Sustainable land use: landlord–tenant contracting in the United States of America

W.E. Huffman [1,*] and K. Fukunaga [2]

[1] Iowa State University, Ames, Iowa, United States of America
[2] National Economic Research Associates, Inc., Tokyo, Japan
* Corresponding author (e-mail: whuffman@iastate.edu)

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Abstract

This paper provides new perspectives on USA landlord–tenant contracting, where technical change is creating scale economies in farming and farm enlargements, and results that are important to the sustainability of land use and environmental quality. We develop a conceptual model of landlord–tenant contracting that emphasizes minimizing transactions costs and setting incentives for effort when tenants are risk averse, and provide empirical evidence from the USA supporting the model. We find support for both models and that landlords' as well as tenants' attributes determine whether a contract is crop share or cash. We also find that highly erodible land and land that is expected to remain in farming in the future are most likely to be operated with share contracts, which include owners' interests in production and management decisions. We then examine evidence showing how contract choice affects the adoption of short- versus long-term conservation practices, participation in public conservation programmes, and tendencies for conversion of farmland to urban uses. We conclude that, under diverse economic, technical, climatic, ecological and political conditions, crop-share contracts have sustainability advantages relative to cash rental contracts.

Additional keywords: cash rental contracts, conservation programmes, crop-share contracts, incentives, risk sharing, transaction costs

Introduction

In all parts of the world that have private land ownership or private property, a variety of institutions have developed to facilitate agricultural production (Roumasset, 1995; Oskam & Feng, 2008). This includes the use and management of land for agricultural and associated purposes, including the bundling of property rights, which is important in Europe (Otsuka *et al.*, 1992). Agricultural land is frequently categorized into the following tenure types: owner-operated lands, where the farmer farms only land that he owns (without hired labour), tenant-operated lands where the tenant rents all of the farm land that he operates, and part-owner operated lands, where the farmer uses

owned and rented farmland in his farming operation. For example, in USA agriculture in 2003, 62% of the farms were operated by full owners; these were largely small farms. Thirty-two percent of the farms were operated by part-owners; these were the large farms. Six percent of the farms were operated by tenants who operated small farms and rented all of the land that they farmed (Anon., 2006). In 2002, USA farm operators rented 38% of their total farmland, which was a decline by 5 percentage points relative to a decade earlier.

Hypothetical reasons for the existence and type of farmland leasing include: risk-sharing, incentives for effort, maintenance of productivity or sustainability, transaction costs, a credit constraint and screening/sorting. In North America, risk sharing (Newberry & Stiglitz, 1979) and transaction costs (Allen & Lueck, 2002) have received most of the recent emphasis (Fukunaga & Huffman; in press). The institution of farmland tenancy has at times been under attack because of alleged inefficient land and labour uses (Otsuka, 2007), but in recent years, new and more penetrating thinking about optimal incentive contracting has shown that cash and share-leasing of farm land can both be optimal, given the right set of circumstances including bundling of rights to land for lease (Slangen & Polman, 2008). However, the physical and biological attributes of the land, attributes of the tenant (ability, risk preferences, cost of effort, opportunity cost of time, and credit worthiness) and of the landlord (risk preferences, management ability, residence location relative to the land in question, and asset portfolio) can all be taken into account under efficient contracting. However, in developed countries, access to credit and management skills of tenants are not central to landlord–tenant contract choice. In the USA, the dominant forms of landlord–tenant contracts are cash and share. With a cash lease, the tenant pays the landlord a fixed nominal amount per hectare rented for the right to use the land for agricultural purposes and then makes all the production and marketing decisions, thereby bearing all the risk, but he also obtains all of the net return. With a share lease, the landlord provides the land services and the tenant provides the labour, machinery services and fuel. Moreover, the landlord and tenant share production and marketing decisions, and the most common contract is to share equally (50–50) output produced and current production expenses, e.g., fertilizers, seeds, and pesticides.[1] Because cash-lease contracts are fixed in nominal payment for land services, e.g., US$300 (or 190 Euros) per hectare-year, and share contracts being stated in real terms as a share of output and production expenses, share contracts can easily withstand a wider range of changes in prices of outputs and inputs and crop yields without the parties needing to renegotiate terms. But cash contract terms are more fragile. For example, with the dramatic increase in grain and oilseed prices in late 2007 and early 2008, many Midwestern USA farmland owners who have cash-lease terms that were set early last fall are wishing that they could renegotiate their leases in the spring of 2008. When renegotiation has occurred, cash rental rates are substantially higher.

The landlord–tenant models developed by agricultural economists have generally been behind the curve in applying recent advances in principal-agent models to optimal incentive construction in landlord–tenant contracting. Otsuka (2007) hardly mentions principal-agent models in his recent review of the literature dealing with efficient allocation of land across a wide range of environments and countries, and only as an afterthought Roumasset

(1995) includes some treatment of a principal-agent model of contracting.

