant, and β stands for the fixed payment for the tenant. The reservation utility for the tenant is given by k. Under these settings, the landlord decides whether or not to participate in production, and also determines the contract terms. When she decides to participate in production, the landlord's effort L is greater than zero; it is zero when she decides not to participate in production. It is also assumed that landlord input is not necessary in the sense that $f(0,l) > 0$ for positive l, but that tenant input is necessary in the

sense that $f(L,0)=0$ for positive L. This assumption assures tenant participation in equilibrium.

The timing of the game is as follows. In the first stage, the landlord decides whether or not he/she participates in production and on contract type, simultaneously. Then, the landlord makes a take-it-or-leave-it offer to the tenant. In the second stage, the tenant receives the offer, and decides whether or not to take the offer. If the tenant decides to take the offer, he/she determines the effort level. In the third stage, the landlord (if he/she decides to participate) and tenant exert effort, and they observe the output.

The landlord's problem is to maximize her expected utility subject to the landlord's incentive constraint, the tenant's incentive constraint, and the tenant's participation constraint:

$$\max_{L,l,\alpha,\beta}\{(1-\alpha)f(L,l)-\beta-V(L)\}$$

s.t.

The landlord's incentive constraint:

$$\begin{cases} L\geq 0 \\ (1-\alpha)f_L - V' \leq 0 \\ L\left((1-\alpha)f_L - V'\right)=0 \end{cases};$$

The tenant's incentive constraint: $\alpha f_l(L,l)-U'(l)=0$; and

The tenant's participation constraint: $\alpha f(L,l)+\beta-U(l)\geq k$

We assume that the first order approach is valid in this problem. First, we start by investigating the conditions under which the landlord optimally chooses not to participate in production, focusing on the cost and productivity of the landlord's effort.

Proposition 1. *When the marginal cost of effort for the landlord is great enough compared to the marginal production of effort around* $L=0$, *the landlord optimally chooses not to participate in production.*

Proof. Suppose $(1-\alpha)f_L - V' < 0$ in the neighborhood of $L = 0$ and for any $\alpha \in [0,1]$. Then, from the third condition in the landlord's incentive constraint, L must be equal to zero. That the second condition in the landlord's incentive constraint holds with strict inequality implies that the marginal cost of effort for the landlord is greater than the marginal production of effort. *Q.E.D.*

Proposition 1 has intuitive implications. For example, if the landlord lives far from the rented land, and thus, the marginal cost of making efforts in production is very high, the landlord chooses not to participate in production. For another example, if the landlord has only a little experience in farming and the benefit of taking part in production is very low, then the landlord chooses not to participate in production. Now we investigate the optimal contract type when the landlord chooses not to participate in production.

Proposition 2. *When the landlord does not participate in production ($L^* = 0$), then a cash rent contract ($\alpha^* = 1$) is optimal.*

Proof. The landlord problem stated above becomes the following problem, given that the landlord does not participate:

$$\max_{\alpha,\beta} \left\{(1-\alpha)f(L^*,l^*) - \beta - V(L^*)\right\}$$

s.t.

The landlord's incentive constraint:

$$\begin{cases} L^* = 0 \\ \left[(1-\alpha)f_L - V'\right]_{L=L^*} < 0 \end{cases};$$

The tenant's incentive constraint: $l^* = \arg\max_l \left\{\alpha f(L^*,l) + \beta - U(l)\right\}$; and

The tenant's participation constraint: $\max_l \left\{\alpha f(L^*,l) + \beta - U(l)\right\} \geq k$

Because of β, the participation constraint holds with equality. For now, suppose that the second condition in the landlord's incentive constraint holds. Then the above problem becomes

$$\max_{\alpha} \left\{ f(L^*, l^*) - V(L^*) - U(l^*) - k \right\}$$

s.t.

