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Contractual Externalities and Contract Design
-Evidence from Farmland Lease Contracts in U.S. Agriculture

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Abstract

In modern U.S. agriculture, a tenant typically contracts with more than one landlord, although most of the past literature has focused exclusively on bilateral contracts with a single tenant and a single landlord. We argue that, in the presence of contractual externalities under which the landlords do not cooperatively act, multilateral contracting results in higher-powered contracts for the tenant, due to inefficient competition among the landlords, and that this incentive effect becomes a motivation for the use of cash rental contacts. Using the USDA's AELOS data set, we show that the number of landlords per tenant indeed increases the likelihood of cash rent and changes the qualitative properties of the contract choice equation. These outcomes provide empirical evidence supporting the incentive hypothesis.

* We are grateful to USDA-NASS and NASS Des Moines Office for allowing us to use the AELOS data set. We carried out the statistical analyses in NASS Des Moines Office, following the USDA's confidentiality policy. The usual disclaimer applies.

Introduction

The design of economic transactions has been a prominent subject of research in the economics of industrial organization. Lafontaine and Slade (2001) argue that the following three areas have received great attention in the empirical literature on organizational forms in economic transactions: executive compensation, sales-force and franchise contracting, and industrial procurement. In the area of executive compensation, the insurance/incentive aspects of contract theory has been the major interest, while in the area of industrial procurement, the role of transaction-specific assets in the design of contract has been the major issue (Lafontaine and Slade, 2001). In the area of sales-force and franchise contracting, the main interests include the role of the trade-off between risk sharing and incentives in the decision of contracting out (Lafontaine, 1992), the relationship between the importance of the agent effort and the decision of contracting out (Norton, 1988; Lafontaine, 1992; Shepard, 1993; Slade, 1996), and the relationship between monitoring cost and the decision of contracting out (Lafontaine, 1992; Scott, 1995). Using the data set of franchising firms from all sectors, Lafontaine (1992) finds that the proportion of franchising in a sector increases as the importance of the agent effort rises, while the author does not find consistent evidence of risk sharing. Norton

(1988) and Lafontaine (1992) find that the likelihood of franchising increases as monitoring agent effort becomes more costly. As regards the role of risk and transaction costs such as monitoring cost of agent effort and observing cost of realized output, farmland lease contracts have been another important area of considerable research[1]. 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 prediction based on the risk sharing hypothesis that contracts with weaker incentives are more likely when the tenant is more risk averse and/or when the transaction is more risky. 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.

While bilateral contracts are exclusively used in some transactions, multilateral contracts in which a single agent contracts with multiple principals are prevalent in other transactions, including farmland leasing in developed countries. For example, in wholesale trade, numerous products are marketed by brokers who often represent the potentially conflicting interests of several principals (Bernheim and Whinston, 1986). In farmland leasing in developed countries like the United States, a tenant typically

contracts with multiple landlords. According to the USDA's Agricultural Economics and Land Ownership Survey (hereafter, AELOS), the average number of landlords per tenant was 3.2 in 1988 and 4.4 in 1999. In developed countries, the body of tenants tends to become smaller than that of landlords as the labor productivity increases thanks to developed machineries and the number of farmers retiring from farming being greater than that of people becoming new farmers.

Most past empirical studies carried out in various industries, however, have focused exclusively on bilateral contracts with a single agent and a single principal. Lack of data on principal attributes partly explains the absence of the empirical literature on multilateral contracting. In the empirical literature on farmland lease contracts, Allen and Lueck (1992, 1993, 1999), Laffont and Matoussi (1995), and Bierlen, Parsch, and Dixon (1999) have not included landlords' attributes (except crop type) in the contract-choice equation, while there are some studies that control unavailable landlord attributes using panel data techniques (Pudney, Galassi, and Mealli, 1998; Dubois, 2002; Ackerberg and Botticini, 2002). To our knowledge, there have been no empirical studies in any sectors that focus on the role of multilateral contracting in contract design, except Moss and Barry (2002). Focusing on farmland lease contracts, Moss and Barry (2002) argue

informally that having more landlords increases transaction costs under a cropshare contract, and that all else equal, this increases the likelihood of cash rent. Using a sample of 61 Illinois farmers, they tested this hypothesis by looking at the effect of the number of landlords on contract choice, and found no significant effect. Although they include in the contract choice equation some landlord attributes such as crop type and information on whether or not the landlord is opportunistic, in addition to tenant attributes, the available information on landlord attributes is limited. Furthermore, the sample size may not be large enough to capture the effect of multilateral contracting on contract design.