Although Stiglitz (1974) and Newberry & Stiglitz (1979) applied early versions of principal-agent models to landlord–tenant contracting, this was before modelling advances by Holmstrom & Milgrom (1987) and Holmstrom (1989), who are associated with modern contracting theory, including incentive compatibility and participation constraints (Laffont & Martimort, 2002). Their models consist of linear contracts, which are robust to unobservable and non-contractable effort, infeasibility of third-party verification or enforcement and gaming strategies of agents over time. Optimal contracts consist of two parts: (1) a fixed 'guarantee' payment, and (2) an incentive rate that is a share of the principal's payoff. Both agents and principals have an incentive to follow through on their agreed upon arrangement or contract because the contracts are constructed so that they are better off by doing so. The conceptual papers by Huffman & Just (2004) and Fukunaga (2006) and the empirical paper by Fukunaga & Huffman (in press) have recently enriched the landlord–tenant contracting literature.

The objective of this paper is to provide new perspectives on landlord–tenant contracting that are important to the sustainability of land and environmental quality. As a reflection of the recent empirical research by Fukunaga & Huffman (in press), we develop a conceptual model of contracting that incorporates models of transaction costs and incentives for effort with risk sharing (between a tenant and a landlord) [2]. Furthermore, it will be shown that contract choice is related to the adoption of short- versus long-term conservation practices, participation in public conservation programmes and tendencies for conversion of farmland to urban uses. The final chapter will draw conclusions about future research and policy needs in this area.

Risk sharing and transaction costs: setting incentives in a complex environment

This chapter develops a model that encompasses two strands of agency theory: (1) a principal-agent model with incentives for effort with risk sharing, and (2) a model emphasizing low transaction costs. Combining these diverse models into one model of landlord–tenant contracting is unusual but insightful. Although it has been argued informally that tenant's risk aversion increases the likelihood of a crop-share contract and landlord's risk aversion increases the likelihood of a cash contract, no one has derived the argument directly from a formal model. However, in the next few paragraphs we explicitly derive these conditions.

Our model builds upon earlier models by Allen & Lueck (1999), Laffont & Martimort (2002) and Huffman & Just (2004). Let us assume the following simple production function for farm output (y):

$$y = L + \delta \qquad (1)$$

where L is the tenant's effort level and δ is a random disturbance term following a normal distribution with a zero mean and variance σ^2. The landlord is assumed to offer a linear contract to the tenant of $w = \alpha y + \beta$, where α is the share of output going to the tenant and β is the landlord's guarantee to the tenant, wich can be negative as in

cash rented. The tenant's private cost of effort is assumed to be represented by the simple function that is quadratic in effort, $\frac{1}{2} kL^2$, where k denotes the cost sensitivity of the tenant's effort. Given these definitions, the tenant is assumed to have the following utility function, $U[\alpha(L + \delta) + \beta - kL^2/2]$, which is a concave, monotonically increasing function. Finally, the tenant's reservation utility is denoted as U_0, which is assumed to be greater than zero. Under a second-order Taylor approximation, the tenant's expected utility from effort L is:

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

where E is the expectation operator, $E(I) = \alpha(L + \delta) + \beta - kL^2/2$, U'( ) denotes the first derivative of U with respect to I, and U''( ) the second derivative. Alternatively, let us define CE as the tenant's certainty equivalent income from I and risk premium RP, then $CE = E(I) - RP$. Expected utility of I now has a first-order Taylor approximation,

$$E[U(I) = U(CE) = U(E[I] - RP) = U(E[I]) - U'(E[I])\ RP \quad (3)$$

Therefore, from Equations (2) and (3), $RP = -\frac{1}{2}\frac{U''(E[I])}{U'(E[I])}\alpha^2\sigma^2 = -\frac{1}{2} r_t\ \alpha^2\ \sigma^2$,

where $r = U''/U'$ is the Arrow-Pratt definition of risk aversion, and r_t denotes the degree of risk aversion for the tenant (and r_l denotes the degree of risk aversion of the landlord). Thus, the tenant's optimal allocation of effort is determined as

$$\max_L \{E[I] - RP\} = \max_L \left\{\alpha L + \beta - \tfrac{1}{2} k(L)^2 - \tfrac{1}{2}\ \alpha^2\ r_t\sigma^2\right\} \quad (4)$$

Similarly, the landlord's certainty equivalent income/welfare is given by $(1 - \alpha)\ L - \beta - \frac{1}{2} r_1\ (1 - \alpha)^2\ \sigma^2$, and under these settings, the landlord sets the sharing rate α that the tenant will accept

$$\begin{aligned} &\max_\alpha \left\{(1 - \alpha)L^* - \beta - \tfrac{1}{2}\ (1 - \alpha)^2\ r_1\sigma^2\right\} \quad (5) \\ &\text{s.t.} \\ &L^* = \arg\max_L \left\{\alpha L + \beta - \tfrac{1}{2}\ k(L)^2 - \tfrac{1}{2}\ \alpha^2 r_t\sigma^2\right\} \\ &\alpha L^* + \beta - \tfrac{1}{2}\ k(L^*)^2 - \tfrac{1}{2}\ \alpha^2 r_t\sigma^2 \geq U_0 \end{aligned}$$

The first constraint in Equation (5) is the tenant's incentive constraint providing the optimal marginal conditions for his effort, and the second constraint in Equation (5) guarantees that the tenant is better off with the contract offered than pursuing his next best alternative.