The landlord's incentive constraint: $L^* = 0$; and

The tenant's incentive constraint: $\alpha f_l(L^*, l^*) - U' = 0$

The Lagrangian for this problem is

$$\ell = f(0, l^*) - V(0) - U(l^*) - k + \lambda(\alpha f_l(0, l^*) - U') \tag{1}$$

where λ is the Lagrangian multiplier for the tenant's incentive constraint. The first order condition is

$$\left[\left\{ f_l - U' + \lambda(\alpha f_{ll} - U'') \right\} \frac{\partial l^*}{\partial \alpha} + \lambda f_l \right]_{\alpha=\alpha^*} = 0 \tag{2}$$

From the tenant's incentive constraint, we have

$$\left[f_l + (\alpha f_{ll} - U'') \frac{\partial l^*}{\partial \alpha} \right]_{\alpha=\alpha^*} = 0 \tag{3}$$

Plugging this into the first order condition, and noting that $f_l - U' = (1-\alpha) f_l$ from the tenant's incentive constraint, we have

$$(1-\alpha^*) f_l \frac{\partial l^*}{\partial \alpha} |_{\alpha=\alpha^*} = 0 \tag{4}$$

Since $f_l \frac{\partial l^*}{\partial \alpha} \neq 0$ in general, α^* needs to be unity for the above condition to be satisfied. Note that the second condition in the landlord's incentive constraint indeed holds when $\alpha^* = 1$. *Q.E.D.*

When the marginal cost of landlord effort is so high that the landlord optimally chooses not to participate in production, then the landlord problem turns out to be the standard principal-agent problem in which the agent (tenant) is risk neutral. Because the tenant is risk neutral, a cash rent contract is optimal and there is no incentive cost in order for the landlord to elicit the first best effort from the tenant.

Finally, proposition 3 states that, when the landlord chooses to participate in production, then a cropshare contract is optimal. This result is obtained by Bhattacharyya and Lafontaine (1995).

Proposition 3 (Corollary 1 in Bhattacharyya and Lafontaine (1995)). *When the landlord participates in production ($L^* > 0$), then the optimal linear contract is a cropshare contract ($0 < \alpha^* < 1$) with fixed payment.*

Proof. See the proof of Corollary 1 in Bhattacharyya and Lafontaine (1995).

As the above model shows, the landlord optimally decides whether or not she participates in production, and jointly determines the type of contract in accordance with the participation decision. The model shows that when the landlord decides not to participate in production, then a cash rent contract is chosen; when the landlord decides to participate in production, then a cropshare contract is chosen. In the following section, I evaluate the model empirically, and suggest which factors actually affect contract choice and landlord participation. Summarizing the results above, I obtain the following testable predictions.

Prediction 1. *When the landlord's marginal cost of participation is great enough, or when the landlord's marginal production of participation is small enough, then the landlord does not participate in production.*

Prediction 2. *When the landlord does not participate in production, then a cash rent contract is chosen.*

Prediction 3 (Bhattacharyya and Lafontaine (1995)). *When the landlord participates in production, then a cropshare contract is chosen.*

Empirical Analysis

Data set

I use the 1999 Agricultural Economics and Land Ownership Survey (AELOS) for the empirical analysis of the predictions above. AELOS is a comprehensive data set consisting of tenants' demographic information, economic attributes and household characteristics, and landlords' demographic information and economic attributes. The survey questionnaires were first sent to producers/tenants all over the United States. They were asked to answer a set of questions and to provide the addresses and names of their landlords. Then questionnaires were sent to those listed landlords. This procedure has made it possible for us to identify a tenant and a landlord for every contract in the data set. In the United States, a tenant usually has more than one landlord. Reflecting this fact, the information for a tenant may appear more than once in our data set, but in combination with the information for different landlords. In other words, in our data set, the sample unit of the data is not an individual tenant or landlord, but a contract between a tenant and a landlord. After deleting unusable observations, we have a total of 44,515 observations (contracts) in our data set. A more detailed description of the data set is provided by Fukunaga and Huffman (2006).