This article presents some empirical evidence for the effect of multilateral contracting on contract design, using a data set from farmland lease contracts in the United States. We overcome the problem of data availability by using AELOS, which is a comprehensive data set with a large sample size that contains the information on both tenant and landlord attributes. Taking the advantage of the rich information in AELOS, we evaluate empirical determinants that affect contract choice, focusing on the effect of the number of landlords that a tenant has. As far as we know, this is the first article that presents empirical evidence on the relationship between multilateral contracting and contract design, reasonably controlling both the principal and agent attributes.

In contrast to the lack of empirical studies on multilateral contracting, it is well known that multilateral contracting affects the optimal effort level of the agent in the literature on contract theory. Bernheim and Whinston (1986) develop a general model, in which they show that the second best cannot generally be achieved in the case of multilateral contracting with contractual externalities. They argue that, in the presence of contractual externalities under which cooperation among the principals is not feasible and thus each principal strategically designs the contract so that she can elicit greater effort from the agent, the competition among the principals results in socially inefficient contract design compared to the case without contractual externalities under which the principals can cooperatively design contracts. They argue that contractual externalities are likely to exist in both public sectors (e.g., the lack of coordination between state and federal agencies) and private sectors (e.g., legislative proscription of explicit cooperation between principals). Dixit (1996) and Itoh (2003) adopt a simple version of multilateral contracting model and evaluate how an increase in the number of principals affects the design of contract. They show that, when the risk neutral principals can cooperatively design the contract, an increase in the number of principals results in a lower-powered incentive contract, because an increase in the number of principals adds additional source

of variability. This can be understood by considering the case in which a benevolent principal representing cooperating principals maximizes the total welfare subject to the agent participation and incentive constraints. The participation of an extra principal merely results in greater production variability, while the benevolent principal still maximizes the total welfare given the additional variability. Due to the additional variability in the society, the optimal power of incentives for the agent becomes lower. On the other hand, when contractual externalities exist and the principals cannot cooperate, an increase in the number of principals results in higher-powered incentive contracts, because each competing principal strategically designs the contract so that she can elicit greater effort for her from the agent and the incentive effect overwhelms the loss in the welfare due to inefficient allocation of risk.

Applying these results to farmland lease contracts, we argue that, such a strategic increase in the incentive power for the tenant under the inefficient competition among the landlords results in an increase in the tendency for each party to adopt a cash rent contract[2]. In this case, an increase in the number of landlords results in lower likelihood of cropshare. On the contrary, when there are no contractual externalities and the landlords cooperatively determine contract design, an increase in the number of

landlords results in greater likelihood of cropshare. This argument leads us to a testable hypothesis: in the case in which contractual externalities exist and individual landlords strategically determine contract design, then cash rent contracts become more likely. On the same token, evidence that an increase in the number of landlords increases the likelihood of cash rent, if any, is consistent with the hypothesis that contractual externalities exist. In contrast to the setting considered in Bernheim and Whinston (1986), there is no a priori reason that contractual externalities exist in farmland leasing in the United States. It is possible, although we have not observed the evidence, that landlords cooperatively act and design contracts in farmland leasing. Therefore, it is an interesting empirical question whether contractual externalities exist in farmland leasing in U.S. agriculture. By testing the hypothesis above, we provide evidence that contractual externalities exist in farmland leasing in U.S. agriculture. Also, we provide further evidence by examining if there are structural differences in the contract choice equations under bilateral contracting and multilateral contracting. If contractual externalities actually exist, then the structure of the contract choice equation in multilateral contracting should differ from that in bilateral contracting. In bilateral contracting, contractual externalities do not matter at all, because a single landlord contracts with a single tenant,

while contractual externalities affect contract choice in multilateral contracting.

In addition to investigating the role of contractual externalities in multilateral contracting, we provide careful discussion on the specification of econometric models of contract choice, which has been informally and somewhat carelessly done in the past literature. We argue that the contract choice equation is likely highly nonlinear in parameters, and provide empirical evidence for it. The result indicates that the past studies that ignore nonlinear structure of the contract choice equation may be subject to misspecification bias.

Data

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 44,515 observations (contracts) in the data set[3]. 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)[4].

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 problem of the choice between bilateral and multilateral contracting in the contract choice equation, and see if this endogeneity problem affects our conclusions in the second phase.

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.

First, we carefully 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[5]. Since landlords typically participate in management under cropshare and are considered to materially participate in production, landlords would 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 not generally earned 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 B_{ij}. We assume that B_{ij} is observed by the landlord-tenant party but cannot be observed by econometricians. We assume that, from the perspectives of econometricians, B_{ij} is a random variable that follows a standard normal distribution. The landlord-tenant party chooses cash rent if and only if

(1) $$W_{ij}^1 < W_{ij}^0 + B_{ij}$$

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

(2) $$c_{ij}^* = X_{ij}\beta - B_{ij}$$

where c_{ij}^* is a latent variable such that $c_{ij} = 1$ when $c_{ij}^* > 0$ and $c_{ij} = 0$ when $c_{ij}^* \leq 0$, 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, 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, and county-level erodibility index among others. The definitions and descriptive statistics of these variables are given in Table 2. The vector of regressors also includes nonlinear terms of the proxies.