Solving the tenant's optimal incentive constraint, the tenant's effort is $L^* = \alpha/k$. If $\beta \neq 0$, the tenant's participation constraint holds with equality (whenever the participation holds with inequality, the landlord can reduce the fixed payment so that he is better off) and the optimal $\beta = U_0 - \alpha L^* + \frac{1}{2}\ k(L^*)^2 + \frac{1}{2}\ \alpha^2\ r_t\sigma^2$. Given these values of L^* and β, the landlord chooses the sharing rate under the following updated statement:

$$\max_{\alpha}\left\{\frac{\alpha}{k}-\frac{1}{2}k\left(\frac{\alpha}{k}\right)^2-\frac{1}{2}\alpha^2 r_t\sigma^2-\frac{1}{2}(1-\alpha)^2 r_1\sigma^2-U_0\right\} \tag{6}$$

It can be shown that the general expression for the optimal sharing arrangement becomes:

$$\alpha^* = \frac{1 + kr_1\sigma^2}{1 + k(r_1 + r_t)\sigma^2} \quad . \tag{7}$$

Because $\alpha^* \neq 1$ unless $\sigma^2 = 0$, which implies that production is certain, or $r_t = r_1 = 0$, which implies that the tenant and landlord are risk neutral, the optimal contract becomes some type of sharing arrangement.

It is useful to compare the welfare of the landlord under different contracting solutions. Denote total landlord's welfare under an optimal contract as π_{CS}, where the subscript CS denotes crop share. Now suppose that the landlord gains from reducing transaction costs (see Allen & Lueck, 1999) for a list of important transaction costs) when he uses a cash-rent contract instead of the optimal crop-share contract, and denote B as the added landlord benefits under cash rent. Then, the total welfare, when the landlord uses cash-rent instead of the optimal crop-share contract, is denoted as:

$$\pi_C = \frac{1}{2}\cdot\frac{1}{k} - \frac{1}{2}r_t\sigma^2 + B \tag{8}$$

Thus, the landlord is better off under a crop-share contract if and only if

$$\pi_{CS} - \pi_C = \frac{kr_t^2\sigma^4}{2}\cdot\frac{1}{1 + k(r_1 + r_t)\sigma^2} - B > 0 \tag{9}$$

One can show that $\pi_{CS} - \pi_C$ is monotonically increasing in σ^2, variance in production, and in r_t, tenant's risk aversion, and monotonically decreasing in r_l, landlord's risk aversion, and in B. *The past literature on contract choice has implicitly relied on this result to obtain testable hypotheses about the effects of risk and transaction costs on contract choice.*

Because key parameters in the optimal contract choice equations are not directly observable, the empirical contracting literature uses proxy variables for various parameters of these equations. Moreover, the authors of these studies normally assume very simple linear proxies of the parameters and this undoubtedly leads to approximation error. However, given that econometric specifications of these relationships include a random disturbance term, the approximation error can be harmlessly included there, provided that the regressors are not correlated with the errors.

An empirical model, data and results

Given the conceptual model of landlord–tenant contracting developed in the foregoing, the goal is to formulate an empirical model that can be fitted to a sample of contracts. In particular, we present and discuss the empirical model for choice of a crop-share contract, discuss the set of variables that relate to risk sharing and then the set of variables that relate transaction costs. See Table 1 for the list of variables and definitions.

Empirical model

Contract choice is a latent variable $contract^{*}_{ij}$ for contract type, which is hypothesized to have the following economic relationship:

$$contract^{*}_{ij} = \alpha^{*} x_i + \beta^{*} y_j + \gamma^{*} z_{ij} - \varepsilon_{ij}{}^{*}, \tag{10}$$

where x_i denotes a vector of tenant *i*'s attributes; y_i denotes a vector of landlord *j*'s attributes; and z_{ij} denotes the vector of local conditions in the area where the contracting occurs, such as the contracted land area, the total market value of the land and buildings on the contracted land, variability of area crop yields, erodibility of area soils, as well as a constant term. These variables serve as proxies for underlying conceptual parameters in the conceptual model. Moreover, ε_{ij}* is a random disturbance term that exists in part because our empirical model is at best a rough approximation to the conceptual model of landlord–tenant contract choice. However, what can be observed is not $contract^{*}_{ij}$, but rather, the dichotomous indicator $contract_{ij}$

$$contract_{ij} = \begin{cases} 1, \text{ if } contract^{*}_{ij} > 0 \\ 0, \text{ if } contract^{*}_{ij} \leq 0 \end{cases}, \text{ or 1 for crop-share, and 0 for a cash lease.} \tag{11}$$

Our likelihood function then becomes:

$$\prod_{ij} F(\alpha' x_1 + \beta' y_j + \gamma' z_{ij})^{contract_{ij}} \{1 - F(\alpha' x_i + \beta' y_j + \gamma' z_{ij})\}^{(1-contract_{ij})}, \tag{12}$$

where $F_\varepsilon(v)$ denotes a cumulative distribution function F_ε evaluated at v. Hence, $F_\varepsilon(\alpha' x_i + \beta' y_j + \gamma' z_{ij})$ gives the probability of a crop-share contract being chosen, conditional on the covariates, x, y and z. For example, if the ε_{ij}s follow a standard unit normal with a mean of 1 and a variance of 0, then F( ) follows a cumulative standard unit normal distribution function. Equation (12), which is the joint probability of the sample viewed as a function of the unknown parameters, is denoted as the likelihood function for the empirical model. Now maximize the likelihood function with respect to the unknown parameters α, β, and γ to obtain parameter estimates of the probit model of crop-share choice (Greene, 2003). A positive value for the coefficient of an explanatory variable implies that an increase in the associated explanatory variable increases the probability that a crop-share contract is the contract choice (and reduces the probability that a cash contract is the choice).