Empirical method

Using table 1, I start with reevaluating the likelihood of landlord participation in management decisions under cash renting and sharecropping. According to prediction 2 and prediction 3,

if the landlord provides input, then the contract should always be cropshare; if the landlord does not provide input, then the contract should always be cash rent. Table 1 shows that landlords more often participate in management decisions under sharecropping than under cash renting. If I interpret the landlord participation in management decisions as the landlord provision of input, the fact that landlords more often participate in management decisions under sharecropping than under cash renting seems consistent with the predictions of the model above. However, the facts are that about 13% of landlords who use cash rent contracts participate in management decisions and that about 74% of landlords who use cropshare do not participate in management decisions, which are not consistent with the prediction that the contract should be always cropshare when the landlord provides input. The result indicates that there may be factors other than those explained in the above model that affect contract and landlord participation decisions. In the following analysis, I investigate the causal factors that affect contract and landlord participation decisions, using regression analysis.

According to the three predictions above, greater marginal cost of effort and smaller marginal product of effort reduce the likelihood of cropshare, while greater marginal cost of effort and smaller marginal product of effort reduce the likelihood of landlord participation. Analytically, the landlord's decision rule that is directly derived from the model above is represented as follows.

$$(5) \qquad \begin{cases} cropshare = 0, \text{ if } \left[f_L - V'\right]_{L=0} \le 0 \\ cropshare = 1, \text{ if } \left[f_L - V'\right]_{L=0} > 0 \\ L^* = 0, \text{ if } \left[f_L - V'\right]_{L=0} \le 0 \\ L^* > 0, \text{ if } \left[f_L - V'\right]_{L=0} > 0 \end{cases}, \text{ where } \begin{cases} cropshare = 1, \text{ if cropshare} \\ cropshare = 0, \text{ if cash rent} \end{cases}$$

Econometricians do not observe the term $\left[f_L - V'\right]_{L=0}$. Therefore, I need to find a proxy variable for this term. As proxies for marginal cost and benefit of landlord participation, I use dummy variables indicating whether or not the landlord lives on the contracted land, whether or not the landlord lives close to the land, whether or not the landlord operated a farm or a ranch in 1999, and the landlord's age, in addition to other landlord and tenant demographic attributes. Landlords who live on the contracted land or live close to the land would have a lower marginal cost of effort, because they can easily access information useful for decision making, such as soil conditions, weather, and tenant actions, at lower cost. Therefore, they should be more likely to participate in management decisions, and use cropshare. I use a dummy variable that indicates whether or not the landlord operated a farm or a ranch as a proxy for either marginal cost or marginal product of landlord effort. Landlords who have farming experience would be less hesitant to participate in management decisions because they would be more confident about their decisions, which would decrease the marginal cost of landlord effort. Or landlords who have farming experience could make timely and useful management decisions, which would increase the marginal product of landlord effort. Either way, landlords who have farming experience will be more likely to participate in management decisions, increasing the likelihood of cropsharing. The landlord's age is a proxy for the landlord's entrepreneurial skills, although it may be positively correlated with the cost of landlord participation. Although greater landlord's entrepreneurial skills should increase the likelihoods of cropshare and landlord participation, greater cost of landlord participation should decrease the likelihoods. Therefore, the predicted sign of this variable can be either positive or negative. Table 2 summarizes the definitions and descriptive statistics of the variables used in the analysis.

Because L^* is not observable either, I also need a proxy for it. I use dummy variables that indicate who makes managerial decisions: the landlord (or a professional farm manager hired by the landlord), the tenant, or both. The category of managerial decisions includes the selection of crop varieties or livestock breeds, the selection of fertilizer and chemicals, harvesting decisions, and cultivation practices. I assume that landlords can participate in production only through participating in decision making[2]. This assumption implies that, if the landlord participates in managerial decisions, L^* is greater than zero. Analytically, the assumption can be written as follows:

$$(6) \quad \begin{cases} decision = 1, \text{ if } L^* > 0 \\ decision = 0, \text{ if } L^* = 0 \end{cases}, \text{ where } \begin{cases} decision = 1, \text{ if landlord participates in decision} \\ decision = 0, \text{ otherwise} \end{cases}$$

I try two different proxies for the landlord participation variable. Since my major interest is in whether the landlord's input, L^*, is greater than zero or equal to zero, I first use a dummy variable that is equal to one when the landlord either solely or jointly makes decisions, and zero when the landlord makes no decisions, solely or jointly. Secondly, I define a dummy variable for each management category that is equal to one when the landlord either solely or jointly makes the specific decision, and zero when the landlord does not make the decision. Because the decisions are highly correlated with each other, as table 3 shows, the first specification may be reasonable.