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.

Table 3 shows the summary of the effects of the number of landlords in the

contract choice equation for the linear and nonlinear specifications. In the linear specification, 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 nonlinear specification, the average of the marginal effect of an increase in the number of landlords is -0.0042, which indicates that an increase in the number of landlords decreases the likelihood of cropshare on average. These results, therefore, are 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. The joint test of the hypothesis that all the nonlinear terms are zero is rejected[6], which implies that the term $W_{ij}^{1} - W_{ij}^{0}$ is indeed a nonlinear function of the proxies. This result implies that models with linear specification may be subject to specification bias. Although the qualitative result does not change between the linear and nonlinear specifications, this may be due to a large sample size of our data set.

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. We do not include nonlinear terms in the model for simplicity purpose, but exclusion of nonlinear terms should not affect the result qualitatively, given that having nonlinear terms in the equation does not affect qualitative result in our data set, as the analysis above shows. The test rejects the hypothesis that all the coefficient estimates are identical across the two regimes[7]. 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 contract choice may be correlated with the regime selection between bilateral and multilateral contracting. If the two are correlated, 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. If this is the case,

the number of landlords is not a dependent variable, not an independent variable. 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 estimate a bivariate probit model in which contract type and regime 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 and regime 2 to differ, because we find that the coefficients are not identical in the analysis above. We do not include nonlinear terms in the model in order to facilitate convergence. Exclusion of nonlinear terms, however, should not affect the result qualitatively, as we observe that having nonlinear terms in the equation does not affect qualitative result in the analysis above. Table 4 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, although the effect is statistically insignificant. The result implies that the endogeneity problem does not significantly affect the contract choice. 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.

Discussion

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 nonlinear

specification, and 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 suggested by Moss and Barry (2002). They argue 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.

Footnotes

[1] In farmland lease contracts, the landlord is the principal who contracts out farming, while the tenant is the agent who farms the contracted land for the landlord.

[2] The discussion below on the effect of contractual externalities on contract design, and specification of econometric models is based on a modified version of Dixit (1996) and Itoh (2003) that we develop for this article. The detailed description of the model is provided in Appendix.

[3] 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.

[4] This average number of landlords per tenant is not the same as that reported on page 3 because of the data refinement stated above.

[5] A landlord is materially participating if he/she has an arrangement with the tenant for

the landlord participation and the landlord meets one of the four following tests:

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 your 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.

[6] The chi-squared statistics is 1838.88, which is great enough to reject the null hypothesis at the 1% significance level.

[7] The chi-squared statistics is 83.56, which is great enough to reject the null hypothesis at the 1% significance level.

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Table 1. The Percentage of Cropshare by Tenant Farm Type and the Number of Landlords

Tenant Farm Type	Single Landlord	Multiple Landlords	Difference
Grain-Oilseed	0.3573	0.3129	0.0444*
Tobacco-Cotton	0.3355	0.2012	0.1343*
Vegetable-Friut	0.1692	0.0941	0.0751*
Beef	0.1278	0.1430	-0.0152
Dairy	0.0829	0.0318	0.0511*
Other Livestock	0.1235	0.1298	-0.0063

Tenant Farm Type	1<Landlords<5	5<=Landlords	Difference
Grain-Oilseed	0.413	0.2841	0.1289*
Tobacco-Cotton	0.3818	0.175	0.2068*
Vegetable-Friut	0.1396	0.08	0.0596*
Beef	0.1285	0.1564	-0.0279*
Dairy	0.0397	0.0281	0.0116*
Other Livestock	0.1287	0.1307	-0.002