Risk-related factors

The erosion of soil from a landlord's land is a major concern, unless he anticipates converting it to non-farm uses soon, and according to Allen & Lueck (1992; 1993; 1999), a landlord monitoring for overuse of his leased land is an important transaction cost facing the landlord. In order to capture the effect of this risk, Fukunaga & Huffman (in press) proxy the potential for 'overuse' by a land erodibility index for the county where the tenant resides. Under the transactions cost motive for contract choice,

the landlord is expected to offer a crop-share contract to reduce erosion risk on his land.

However, if the landlord expects to convert his land to non-farm uses in the near future, erosion concerns will be relatively unimportant and he will offer a cash-rental contract (Fukunaga & Huffman, in press). This likelihood of conversion to non-farm uses can be proxied by the Beale-code land use index, a code that ranges from 1 to 9, with 1 indicating the most urbanized areas and 9 indicating the most rural areas. For example, if the code is 1, i.e., the land is urban, then it is reasonable for the landlord to anticipate conversion of his farmland to non-farm uses soon and he will have greatly reduced concerns about erosion under a cash lease. Thus, the landlord will be less likely to offer a crop-share lease. In contrast, if the land is located in a remote rural area, then it is more likely to remain in agricultural use for the foreseeable future, and the landlord is more likely to offer crop-share. Thus, following this concern for future productivity of rented land, landlords in areas with higher Beale-code numbers are more likely to offer a crop-share contract.

As a tenant becomes wealthier, he has larger net worth to withstand a bad harvest under crop share, and the general belief is that if his wealth increases, he becomes less risk averse and is less likely to accept a crop-share contract. However, as a landlord at retirement age gets wealthier, he may prefer to avoid production and marketing risk and lease for cash. Using this reasoning, an elderly and wealthy landlord is expected to offer a cash lease. Proxies for wealth are the value of farm assets and of agricultural land and buildings net of debt (owned assets).

One of the important risks of farming is crop yield variability. Fukunaga & Huffman (in press) proxy this by an indicator of crop yield variability in the area where leased land is located. The USDA's county level annual yield data over 1990 to 1999 (Anon., 2005) were converted into a county average standardized yield variability index using data for the yields of maize, soya bean, hay, common bean, and other crops. Because output units differ across different crops, Fukunaga & Huffman (in press) divided the standard deviation of local county yields by their respective mean values. Finally, using data for the 10-year average share of harvested hectares for each crop, they summed up the standardized deviations and obtained a weighted and standardized yield variability index. Then, as the local yield variability index increases, landlords are less likely to offer crop-share leases whereas tenants prefer crop share in these circumstances. However, if landlords and tenants are risk neutral rather than risk averse, an increase in yield variability will not affect the type of contract that they offer or accept, but risk-averse tenants will be more likely to accept a crop-share contract and risk-averse landlords more likely to offer cash contracts.

Transaction cost factors

Fukunaga & Huffman (in press) argue that proxies for transaction costs include the type of crop-rotation, the number of landlords from which a tenant contracts, the hectares of contracted land, the total value of contracted 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 or not, whether the landlord lives close to the contracted land or not, and the Beale code for the area

where the tenant resides.

In a grain–oilseed crop rotation, Fukunaga & Huffman (in press) argue that a crop-share contract is more likely to be chosen because it is relatively easy for the landlord and tenant to divide the product from the land, as it is not perishable, and hence each of them can market his own share of the product (Allen & Lueck, 1993; 1999). With the landlord having easy access to marketing channels, he is more likely to offer a crop-share contract. On the other hand, if vegetables or fruits are produced on leased land, dividing the output between landlord and tenant is more problematic, as the product is more perishable, which means that transaction costs are high to the landlord for a crop-share contract. Hence, under these circumstances, the landlord is less likely to offer a crop-share contract.

Under modern principal agent theory with unobservable effort, optimal contracts are constructed to be incentive compatible for the tenant (and landlord). Since monitoring is ineffective, it is not undertaken. Under the transaction costs perspective, contracts are constructed to reduce these monitoring costs, which decrease the likelihood of the landlord offering crop share. Fukunaga & Huffman (in press) proxied the landlord-monitoring costs using two variables tied to the location of the landlord relative to his land; whether the landlord lives on his leased land or whether he lives within 5 miles of his leased land. The idea is that landlords who do not live on or near their leased land have higher costs of monitoring the activity of their tenants relative to timeliness of field operations and judicious use of the land (Allen & Lueck, 1993; 1999). Hence, under the transaction cost model, the landlord is less likely to offer a crop-share contract, but under the incentive-compatible principal-agent contract, the landlord knows that monitoring is unnecessary and his residence relative to the leased land is unimportant.

Externalities may arise with tenants who contract with multiple landowners, as is common in the USA and Canada. As the number of contracts a tenant has with landlords increases, the greater the risk to any landlord that farming activities on his land will be conducted at a suboptimal date. Hence, each landlord is less likely to offer a cash contract in these circumstances. Also, as the number of contracted assets (land, buildings and dwellings) increases, the importance of the landlord's land to the tenant increases and represents a larger potential loss to opportunistic behaviour. Hence, crop share is more likely to be offered and chosen.