As pointed out above, factors other than marginal cost and benefit of the landlord input may affect contract and landlord participation decisions. Risk and transaction costs are examples of possible factors that may affect contract and landlord participation choices. In the empirical analysis, I also attempt to capture the effects of the factors that are not explicitly dealt with in the model above. I denote the vector of factors that contains proxies

for the marginal cost and benefit of the landlord input as X, the vector of factors other than the marginal cost and benefit of landlord input that could affect contract choice as Z_1, and the vector of factors other than the marginal cost and benefit of landlord input that could affect contract choice as Z_2. Z_1 and Z_2 contain regional dummies, the tenant's age, the tenant's farm type dummies, the number of landlords with whom the tenant contracts, the tenant's total assets, the market value of land and buildings on the contracted land, the county-level yield variability index, the county-level average Beale code, and the county-level erodibility index. The tenant's age may be used as a proxy for the tenant's entrepreneurial skills. Because the tenant is likely to accumulate entrepreneurial skills as he/she gets older, the selection hypothesis (Hallagan, 1978) would predict that older tenants are more likely to use cash rental contracts. The hypothesis would predict that the sign of the estimated coefficient for the tenant's age in the contract choice equation is negative and that in the landlord participation equation it is negative. The tenant's total assets and the market value of land and buildings on the contracted land can be used as proxies for the tenant's and landlord's risk preferences, respectively; one who has greater assets is less risk averse. The county-level yield variability index is correlated with the risk involved in production. The risk sharing hypothesis predicts that cropshare is more likely as the tenant becomes more risk averse, the landlord becomes less risk averse, and/or the risk involved in the transaction becomes greater. Thus, the risk sharing hypothesis predicts that, in the contract choice equation, the coefficient estimate for the tenant's total assets is negative, the coefficient estimate for the landlord's total value is positive, and the coefficient estimate for the county-level yield variability is positive. The county-level average Beale code and the county-level erodibility index can be used as proxies for transaction costs. If the contract is in a county

with a greater average Beale code value, the contracted land as agricultural land tends to be more important. If the county-level erodibility index is high, maintenance of land quality becomes more important. These factors are likely to affect both contract choice and landlord participation. As mentioned earlier, Dubois (2002) argues that cropshare is more likely when the contracted land is subject to high risk of land overuse, given that the landlord cannot observe the tenant action at all. Thus, in a situation in which the landlord decides contract type only and cannot participate in production, both the county-level average Beale code and the county-level erodibility index should increase the likelihood of cropshare. However, without formalization it is difficult to derive testable predictions as to the effect of transaction costs when the landlord can participate in production. The formalization of the argument is left for future research, and I do not derive predictions as to the effect of transaction costs on landlord participation in this article.

Finally, although the term $\left[f_L - V'\right]_{L=0}$ is not a linear function in general, I use a linear approximation for the proxies for this term $\left[f_L - V'\right]_{L=0}$ because the variables in which I am most interested are dummy variables. I also assume that other factors enter the landlord's decision rule in a linear fashion. Then the regressions I actually estimate are represented as follows:

$$(7) \qquad \begin{cases} cropshare = 0, \text{ if } X\beta_1 + Z_1\gamma_1 - \varepsilon_1 \le 0 \\ cropshare = 1, \text{ if } X\beta_1 + Z_1\gamma_1 - \varepsilon_1 > 0 \\ decision = 0, \text{ if } X\beta_2 + Z_2\gamma_2 - \varepsilon_2 \le 0 \\ decision = 1, \text{ if } X\beta_2 + Z_2\gamma_2 - \varepsilon_2 > 0 \end{cases}$$