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

Table 2. Definitions of Variables

Variables	Definitions	Mean	S.D.
Dependent variables			
CONTRACT_TYPE	=1 if contract is cropshare, =0 if contract is cash rent	0.20	0.40
REGIME	=1 if tenant has more than one landlord, =0 otherwise	0.92	0.27
Independent variables			
Regions			
NE	=1 if location of tenant's farm is Northwest region	0.12	0.33
MW	=1 if location of tenant's farm is Midwest region	0.37	0.48
SR	=1 if location of tenant's farm is South region	0.35	0.48
WR	=1 if location of tenant's farm is West region	0.16	0.36
Tenant's farm type			
CROP_TYPE	=1 if tenant farm type is grain, oilseed, tobacco, or cotton	0.52	0.50
Other tenant's attributes			
T_AGE	age of tenant	51.65	12.09
T_TOTAL_ASSET	value of farm and nonfarm assets in tenant's household ($100,000)	23.86	67.53
N_LANDLORDS	number of landlords whom tenant contract with	13.35	19.83
Landlord's attributes			
L_AGE	age of landlord	65.09	14.47
L_LIV_ON_FARM	=1 if landlord lives on contracted land	0.13	0.34
L_TOTAL_VALUE	market value of all lands and buildings owned by landlord ($100,000)	5.50	137.79
Other factors			
VARIABILITY	standardized and weighted production variability for county of tenant's residence	0.26	0.10
ERODIBILITY	erodibility index for county of tenant's residence	2.68	2.72

Table 3. Probit Model of Contract Choice (Probability of Cropshare Being Chosen)

Variable	-Log Likelihood=19178.94	-Log Likelihood=18259.50
N_LANDLORDS	-0.0084***	0.0395***
N_LANDLORDS^2	-	-0.0023
Interaction Terms with		
CROP_TYPE	-	-0.0293***
T_AGE	-	-0.0395***
T_TOTAL_ASSET	-	-0.0005
L_AGE	-	-0.0093**
L_TOTAL_VALUE	-	-0.0193***
L_LIV_ON_FARM	-	0.0506
VARIABILITY	-	0.0776
ERODIBILITY	-	-0.0194
Average Marginal Effect	-0.0084	-0.0042

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

Table 4. Bivariate Probit Model of Contract and Regime Choices

	Contract Choice	
	Regime 1	**Regime 2**
	-Log Likelihood=30409.5	
INTERCEPT	-1.6968***	-1.0732***
NER	-0.8433***	-1.5890***
MWR	-0.2067***	-0.6352***
SR	-0.1210	-0.6117***
N_LANDLORDS	-	-0.0073***
CROP_TYPE	0.5879***	0.5922***
T_AGE	0.0038*	-0.0015**
T_TOTAL_ASSET	-0.0046***	-0.0070***
L_AGE	0.0028	0.0045***
L_TOTAL_VALUE	0.0001	-0.0004
VARIABILITY	-0.2562	0.9242***
ERODIBILITY	0.0702***	0.0827***
Correlation in Disturbance	-0.1757	

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

Appendix

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 two regimes: in regime 1, there are *n* landlords and each of them contracts with a tenant; in regime 2, there are *n* landlords and they contract with the same tenant. Suppose that the production function for landlord *j* is given by

(A-1) $$y_j = L_j + \delta_j$$

where L_j is the tenant's effort level provided for landlord *j*, and δ_j is an unobservable disturbance factor that follows a normal distribution, $N(0, \sigma_j^2)$. Landlord *j* receives revenue 1 per unit of output. Landlord *j* utilizes a linear contract denoted as

$w_j = \alpha_j y_j + \beta_j$. Furthermore, it is assumed that the landlords are risk neutral while the tenant is risk averse (constant absolute risk averse, CARA is assumed too), and the Arrow-Pratt risk aversion coefficient is denoted by *r*. The reservation utility of the tenant is denoted as U_0.

Regime 1 One-on-one contract

This is the standard principal-agent model that Holmstrom and Milgrom (1987) presented. The expression of the optimal output share for the tenant is

(A-2) $$\alpha_j^* = \frac{1}{1 + rk\sigma_j^2}$$

Regime 2 n landlords and one tenant, and the landlords act non-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 non-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 (A-1), but now we assume that the disturbance terms follow a multi-variate normal distribution, $N(0, \Omega)$, where

$\Omega = \begin{pmatrix} \sigma_1^2 & 0 & \cdots & 0 \\ 0 & \ddots & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \sigma_n^2 \end{pmatrix}$. Let the tenant's private cost function be $C(L) = \frac{1}{2} LCL'$, where

$L = (L_1, \cdots, L_n)$ and $C_{n\times n} = \begin{pmatrix} k & ks & \cdots & ks \\ ks & k & & ks \\ \vdots & & \ddots & \vdots \\ ks & ks & \cdots & k \end{pmatrix}$. $k > 0$ and $0 \le s \le 1$. 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 tenant maximizes the certainty equivalent given by

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

where $\alpha = (\alpha_1, \cdots, \alpha_n)$. Solving the first order condition with respect to L, one obtains

(A-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

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

The solution for β_j cannot be determined unless further assumptions are made. Here, for simplicity purposes, we assume that each landlord makes the equal amount of fixed payment. That is,

(A-6) $$\beta_j = \frac{1}{n}\sum_{j=1}^{n}\beta_j$$

Given these constraints for the landlords, landlord *j*'s objective function becomes

$$\max_{\alpha_j}\left\{(1-\alpha_j)L_j + \beta_j\right\}$$
$$\text{s.t. Equations (A-4) and (A-6)}$$

Solving this problem, one obtains

(A-7) $$\alpha_j^{**} = \frac{1}{1 + r\sigma_j^2 \dfrac{k + (n-2)ks - (n-1)ks^2}{1+(n-2)s}}$$

Plugging this into equation (A-5) and divide it by *n*, one can obtain the fixed part of the payment, β_j^{**}. From equation (A-7), the following proposition is obtained.