Data

Fukunaga & Huffman (in press) used as primary data the 1999 US Agricultural Economics and Land Ownership Survey (AELOS; Anon., 2005). It is a relatively 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 USA producers/tenants included in the 1998 Census of Agriculture. Farmers were asked to answer a set of questions and, where relevant, to provide the addresses and names of their landlords. Questionnaires were then sent to this list of landlords. Hence, this procedure made it possible to identify a tenant and a landlord for every contract in the data set. See Table 1

Table 1. Definitions of variables and summary statistics, 1999 US AELOS Data (n = 44,515).

Variables	Definitions	Mean	SD
DEPENDENT VARIABLE			
contract_type	= 1 if contract is cropshare, = 0 if contract is cash rent	0.20	0.40
INDEPENDENT VARIABLES			
Regions			
NE	= 1 if location of tenant's farm is Northeast 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			
grain_oil	= 1 if type of tenant's farm is grain and/or oilseed production	0.39	0.49
tobacco_cotton	= 1 if type of tenant's farm is tobacco and/or cotton production	0.12	0.33
vegetable_fruit	= 1 if type of tenant's farm is vegetable and/or fruit production	0.08	0.27
other_crop	= 1 if type of tenant's farm is other crop production	0.08	0.29
beef	= 1 if type of tenant's farm is beef cattle ranching and farming	0.10	0.30
dairy	= 1 if type of tenant's farm is dairy	0.15	0.36
other_animal	= 1 if type of tenant's farm is producing other animals	0.17	0.37
crop_type	= 1 if grain_oil=1 or tobacco_cotton=1	0.52	0.50
Other tenant's attributes			
t_age	age of tenant	51.65	12.09
t_gender	= 1 if tenant is male	0.98	0.12
t_white	= 1 if race of tenant is white	0.98	0.14
ind_farm	= 1 if type of tenant's farm is individual farm	0.63	0.48
n_family_members	number of family members living in tenant's household	3.17	1.52
t_n_landlords	number of landlords whom tenant contracts with	13.35	19.83
t_total_income_net	tenant's net total income (US$1,000)	206.05	795.27
t_farm_share	= 1 if share of farm income in tenant's household is greater than 75%	0.50	0.50
t_total_assets	value of farm and nonfarm assets in tenant's household (US$100,000)	23.86	67.53
t_share_owned	share of number of acres of land owned by tenant (%)	29.64	26.64
t_dwelling_value	market value of tenant's dwelling on contracted land (US$100,000)	0.08	0.31
t_debt_free	= 1 if tenant has no debt	0.12	0.33
t_da_50	= 1 if tenant's farm debt-asset ratio is greater than 50%	0.13	0.34
Landlord's attributes			
l_age	age of landlord	65.09	14.47
l_white	= 1 if race of landlord is white	0.94	0.23
l_n_tenants	number of tenants whom landlord contracts with	1.36	2.82
l_ope_99	= 1 if landlord operated farm or ranch in 1999	0.11	0.32
l_liv_on_farm	= 1 if landlord lives on contracted land	0.13	0.34
l_liv_close	= 1 if l_liv_on_farm =0 and landlord resides within 8 km from contracted land	0.42	0.49
l_farm_income	= 1 if landlord's net farm income is greater than US$25,000	0.06	0.23

Table 1. (cont'd)

Variables	Definitions	Mean	SD
l_farm_share	= 1 if share of gross farm income in landlord household is 76% or more	0.08	0.27
l_farm_assets	market value of all farm assets owned by landlord (US$100,000)	2.83	9.68
l_total_value	market value of all lands and buildings owned by landlord (US$100,000)	5.50	137.79
l_land_owned	number of units owned by landlord (40 ha)	5.32	34.55
l_debt_free	= 1 if landlord has no debt	0.86	0.35
l_da_50	= 1 if landlord's farm debt-asset ratio is greater than 50%	0.05	0.21
total_value	market value of land and buildings on contracted land (US$100,000)	2.76	9.55
Other factors			
yield_variability	standardized and weighted production variability for county of tenant's residence	0.26	0.10
average_beale	average of Beale code in 1993 and 2003 for county of tenant's residence	4.74	2.48
contracted_area	number of units (40 ha)	2.17	10.91
land_erodibility	erodibility index for county of tenant's residence	2.68	2.72

for a list of the variables and their definitions.

In the data set, the sample unit is not an individual tenant or landlord, *but a particular contract*, and, hence, a tenant may appear more than once in the data set, but always in combination with a different landlord. Likewise, a landlord could appear more than once if he contracts with more than one tenant. After some refinements, the data set included 44,515 landlord–tenant contracts. From the results (Table 1) it appears that the tenants were on average 51.6 years of age and 13.5 years younger than the landlords. Hence, the majority of landlords associated with our contracts were retirement aged. Roughly 70% of the landlords were women, many of them elderly widows whose husbands had been farmers. Forty-two percent of landlords lived near their leased land, but only 11% lived on the premises. The tenants contracted on average with 13 landlords, and the landlords associated with these contracts contracted on average with only 1.4 tenants. These data are a reflection of what happened in the USA over the past four decades: a rapid increase in farm size due to consolidation of existing farmland into fewer farming units. Hence, during the post-War II period it has been atypical to have landlords holding large tracts of land and each owner leasing land to a large number of tenants, as occurred in the post-Civil War era in the southern states of the USA. Individual farmers who rent farmland are typically part-owners who use leased farmland as a means of acquiring sufficient land to take account of scale size in the use of farm machinery.