Because X, Z_1, and Z_2 may be correlated, I allow the coefficients for X in the contract choice and participation equations to differ. Furthermore, I assume $Z_1 = Z_2$, because I do not have a

priori reasons that the factors affecting contract choice differ from those affecting landlord participation. The disturbance terms ε_1 and ε_2 capture determinants of contract and participation decisions that are not observable for econometricians. I allow the disturbance terms ε_1 and ε_2 to be correlated, because the proxies imperfectly substitute for true variables in the regression, and the factors that affect both contract and participation choices may enter the disturbance terms. Other factors that can affect both contract and participation decisions include savings in self-employment taxes and receipt of full social security payments (Hardin, 2004; Harrison, 2004). If landlords "materially participate" in production, the income from the transaction is subject to self-employment tax[3]. Under cropshare, in which the income for the landlord depends on the realized outcome and the landlord materially participates in production, the income is subject to self-employment tax. Under cash rent, since the income does not depend on the realized outcome, the income is not subject to self-employment tax. This may motivate landlords to use cash rent and not to participate in production. In addition, prior to 2000, landlords aged 65 and older on social security were required to count material participation income or other earned income toward the maximum amount of income that they could earn before social security benefits were reduced. The income from cash rent is generally unearned income and thus was not counted toward the maximum amount of income that they could earn before social security benefits were reduced. This may have also motivated landlords to use cash rent and not to participate in production. On the other hand, landlords have to materially participate in farming for at least five years before death to be eligible for estate tax reduction. This may motivate landlords to cropshare and participate in production. All of these factors are captured in the disturbance terms. For all of these reasons, I use a bivariate discrete choice model. A bivariate probit model is appropriate if the

disturbance terms follow a standardized bivariate normal distribution. This seems like a reasonable assumption.

Results

Table 4 presents the regression results from fitting a bivariate probit of contract choice and landlord participation in any decision. In table 4, I find some evidence for the double-sided moral hazard hypothesis. If the landlord lives on the contracted land, she is more likely to participate in decisions, which is consistent with the model. In addition, if the landlord operated a farm or a ranch in 1999, then she is more likely to use a cropshare contract and participate in decisions, which provides more supporting evidence for the model. Landlord age, used as a proxy for the landlord's entrepreneurial skills, increases the likelihood of cropshare as it increases, while it decreases the likelihood of landlord participation. As I mentioned above, landlord age is likely to be positively correlated with both the landlord's marginal productivity and cost; this result does not contradict the double-sided moral hazard hypothesis. On the other hand, if the landlord lives on the contracted land or lives within 5 miles of the contracted land, then a cropshare contract is less likely, and the coefficient estimate in the landlord participation equation is insignificant. This contradicts the prediction of the double-sided moral hazard hypothesis.

Other results in table 4 suggest that factors other than double-sided moral hazard affect contract and landlord decision choices. The coefficient estimate for tenant age in the contract choice equation has a consistent sign, while in the landlord participation equation it is not significant. Tenant age, used as a proxy for the tenant's entrepreneurial skills, decreases the likelihood of cropshare, but it does not affect landlord participation significantly. This result does not provide strong support for the selection hypothesis. The

tenant's total assets, which can be used as a proxy for the tenant risk preference, and the county-level yield variability index significantly affect contract choice. Tenants who have greater total assets, and thus are less risk averse, are less likely to use cropshare. Greater yield variability increases the likelihood of cropshare. These results are consistent with the risk sharing hypothesis of contract choice. The county-level erodibility index, a proxy for the sensitivity of land for land overuse, significantly increases the likelihood of cropshare. This result is consistent with the pure transaction cost hypothesis of contract choice developed by Allen and Lueck (1992, 1993, 1999) and Dubois (2002). The county-level average Beale code, a proxy for the importance of land for agricultural usage, also affects contract choice: the more important for agricultural usage the land is, the more likely cropshare will be used. This result is also consistent with the pure transaction cost hypothesis.