Proposition 1. *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.

$$\alpha_j^{**}|_n - \alpha_j^{**}|_{n-1}$$
$$= \frac{1}{1 + \dfrac{kr(1-s)(1+(n-1)s)\sigma_j^2}{1+(n-2)s}} \cdot \frac{1}{1 + \dfrac{kr(1-s)(1+(n-2)s)\sigma_j^2}{1+(n-3)s}} \cdot \frac{kr\sigma_j^2(1-s)s^2}{(1+(n-3)s)(1+(n-2)s)}$$
$$> 0, \text{ for } n \geq 3$$

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

Proposition 1 indicates that the power of incentives provided by the optimal contracts becomes stronger as the number of landlords increases given that there is an externality between the tenant's efforts for the multiple landlords and contractual externalities exist. This result seems 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 $(\alpha_j^{**}, \beta_j^{**})$ is not generally a cash rent contract (actually, it is the optimal *cropshare* contract, as long as $0 < \alpha_j^{**} < 1$), we need more formal discussion in order to clarify the implication of proposition 1 and derive a testable prediction based on the proposition. 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 2. 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

$$
\begin{aligned}
W_1 &= \sum_{j=1}^{n}\left\{\left((1-\alpha_j^*)L_j^* - \beta_j^*\right) + \left(\alpha_j^* L_j^* + \beta_j^* - \frac{1}{2}k(L_j^*)^2 - \frac{1}{2}r(\alpha_j^*)^2\sigma_j^2\right)\right\} \\
&= \sum_{j=1}^{n}\left(L_j^* - \frac{1}{2}k(L_j^*)^2 - \frac{1}{2}r(\alpha_j^*)^2\sigma_j^2\right) \qquad \text{(A-8)} \\
&= \sum_{j=1}^{n}\frac{1}{2}\frac{1}{k(1+kr\sigma_j^2)}
\end{aligned}
$$

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 2, the social welfare when the landlords make contracts with one tenant is given by

$$
\begin{aligned}
W_2 &= \sum_{j=1}^{n}\left((1-\alpha_j^{**})L_j^{**} - \beta_j^{**}\right) + \sum_{j=1}^{n}\left(\alpha_j^{**}L_j^{**} + \beta_j^{**} - \frac{1}{2}r(\alpha_j^{**})^2\sigma_j^2\right) \qquad \text{(A-9)} \\
&\quad - \sum_{i}^{n}\sum_{j\neq i}^{n}\left(\frac{1}{2}k(L_i^{**})^2 + ksL_i^{**}L_j^{**}\right) + (n-1)U_0
\end{aligned}
$$

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 2. The last term represents the sum of reservation utilities of the $n-1$ tenants who are out of leasing in regime 2.

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 B_j. Then, the social welfare when the landlords use cash rent contracts in regime 1 becomes

(A-10)
$$\begin{aligned} W_1^C &= \sum_{j=1}^{n}\left(\frac{1}{k}-\frac{1}{2}k(\frac{1}{k})^2-\frac{1}{2}r(1)^2\sigma_j^2+B_j\right) \\ &= \frac{n}{2k}+\sum_{j=1}^{n}\left(-\frac{1}{2}r\sigma_j^2+B_j\right) \end{aligned}$$

Similarly to the above, suppose that the landlords choose cash rent contracts in regime 2. The optimal effort level is now $1/k(1+(n-1)s)$. The social welfare under cash rent contracts becomes

(A-11)
$$\begin{aligned} W_2^C &= \sum_{j=1}^{n}\left(\frac{1}{k(1+(n-1)s)}-\frac{1}{2}r(1)^2\sigma_j^2+B_j\right)-\frac{1}{2}(L^{**}|_{\alpha=1})C(L^{**}|_{\alpha=1})'+(n-1)U_0 \\ &= \frac{n}{2k(1+(n-1)s)}+\sum_{j=1}^{n}\left(-\frac{1}{2}r\sigma_j^2+B_j\right)+(n-1)U_0 \end{aligned}$$