Empirical results

Our empirical model of landlord–tenant contracting was fitted (Table 2, column 1). The

Table 2. Maximum Likelihood estimation of probit models of crop share contract choice for USA Farmland, 1999 US AELOS Data (n = 44,515). [1]

Explanatory variables	(1) Contract choice: landlord, tenant and other attributes	(2) Contract choice: no landlord attributes	(3) Marginal effect of regressor change on prob. (%) of crops-hare [using coefficients in (1)] [2]
	Value ln(likelihoodfn) = 18,573.12	Value ln(likelihoodfn) = 18,713.34	
Intercept	–4.0460***	–3.9085***	
Regions			
NE	–1.2606***	–1.3207***	–0.01717
MW	–0.5024***	–0.5264***	–0.00684
SR	–0.3806***	–0.4033***	–0.00518
Farm type			
grain_oil	0.3097***	0.3240***	0.00422
tobacco _cotton	–0.0075	0.0198	–0.00010
vegetable_fruit	–0.2823***	–0.2919***	–0.00385
beef	–0.0454	–0.0263	–0.00062
dairy	–0.7333***	–0.7517***	–0.00999
other_animal	–0.3118***	–0.3090***	–0.00425
Tenant's attributes			
t_age	0.0002	0.0005	0.000003
t_gender	0.0112	0.0192	0.00015
t_white	0.2403***	0.2725***	0.00327
ind_farm	0.0198	0.0186	0.00027
n_family_members	–0.0012	–0.0012	–0.00002
t_n_landlords	–0.0100***	–0.0109***	–0.00014
t_total_income_net	<0.0001**	<0.0001***	0.000001
t_farm_share	0.0625***	0.0664***	0.00085
t_total_assets	–0.0019***	–0.0018***	–0.00003
t_share_owned	–0.0047***	–0.0049***	–0.00006
t_dwelling_value	–0.0136	–0.0035	–0.00019
t_debt_free	0.0656***	0.0642***	0.00089
t_da_50	–0.0407**	–0.0378*	–0.00055
Landlord's attributes			
l_age	0.0038***		0.00005
l_white	0.1522***		0.00207
l_ope_99	0.0380		0.00052
l_liv_on_farm	–0.0985***		–0.00134
l_liv_close	–0.1880***		–0.00256
l_farm_income	0.1760***		0.00240
l_farm_share	0.0069		0.00009

Table 2. (cont'd)

Explanatory variables	(1) Contract choice: landlord, tenant and other attributes	(2) Contract choice: no landlord attributes	(3) Marginal effect of regressor change on prob. (%) of crops-hare [using coefficients in (1)] [2]
	Value ln(likelihoodfn) = 18,573.12	Value ln(likelihoodfn) = 18,713.34	
Landlord's attributes			
l_farm_assets	0.0387***		0.00053
l_total_value	–0.0013***		–0.00002
l_area_owned	0.0006		0.00001
l_debt_free	0.0006		0.00001
l_da_50	–0.0463		–0.00063
total_value	–0.0414***		–0.00056
Other factors			
yield_ variability	0.3505***	0.4497***	0.00048
average_beale	0.0318***	0.0361***	0.00043
contracted_area	0.0002	<0.0001	0.000003
land_ erodibility	0.0777***	0.0796***	0.00106

[1] The one, two, or three asterisks to the right of estimated coefficients indicate that a coefficient is significantly different from zero at the 10, 5, and 1% level, respectively. The reference region in the models is the West of the USA.

2 The evaluation of the marginal effects is at these sample means of the regressors (see Table 1), giving a value of the density function of 0.01362.

Source: adapted from Fukunaga & Huffman (in press).

fact that a sizeable number of coefficients in the equation for crop-share contract are statistically significant is evidence that landlords and tenants are risk averse and that transactions costs matter. Moreover, the hypothesis that landlords' attributes are largely unimportant to contract choice is rejected. The unrestricted model for this test and the restricted model under the null hypothesis are reported in Table 2, columns 1 and 2, respectively. The sample value of the χ^2- statistic for this test was 280, and the tabled value of the χ^2- statistic with 13 degrees of freedom at $P < 0.05$ was 27.7.

Returning to the results in column 1 Table 2 the following conclusions can be drawn: (1) the estimated coefficient for the area yield variability (and significantly different from zero) supports the hypothesis that as production variability increases, the probability increases that a crop-share contract is chosen, (2) an increase in the erodibility index of the land increases the likelihood of share tenancy, suggesting that landlords are concerned about conservation of their farmland, (3) the estimated coefficient of the tenant's household income being primarily from farming, increases the probability that crop share is chosen, (4) the estimated coefficients of total tenant assets and the share of operated land that is owned are negative, implying that crop share is less likely to be chosen, and (5) the estimated coefficient for the tenant being

debt-free is positive, indicating that crop share is more likely to be chosen. These results support risk sharing between landlords and tenants.

The tenant's age does not significantly affect contract choice, which is – as we expected – given the pressures for expansion in USA agriculture and landowners selecting against risk-averse tenants. However, the age of the landlord is important, with older landlords showing a slight preference for crop share, other things being equal.