Interestingly, these factors related to risk and transaction costs affect landlord participation, also. As the county-level erodibility index and the county-level average Beale code become greater, the landlord is more likely to participate in management decisions. This implies that landlords are more likely to be involved in management decisions when land overuse is an important issue. As the county-level yield variability increases, the landlord is less likely to participate in decisions. This result indicates that landlords are less likely to be involved in management decisions under more risky environments. Thus, risk, risk preference, and transaction costs affect both contract and landlord participation decisions.

Finally, the estimated correlation of the disturbance terms across the two equations is positive and significant. This implies that contract and landlord participation decisions are correlated in a way such that unobservable factors increase the likelihood of cropshare and landlord participation, even after some factors related to productivity and cost of landlord and

tenant effort, risk, risk preferences, and transaction costs are controlled. These results indicate that various factors affect contract and landlord participation choices jointly. The simple prediction based on the double-sided moral hazard hypothesis that landlord participation in decisions accompanies cropshare does not explain all of the empirical findings, although some evidence is found.

Conclusions

I develop a simple model of double-sided moral hazard that explains the relationship between contract and landlord participation decisions. Based on the predictions from the model, I empirically evaluate the double-sided moral hazard hypothesis, using the 1999 Agricultural Economics and Land Ownership Survey. I find some empirical evidence for the double-sided moral hazard hypothesis. Moreover, I find there are other factors, in addition to the costs and benefits of landlord participation, that affect contract choice and landlord participation. Most importantly, there is evidence that contract choice and landlord participation are correlated, and various factors (e.g., risk, transaction costs, and tax benefits) exist that affect the two decisions. This implies that contract design is not just a matter of designing a monetary compensation scheme, but involves landlord participation and interactively deals with the possibly complicated objectives.

There are several suggestions for future research. First, for evaluating the double-sided moral hazard hypothesis more closely, it will be useful to analyze the relationship between the share rate (or royalty rate, in franchising) and landlord participation as in Lafontaine (1992). It is not feasible in this article because I do not have data on the share rate. Second, in this article, testing the double-sided moral hazard hypothesis against the selection hypothesis is difficult. It is difficult to distinguish the hypotheses using the proxy

variables, because the predictions for the signs of the coefficient estimates for the landlord's productivity and the tenant's productivity based on the double-sided hypothesis coincide with those based on the selection hypothesis. It would be interesting to evaluate the selection hypothesis, perhaps by directly investigating whether or not such a selection actually occurs in practice. Third, tax benefits are likely to play an important role in contract and landlord participation decisions, and thus, more careful attention should be paid to assessing the effect. Due to lack of data on the tax benefits that landlords may receive, there have been no studies in the academic literature, to my knowledge, that address the role of tax benefits in contract and landlord participation decisions. Finally, it seems important to consider the role of risk and transaction costs in the joint decision of contract type and landlord participation, as the empirical results indicate. A dynamic model in which the landlord and tenant are both assumed to be risk averse and the landlord makes contract and participation decisions over time may be an appropriate way of formalizing the argument.

Endnotes

[1] Unlike the allocation of decision rights and principal participation, matching may not be intentionally used in contract design. However, it could still endogenously affect contract terms.

[2] This is a strong assumption, because landlords may participate in production through channels other than decision making, such as monitoring, investment in land, and putting restrictions on tenant activities. Investigation of the role of these factors in contract design is beyond the scope of this article, and remains to be done in future studies. Furthermore, endogenous matching between landlord and tenant attributes may affect contract and landlord participation decisions (Ackerberg and Boticcini, 2003; Serfes, 2005). Fukunaga and Huffman (2006), using AELOS, find that endogenous matching does not change the qualitative result in the contract choice equation in the data set. Since I use the same data set in this article, I do not model endogenous matching in the empirical analysis, based on the result of Fukunaga and Huffman (2006).