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

(A-12) $$W_1^C > W_1, \text{ in regime 1}$$

(A-13) $$W_2^C > W_2, \text{ in regime 2}$$

This reduces to

(A-14) $$\sum_{j=1}^{n} B_j + \frac{n}{2k} - \frac{r}{2}\sum_{j=1}^{n}\sigma_j^2 - \sum_{j=1}^{n}\frac{1}{2}\frac{1}{k(1+kr\sigma_j^2)} > 0, \text{ in regime 1}$$

(A-15) $$\sum_{j=1}^{n} B_j + \frac{n}{2k(1+(n-1)s)} - \frac{r}{2}\sum_{j=1}^{n}\sigma_j^2 - \sum_{j=1}^{n}\left(L_j^{**} - \frac{1}{2}r(\alpha_j^{**})^2\sigma_j^2\right) + \frac{1}{2}L^{**}CL^{**\prime} > 0, \text{ in regime 2}$$

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

Proposition 2. *For sufficiently large value of s, the lowest value of B that satisfies the condition (A-15) is smaller than the counterpart for the condition (A-14).*

Proof. We show that, for sufficiently great value of *s*, the LHS of inequality (A-14) except for the *B* term is greater than the LHS of inequality (A-15) except for the *B* term so that inequality (A-15) can hold with a smaller value of *B*. To show this, we note that the LHS of inequality (A-15) becomes identical with the LHS of inequality (A-14) when $s = 0$. Therefore, it suffices to show that the LHS of inequality (A-15) becomes greater than the LHS of inequality of (A-14) for $s > \underline{s}$, where $\underline{s}$ is some sufficiently great value. Although cumbersome, one can show that the LHS of inequality of (A-15) is in general U-shaped in *s*. The graphs of $W_2^C - W_2$ in cases of $n = 2,3,4,5,6$ are shown in the figure below. As the figure shows, the value of $W_2^C - W_2$ 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.

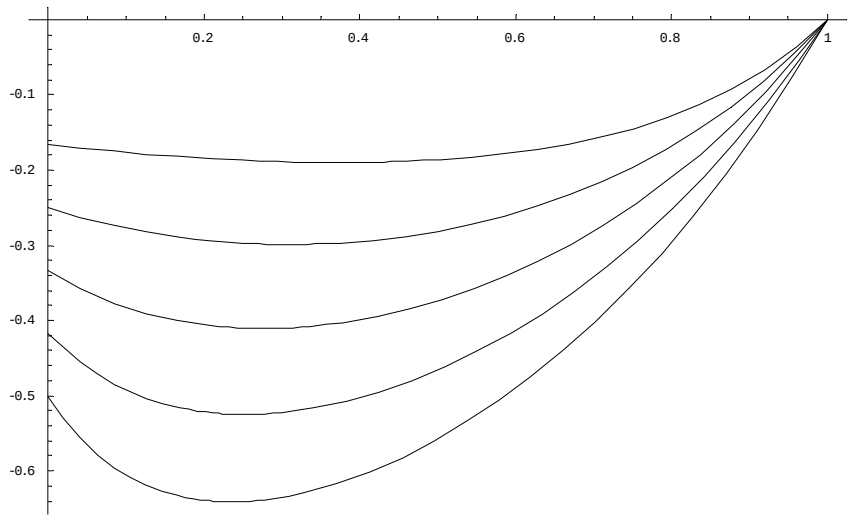

Figure A1. $\boldsymbol{W_2^C - W_2}$ **as a function of** $\boldsymbol{s}$ **for** $\boldsymbol{n = 2,3,4,5,6}$ **(**$\boldsymbol{(\sigma_j^2, k, r) = (0.5, 1, 1)}$**)**

Proposition 2 implies that, when the substituting effects between the tenant's efforts are sufficiently large, the domain of *B* such that cash rent is more preferred is narrower in regime 1 than in regime 2, meaning that the likelihood of cash rent contracts is greater as the shift from regime 1 to regime 2 occurs.

The next proposition claims that an increase in the number of landlords in regime 2 increases the likelihood of cash rent.

Proposition 3. *The lowest value of B per contract that satisfies the condition that cash*

rent contracts are more likely in regime 2 becomes smaller as the number of landlords, n, increases.