If the landlord's farm income is higher than US$25,000, or the market value of farm land and buildings or hectares owned increases, a crop-share contract is significantly more likely to be chosen. Holding the above variables constant, as the market value of the landlord's land and buildings on leased land increases, the probability of a crop-share lease decreases. These results suggest that landlords are risk averse and that risk sharing is also important to them.

If a tenant's farm is categorized as a grain–oilseed farm, the probability that crop share is chosen increases, and if the tenant's farm is categorized as either a vegetable–fruit farm, a dairy farm or a farm that raises other animals, a crop-share contract is less likely to be chosen. If the landlord lives on or close to the contracted land, a crop-share contract is significantly less likely to be chosen. If the tenant contracts with many rather than one landlord, his transaction costs increase and his landlords face a possible tenant-shirking problem or risk of untimely completion of key farming activities so cash is more likely to be chosen. If the landlord lives on the land he can easily monitor potentially land-degrading activities of a tenant under a cash rental lease, which could terminate an otherwise long-term relationship. This becomes more difficult if he lives many miles away, in which case he would offer a crop-share lease, which has direct incentives for judicious management of the leased land. The estimated coefficient for the local Beale code index is positive (and statistically significant), indicating that as the area where the leased land is located becomes more rural and agricultural, the probability that a crop-share contract is offered increases. These results support the transaction costs hypothesis. Previous empirical studies of landlord–tenant contracting have largely ignored the attributes of landlords. However, as the above summary of results shows, a number of landlord attributes are important in contract choice. Furthermore, in a test of the null hypotheses that landlord attributes do not matter in explaining contract choice, the hypothesis is rejected at $P < 0.01$. The sample value of the associated χ^2-value was 280 (d.f. = 13). The tabled value of the χ^2-value at $P < 0.01$ was 28. Hence, economic analyses of landlord–tenant contracting cannot be taken seriously if they ignore the attributes of landlords – both landlords' and tenants' attributes are important to understanding real contract choice and sustainable contracting relationships.[3]

Using the estimated coefficients from regression (1) in Table 2, the marginal effect of changing an explanatory variable was computed (Table 2, column 3). In assessing the contributions of marginal effects, one must make an assessment of what is the relevant unit. For dichotomous variables, comparing the size of the estimated coefficients is sufficient (column 1), but for continuous variables, it is useful to look at the predicted marginal change associated with a one standard deviation change in the explanatory variable (Table 1). With this scheme as a reference, it is clear that region of the country and type of farm matter a relatively large amount in contract choice. Among

the dichotomous tenant attributes, race is most important, and among the landlord attributes, race, living close to the farm, and having a net farm income greater than US$25,000 matter most. Among the other variables, market value of all farm assets owned by the landlord, the value of land and buildings on the contracted land and the land erodibility index have relatively large marginal effects. Looking at the marginal effects from a different perspective, if the market value of the landlord's land and buildings on the contracted land were to increase by a factor of 1000, other things being equal, the probability that a crop-share contract is chosen would be reduced by half a percent. And if the value of a tenant's total farm and non-farm assets were to increase by a factor of 100,000 the probability of a crop-share contract would be reduced by one-quarter of a percent. It may, however, be unrealistic to think of such large changes while holding all of the other regressors constant.

Discussion

Allen & Lueck (2002) have argued and our results support the fact that the inherent tendency for farmland to erode is a major concern to landlords when leasing their land. Also, our results show that the location of contracted land relative to urban-rural areas, which we interpret as a reflection of the likely future use of the land for agricultural versus non-agricultural purposes, is an important factor in contract choice. Keeping soil erosion at a low rate and land quality high are important to sustainability of land for farming. Moreover, a crop-share contract gives the landowner a role in farm production and management decisions, which can moderate a tenant's aggressive farming tendencies to exhaust future productivity. Other literature can be used to shed more light on the decision to adopt sustainable farming practices such as the use of conservation practices. Some conservation practices have an immediate cost saving effect and a longer term saving effect on soil and water erosion. An example is conservation tillage, which includes planting systems that maintain a significant soil surface cover with crop residues on highly erodible land to reduce soil erosion by water or for controlling wind erosion. Other conservation practices, such as grassed waterways, contour farming and strip cropping, require investment up front and returns in the intermediate to distant future. Building terraces on highly sloped land involves large costs and a long-term payoff period. Clearly, private owner–operators should have the longest planning horizon when considering investments in conservation practices because they can sell the land, but many farmers that own part or all of their land choose to quit farming but to retain ownership.

A number of empirical studies have examined the impact of land tenure on the adoption of conservation practices by USA farmers. Rahm & Huffman (1984), Norris & Baatie (1987), Belnap & Saupe (1988) and Featherstone & Goodwin (1993) have used as the tenure variable 'the share of a farm's acres that are rented' to indicate tenure status on USA farms. Others have used dummy variables to identify operators as full-owners, owner–renters or full renters (Lynne *et al.*, 1988), or to identify fields as owner-operated or tenant-operated (Fuglie & Klotz, 1995). Alternatively, a few studies have conditioned on farm operators (Lee, 1980; Lee & Stewart, 1983; Heimlich, 1985), using dummy

variables to distinguish full-owner operators, part-owner operators, and non-operator landlords. These studies are noteworthy for their lack of evidence other than land tenure matters for use of land conserving practices.