[3] A landlord is materially participating if he/she has an arrangement with the tenant for landlord participation and the landlord meets one of the four following tests (Hardin, 2004):

Test No. 1. The landlord does any three of the following: 1) advance, pay, or stand good for at least half the direct cost of producing the crop; 2) furnish at least half the tools, equipment, and livestock used in producing the crop; 3) consult with the tenant; and 4) inspect the production activities periodically.

Test No. 2. The landlord regularly and frequently makes, or takes an important part in making,

management decisions substantially contributing to or affecting the success of the enterprise.

Test No. 3. The landlord works 100 hours or more, spread over a period of five weeks or more, in activities connected with crop production.

Test No. 4. The landlord does things that, considered in their total effect, show that he/she is materially and significantly involved in the production of the farm commodities.

Table 1. The Likelihood of Landlord Participation in Farming Decisions by Contract Type: The 1999 AELOS Data, N = 44,515

	Any Decisions	Fertilizer	Crop Variety / Livestock Breed	Cultivation Practice	Harvesting
Cash Rent	12.8	10.2	10.0	10.4	9.0
Cropshare	25.9	20.6	20.7	18.2	16.9

Table 2. Symbols, Variable Definitions and Summary Statistics

	Definition	Mean	S.D.	Min	Max
cropshare	=1 if cropshare, =0 if cash rent	0.20	0.40	0	1
decision	=1 if landlord at least partly participates in any decision making	0.15	0.36	0	1
fertilizer	=1 if landlord participates in deciding type of fertilizer and other chemicals	0.12	0.33	0	1
seed	=1 if landlord participates in deciding variety/breed of crop/livestock	0.12	0.33	0	1
cultivation	=1 if landlord participates in deciding cultivation practice	0.12	0.32	0	1
harvest	=1 if landlord participates in deciding harvesting	0.11	0.31	0	1
NER	=1 if location of the tenant's farm is Northwest region	0.13	0.33	0	1
MWR	=1 if location of the tenant's farm is Midwest region	0.37	0.48	0	1
SR	=1 if location of the tenant's farm is South region	0.34	0.47	0	1
grain_oil	=1 if type of tenant's farm is grain and/or oilseed production	0.39	0.49	0	1
tobacco_cotton	=1 if type of tenant's farm is tobacco and/or cotton production	0.12	0.33	0	1
vegetable_fruit	=1 if type of tenant's farm is vegetable and/or fruit production	0.08	0.27	0	1
beef	=1 if type of tenant's farm is beef	0.10	0.30	0	1
dairy	=1 if type of tenant's farm is dairy	0.15	0.36	0	1
other_animal	=1 if type of tenant's farm is producing other types of animals	0.17	0.37	0	1
t_age	age of tenant	51.61	12.13	18	96
t_n_landlords	number of landlords tenant contracts with	13.36	19.78	1	171
t_total_asset	value of tenant's total assets ($100,000)	23.75	67.39	0.00	5528.50
l_age	age of landlord	65.05	14.47	2	100
l_liv_on_farm	=1 if landlord lives on contracted land	0.13	0.34	0	1
l_liv_close	=1 if *l_liv_on_farm* =0 and landlord resides within 5 miles of contracted land	0.42	0.49	0	1
l_ope_99	=1 if landlord operated farm or ranch in 1999	0.11	0.32	0	1
total_value	market value of land and buildings on contracted land ($100,000)	2.76	9.54	0.00	584.33
erodibility	erodibility index for county of tenant's residence	2.69	2.71	0.00	29.14
variability	standardized and weighted yield variability for county of tenant's residence	0.26	0.10	0.00	1.29
average_beale	average of Beale code in 1993 and 2003 for county of tenant's residence	4.74	2.48	0.50	9.00

Table 3. Correlations among Landlord's Participation in Tenant's Farm Production Decisions (participation is indicated by a 1 and nonparticipation by a 0): The 1999 AELOS Data, N = 44,515

	fertilizer	*seed*	*cultivation*	*harvest*
fertilizer	1.00	0.84	0.86	0.86
seed		1.00	0.84	0.85
cultivation			1.00	0.86
harvest				1.00