Proof. A calculation shows that the value of the LHS of the condition (A-15) except for the *B* term and the risk term is decreasing in *n* and the rate of decrease is decreasing (see the figure below). This implies that the smallest value of *B* per contract that satisfies the condition becomes smaller as *n* increases. This completes the proof. *Q.E.D.*

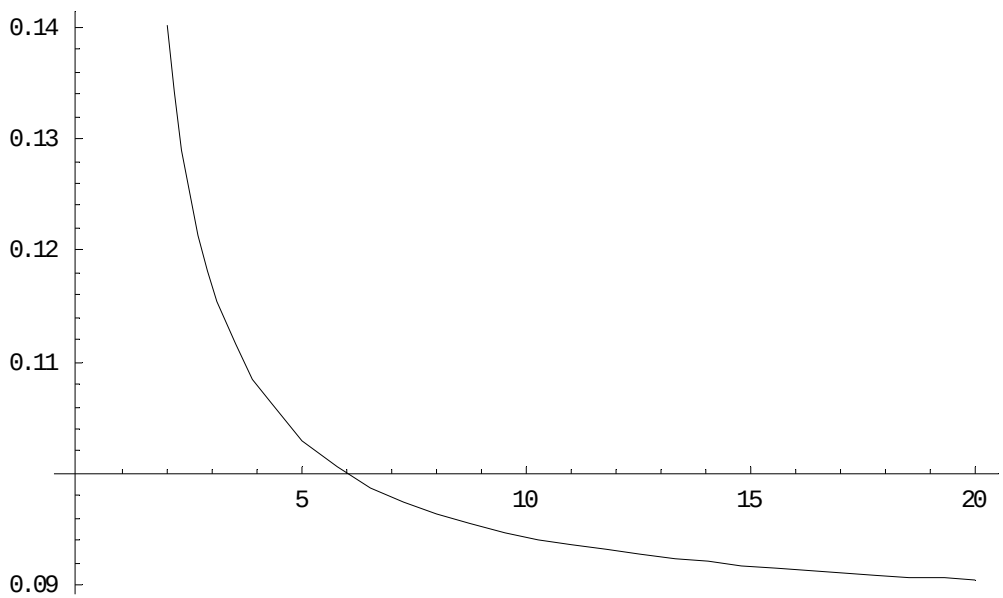

Figure A2. $\boldsymbol{W_2 - W_2^C}$ **as a function of** $\boldsymbol{n}$**:** $\boldsymbol{((\sigma_j^2, k, r, s) = (1, 1, 1, 0.9))}$

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 *B* 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 2, 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 3 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 (A-14) and (A-15), we obtain predictions 3 and 4:

Prediction 3. *The contract choice equation consists of highly nonlinear terms of proxies.*

Prediction 4. *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.*

In the discussion above, it is assumed that all the landlords choose the same type of contract. This is obviously a strong assumption. In reality, one tenant can have

different types of contracts with different landlords at the same time. In the following, we consider whether relaxing this assumption alters our conclusion. For that purpose, we consider a simple case in which there are two identical landlords (identical except for the exogenous benefits of cash rent, B_1 and B_2) and one tenant. This is a preliminary analysis and the more general case is left for further work.

In the model, it is assumed that the landlords act non-cooperatively and move simultaneously. Figure A3 is the payoff matrix for the game. W_1 through W_8 stand for payoffs for each landlord-tenant pair for the corresponding strategy, which do not include the exogenous benefit of cash rent.

		Pair 2	
		Cash Rent	Cropshare
Pair 1	Cash Rent	(W_1, W_2)	(W_3, W_4)
	Cropshare	(W_5, W_6)	(W_7, W_8)

Figure A3. Payoff matrix

Because the landlords are identical except for B_1 and B_2, we have the following relationships: $W_1 = W_2$; $W_3 = W_6$; $W_4 = W_5$; and $W_7 = W_8$. Define the total welfares excluding B_1 and B_2 in each cell as follows: $W_{CC} = W_1 + W_2$; $W_{CS} = W_3 + W_4$; $W_{SC} = W_5 + W_6$; and $W_{SS} = W_7 + W_8$. It readily follows that $W_{SC} = W_{CS}$. Furthermore, one

can show that $W_{SS} - W_{CS} \geq W_{CS} - W_{CC}$.

Depending on the value of B_1 and B_2, any combination of strategies can be an equilibrium, given that B_1 and B_2 can be transferred between the pairs without cost. To show this, define such an allocation (b_1, b_2) of exogenous benefit between the pairs, where b_1 stands for the allocation of the exogenous benefits for Pair 1 and b_2 stands for the allocation for Pair 2. As such, either $b_1 + b_2 = B_1$, $b_1 + b_2 = B_2$, or $b_1 + b_2 = B_1 + B_2$ holds. Suppose that $B_1 \geq W_{SS} - W_{CS}$. Then there is always a feasible allocation of B_1 such that $W_3 + b_1 \geq W_7$ and $W_4 + b_2 \geq W_8$. This implies that if B_1 is great enough, then Cash-Share is an equilibrium. Similarly, if $B_2 \geq W_{SS} - W_{SC}$, then there is always a feasible allocation of B_2 such that $W_5 + b_1 \geq W_7$ and $W_6 + b_2 \geq W_8$, and Share-Cash is an equilibrium. Whether or not the pairs want to move from Cash-Share (or Share-Cash) to Cash-Cash, again, depends on the value of B_1 and B_2. If B_2 (or B_1) is great enough such that $W_1 + b_1 \geq W_3$ and $W_2 + b_2 \geq W_4$ hold, then the pairs will move from Cash-Share (or Share-Cash, respectively) to Cash-Cash and the equilibrium will be in the upper-left cell. Now, noting that $W_{SS} - W_{CS} \geq W_{CS} - W_{CC}$, we can argue that it is easier for the pairs to move from Cash-Share (or Share-Cash) to Cash-Cash than to move from Share-Share to Cash-Share (or Share-Cash), in the sense that smaller value of B_2 (or B_1, respectively) is