In contrast, Soule *et al*. (2000) have shown that the structure of agriculture as reflected in land use by USA owners and cash and share tenants is important to adoption of conservation practices. In their study of maize producers in the 1996 Agricultural Resource Management Study (ARMS; Anon., 2005), they distinguish conservation practices according to the timing of costs and returns. They show that cash-renters are less likely than owner–operators to use conservation tillage (a residual management practice for highly erodible land, which reduces labour, machinery and fuel costs now and has longer term effects on soil depth) but that tenants operating under a crop-share contract are not.[4] This is as expected because under share tenancy the tenant usually faces incentives for judicious uses of the land because the landlord is involved in production decision making. However, Soule *et al*. (2000) show that both cash and crop-share tenants are less likely than owner–operators to adopt practices that provide benefits only over a medium (or long) length time horizon (e.g., grassed waterways, strip cropping and contour farming on hillsides). These results support the belief that share tenancy has weaker incentives than owner–operators for conservation practice requiring buildings or establishing structures.

In the USA, where real wage rates have been rising and new technologies have size economies, farms are under strong pressure to expand their size of farming operations. With private land ownership, retired farmers, widows of farmers, and non-farm farmland owners may prefer to hold their farmland as part of a portfolio of assets for retirement income rather than to sell it. Hence, it seems implausible to contemplate the possibility of only owner–operators. The current value of farmland reflects conversion to non-agricultural uses in the future, so current land prices may be high relative to cash rental rates or cash equivalent share leases. Hence, farmers at any point in time may prefer that some of the farmland is owned by non-farmers because this permits broader risk sharing. Owning one's farmland is not necessary for being a farmer, nor is it optimal diversification of asset holdings from risk-return trade-off considerations (Anon., 2008).

Conclusions

In countries that have private land ownership, share and cash leases have co-existed for decades. Although share-leases are less frequent in USA agriculture today than 50 years ago, they continue to account for about one-quarter of all leases. Furthermore, in the Midwest where farm consolidation has been occurring relatively rapidly and most of the leased land is for growing maize and soya bean, roughly one-half of the leases are share-leases. Our results have shown that both contracting with a goal of reducing transaction costs and setting incentives for effort under risk sharing are needed to explain actual contracting in the United States of America. Furthermore, we found that attributes of tenants and landlords that affect the size of potential transaction costs and risk-sharing incentives affect the probability that a crop-share contract is

chosen. Our work furthermore has shown that the attributes of landlords affect the contract that is chosen, something that has frequently been ignored in landlord–tenant contracting. For example, if landlords live on or close to the land that they lease, the rental contract is less likely to be a crop-share one. Also, if the market value of the land and buildings contracted increases, the probability of a crop-share contract is reduced. Moreover, we summarized results showing that the choice of conservation practices on farmland is related to land tenancy: farms operated by owners, share tenants and cash tenants see the adoption of soil conservation practices differently, with share tenants behaving more like owners than cash tenants. Thus, a hybrid model of landlord–tenant contracting is central to sustainable land tenure and land productivity.

The share contract remains a contract that is more robust to unexpected changes in output prices, input prices and crop yields than the cash lease. The reason is that a fixed sharing arrangement sets the rental rate as a share of the output (and pre-determined share of production expenses). Hence, these contracts can be expected to be serviceable over a much longer time period without modification than a cash rental contract that sets as a fixed nominal annual payment per year for the use of land. And in fact, the empirical evidence for the USA is that share leases have on average been in effect for significantly longer periods than have cash leases. The ideal environment for cash leases is one with stable input and output prices and crop yields.

So we conclude that under diverse economic conditions crop-share contracts are long-run sustainable contracts relative to cash leases. Moreover, they create stronger incentives for long-term sustainability of land quality for agricultural purposes because of the direct involvement of landlords in production and management decisions. Hence, extension agricultural economists should undertake an education programme to help land owners better understand the advantages and disadvantages of crop share and cash leases under diverse economic, technical, climatic, ecological and political conditions. However, for land owners who are in the conservative and late phase of their life, cash leases seem likely to provide the certainty of income that they need to meet retirement expenses and relief from the burden of participatory management.

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Notes

1. In Iowa under a crop-share lease, the dominant contract is without a fixed term, landlord and tenant share fifty–fifty the output produced and production expenses (for seed, liming, fertilizer, herbicide, insecticide and any custom pesticide application). See Edwards *et al.* (2004). It is the custom that if the landlord or tenant is going to terminate the lease, notification must be given in August before the next crop year, which starts officially 1 March. See Allen & Lueck (1999) for information on share contracts in some other locations of the USA.
2 Our landlord–tenant contracts contain an incentive for the landlord and tenant to follow through on their agreement, i.e., they are incentive compatible. Also, repeat contracting is important in landlord–tenant relations and this creates trust between parties.
3 Although the explanatory variables vary in their degree of correlation with each other, this does not permit individual explanatory variables from having statistically significant coefficients.
4 Conservation tillage in this study includes any tillage and planting system that leaves 30% or more of the soil surface covered with crop residue to reduce soil erosion by water or, for control of wind erosion, maintains at least 1120 kg per hectare of small-grain-residue equivalent on the surface throughout the critical wind erosion period.