Table 4. MLE Bivariate Probit Estimates of Contract Choice (*cropshare* = 1) and Landlord Participation in Tenant's Production Decisions (*decision* = 1) , N = 44,515

	Cropshare Chosen	Landlord Paticipates
	-Loglikelihood = 37308.5	
Intercept	-0.9090***	-0.9101***
NER	-1.2578***	-0.1362***
MWR	-0.5351***	-0.0494**
SR	-0.3932***	-0.1581***
grain_oil	0.3635***	0.1776***
tobacco_cotton	0.0100	0.0759**
vegetable_fruit	-0.2364***	0.0495
beef	-0.1161***	0.1188***
dairy	-0.6953***	0.6953***
other_animal	-0.2695***	0.1120***
t_age	-0.0011*	0.0009
t_n_landlords	-0.0054***	-0.0024***
t_total_asset	-0.0061***	<0.0001
l_age	0.0041***	-0.0038***
l_liv_on_farm	-0.1022***	0.2464***
l_liv_close	-0.2107***	0.0262
l_ope_99	0.0662***	0.4233***
total_value	<0.0001	0.0023***
erodibility	0.0788***	0.0127***
variability	0.5384***	-0.4191***
average_beale	0.0289***	0.0104***
Correlation in Disturbance	0.2894***	

Note: Three asterisks indicate the coefficient estimate is significant at the 1% level. Two asterisks indicate the coefficient estimate is significant at the 5% level. One asterisk indicates the coefficient estimate is significant at the 10% level.

CHAPTER 5. GENERAL CONCLUSION

In this dissertation, I have studied farmland lease contracts in U.S. agriculture. Using the data from the 1999 Agricultural Economics and Land Ownership Survey, I investigated the empirical determinants of contract design from the perspective of the principal-agent framework, which emphasizes the role of incentives in contract design. In the empirical analyses, I found evidence that incentives indeed play an important role in contract design. In chapter 2, I investigated the role of risk, transaction costs, and endogenous matching between the landlord and tenant in contract choice. I found that both risk and transaction costs affect contract choice. Furthermore, I found evidence supporting endogenous matching between the landlord and tenant, and found that the matching is likely to affect contract choice. In chapter 3, I investigated whether contractual externalities exist in farmland lease practice in modern U.S. agriculture, and found some evidence that contractual externalities indeed exist and are likely to affect contract choice. I argued that landlords non-cooperatively act and choose contract type due to contractual externalities. This leads to inefficient competition between landlords contracting with a given tenant and greater likelihood of cash rental contracts. In chapter 4, I investigated the link between contract choice and landlord participation decision from the perspective of the double-sided moral hazard hypothesis. I found some evidence to support the hypothesis, and furthermore, I found that other factors, including risk and transaction costs, are likely to affect contract choice and landlord participation decision jointly.

While I believe that each of the chapters above makes unique contributions to the literature, this dissertation as a whole delivers an important conclusion: in farmland lease contracts in the United States, contract design is not just a matter of designing monetary

compensation schemes or reducing transactions costs in accordance with the incentives in bilateral relationships, but involves various incentive devices (e.g., matching between landlords and tenants and landlord's participation in tenant's production decisions) in a way that the landlords can optimally coordinate incentives in multilateral relationships. Compared to the literature on farmland lease contracts that has principally dealt with the problem of designing monetary compensation scheme in bilateral relationships, I showed contract design in farmland tenancy related contracting is relatively complex.

Contract design in practice, however, is even more complicated. For example, landlord frequently monitor tenants' behavior, they sometimes use professional farm managers, they set various lengths to lease contracts, they choice between oral and written contracts, landlord's and tenant's investment in land maintenance, etc. and all of these actions seem to affect farmland lease practices, and there is some evidence that these factors also affect contract choice. In this dissertation, I could not address everything. Hence, much related research remains to be done.

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