needed to motivate them to shift to Cash-Cash. In other words, once one landlord deviates from cropshare to cash rent, the other landlord is more likely to deviate from cropshare to cash rent.

Now, suppose that there are two bilateral contracts, and there are no externalities between the two transactions. Suppose that one pair moves from the optimal cropshare to cash rent. Denoting the loss in the social welfare by $W_S - W_C$, one can show that, for great enough *s*, the loss in the social welfare in the presence of externalities is smaller than that in the absence of externalities. That is, for great enough *s*, $W_S - W_C \geq W_{SS} - W_{CS}$. This implies that it is easier for a pair to move from Share to Cash when the externality is great enough, in the sense that smaller value of external benefits of cash rent is needed to motivate them to shift to Cash.

The following provides analytical description of the discussion above. We focus on the likelihood that one pair chooses a cash rent contract, given the other party's contract type. Suppose that B_1 and B_2 are independently and randomly distributed from the perspective of researchers. We first consider the case in which there exist externalities. The probability that Pair 1 chooses a cash rent contract can be written as Prob(Pair 1 chooses cash rent | Pair 2 chooses cropshare)+Prob(Pair 1 chooses cash rent |

Pair 2 chooses cash rent). The first term can be written as

Prob($W_{CS} + B_1 \geq W_{SS}$)·Prob($W_{SS} \geq W_{SC} + B_2$)= Prob($B_1 \geq W_{SS} - W_{CS}$)·Prob($B_2 \leq W_{SS} - W_{SC}$),

while the second term can be written as

Prob($W_{CC} + B_1 + B_2 \geq W_{SC} + B_2$)·Prob($W_{SC} + B_2 \geq W_{SS}$)=Prob($B_1 \geq W_{SC} - W_{CC}$)

·Prob($B_2 \geq W_{SS} - W_{SC}$). Thus, the probability that Pair 1 chooses cash rent, denoted by P_1,

is P_1=Prob($B_1 \geq W_{SS} - W_{CS}$)·Prob($B_2 \leq W_{SS} - W_{SC}$)+

Prob($B_1 \geq W_{SC} - W_{CC}$)·Prob($B_2 \geq W_{SS} - W_{SC}$). Now, if $W_S - W_C > W_{SS} - W_{CS}$ holds, then

P_1>Prob($B_1 \geq W_S - W_C$)·Prob($B_2 \leq W_{SS} - W_{CS}$)+

Prob($B_1 \geq W_S - W_C$)·Prob($B_2 \geq W_{SS} - W_{SC}$)=Prob($B_1 \geq W_S - W_C$). Note that

Prob($B_1 \geq W_S - W_C$) is the probability that a landlord-tenant pair chooses a cash rent

contract in the absence of externalities. Thus, we want to show that $W_S - W_C > W_{SS} - W_{CS}$

is true at least for some value of *s*.

We define a function $\Delta W(s) = W_{SS}(s) - W_{CS}(s)$. Note that $\Delta W(0) = W_S - W_C$.

One can show that, for great enough *s*, $\Delta W(0) > \Delta W(s)$. This implies that, for great

enough *s*, the loss in the social welfare when a landlord-tenant pair moves from the

optimal cropshare contract to a cash rent contract in the presence of externalities is

smaller than that in the absence of externalities. Intuitively, this is because the optimal

share is close to unity when *s* is great enough, and thus the loss in the social welfare, which mainly arises due to greater risk burdens for the tenant, is small. If this is the case, it is easier for a landlord-tenant pair to move from the optimal cropshare contract to a cash rent contract in the presence of externalities than in the absence of externalities.

The discussion above indicates that our main argument that contractual externalities can increase the likelihood of cash rent contracts is robust to the assumption that landlords can choose different types of contracts, in the case where there are two landlords and one tenant, and exogenous benefits for cash rent can be transferred between the parties without cost. Extending this framework to more general settings is left for future task.