Journal of Agricultural and Resource Economics 24(2):536–552

Searching for Ratchet Effects in Agricultural Contracts

Douglas W. Allen and Dean Lueck

In a dynamic contracting environment, increasing standards over time in light of past performance is known as the *ratchet effect.* Despite the recent theoretical attention given to the ratchet effect, models that include these effects have not been empirically tested against contract data. In this study, we use farm-level data on modern Great Plains agricultural cash rent and cropshare contracts to test for the presence of ratchet effects in the context of a principal-agent model with moral hazard. We find limited evidence for the ratchet effect within share contracts, and no evidence that it is important for the choice of contract between cash rent and cropshare.

Key words: moral hazard, principal-agent model, ratchet effect

Introduction

> *The tendency for performance standards to increase after a period of good performance is called the ratchet effect.*
>
> — Milgrom and Roberts, p. 232

The economic theory of contracts continues to evolve, and in the past 20 years, work on dynamic contract issues has become more common. The bulk of this literature relies on the standard principal-agent model where an uninformed principal deals with an informed agent. In such a model, a principal designs an optimal contract that is both incentive-compatible and profit-maximizing. In general, the optimal contract provides incentives for the agent, so that higher levels of output lead to higher levels of pay. In a dynamic context, the principal and the agent engage in a series of contracts over time. If the principal does not commit to constant contractual terms, then as he collects information on past performance, the principal uses this information to set new standards of agent behavior in order to increase wealth. This increase of standards over time in light of past performance is known as the *ratchet effect.*

The term "ratchet" comes from early studies of manufacturing in the Soviet Union, where planners would often penalize plant managers for increased output—claiming the higher output proved "shirking" in earlier periods.[1] From these earlier studies, and from

Allen is professor, Department of Economics, Simon Fraser University, Burnaby, British Columbia, and Lueck is associate professor, Department of Agricultural Economics and Economics, Montana State University, Bozeman. The authors are grateful for the comments of Nabil Al-Najjar, Chuck Knoeber, Richard Manning, Randy Rucker, Nick Schmitt, Wally Thurman, and Fanis Tsoulouhas. Support for this project came from the National Science Foundation and the Social Science and Humanities Research Council of Canada.

[1] See Berliner for a Soviet application, and Weitzman, and Baron and Besanko for early formal analyses. We examine the ratchet effect in a model with moral hazard, similar to that used by Meyer and Vickers. Other theoretical studies examine this effect in models with adverse selection where the ratchet effect leads to excessive pooling equilibria (e.g., Freixas, Guesnerie, and Tirole; Kanemoto and MacLeod; and Salanié). The general issue in the case of moral hazard or adverse selection is whether or not there is commitment by the contracting parties in a multiperiod relationship.

the theoretical literature, it is well known that using past performance to define future standards creates incorrect incentives for the agent. As a result, in order for optimal (first-best) contracts to emerge, it is important that the principal be able to commit to a stable multiperiod contract.

Commitment to contract terms is critical because when agents anticipate the ratchet effect, they lower their efforts in the current period given that they expect to be punished in the future. This lower level of effort reduces the joint value of the contract and, as a result, provides the incentive for principals to commit themselves to the terms of a contract when dealing with the *same agent over time*.[2] On the other hand, when information is produced by one agent who then leaves, and then a new agent is hired, the principal may exploit what was learned with the past employee by increasing the new agent's incentives within the contract.[3] In this case, there is no reduction in effort in the first period because there is a different agent in each period. This change in contract terms in the second period reflects the better information about the relative contributions of the new agent and the random inputs of nature. More specifically, the better information results in a lower estimated variance of performance in the second period. A lower estimated variance implies the principal makes fewer mistakes in separating the agent's contribution to output from nature's contribution.

Principal-agent models that incorporate a ratchet effect lead to a rather strong prediction regarding the dynamic structure of contracts.[4] When there is a *new* agent, and past performance reveals useful information about the current period, then contract incentives should strengthen over time, with the fixed payment to the principal also increasing over time.[5] However, when the principal continually contracts with the same agent, then the contract incentives and effort levels should remain constant. Milgrom and Roberts characterize this contract structure as follows:

> The theory thus predicts that when the parties write contracts for one period at a time and when past performance embodies useful information for evaluating future performance, incentives will become more intense over time, as the parties utilize past experience to incorporate more accurate performance expectations in their contracts.... [T]he actual effort levels elicited from the worker will also rise over time.... The argument ... is only correct, however, if there is a new occupant in the job in each period (p. 234).

Despite the recent theoretical attention given to the ratchet effect, models that include these effects have not been empirically tested against contract data.[6] In this

---

[2] Methods of commitment may take different forms, including long-term agreements, reputation, and specific investments. Kanemoto and MacLeod show how competition from older workers can ameliorate the ratchet effect under some circumstances.

[3] The principal is made better off from the new knowledge; hence the fixed side payment made by the agent to the principal must also increase with the incentives in the contract.

[4] Refutable implications arising from dynamic models, like the ratchet effect, are rare. This may explain the common use of adjectives such as "celebrated" (Salanié, p. 158) in discussions of the ratchet effect.

[5] In a standard principal-agent model, lower standards over time are not possible. This is because informed agents would never accept the initial contract if it contained performance standards that were too high and violated their individual rationality constraints.

[6] Much of the ratchet literature still examines Soviet-style organizations. More recently, however, the applications have expanded to include the U.S. military (Ickes and Samuelson), private ownership (Olsen and Torsvik), and labor markets (Kanemoto and MacLeod). The analysis of ratchet effects is now found in theoretical textbooks (e.g., Milgrom and Roberts; Laffont and Tirole; and Salanié).

analysis, we use farm-level data on modern Great Plains agricultural cash rent and cropshare contracts—classic examples of a principal-agent relationship—to test for the presence of ratchet effects.

A Two-Period Model of Farmland Contracts with Ratchet Effects

We use a two-period principal-agent model of farmland contracting, adapted from Milgrom and Roberts, to clarify the ratchet effect and demonstrate its testable implications. We make the following assumptions: (*a*) the landowner (principal) is risk neutral and the farmer (agent) is risk averse, (*b*) all cost and revenue functions are the same each period, (*c*) there are no wealth effects, (*d*) there is no discounting, and (*e*) nature draws from the same distribution in both periods. These are the standard assumptions made in a dynamic principal-agent model in order to focus on the ratchet effect. The no-wealth-effect assumption implies that the coefficient of risk aversion is constant, and that the optimal contract maximizes the total certainty equivalent income, subject to any incentive constraints.[7]

Furthermore, we assume there is a pool of homogeneous farmers, which rules out adverse selection and leaves only a moral hazard problem.[8] Farmer moral hazard exists because nature plays a large role in agricultural production, and because farmer effort is costly to observe. Pests, weather, and other seasonal effects often have large impacts, and can disguise the true effort of a farmer. Over time, however, landowners become more knowledgeable about nature, and they might use this information to alter the contract in their favor.

In modern agriculture, landowners often rent out their land to farmers, and two forms of incentive contracts dominate—cropshare and cash rent contracts. In principle, a cash rent contract is the limiting case of a share contract, where the share to the farmer reaches 100%, and the only payment to the landowner is the fixed rent. In practice, however, modern cropshare contracts seldom have shares greater than 80%.[9] Hence, there are two potential ways in which a ratchet effect might manifest itself. First, there may be a ratchet effect in the choice of one type of contract versus another. Second, the ratchet effect might arise within share contracts. We search for ratchet effects in both contexts, beginning with the choice between cash rent and cropshare contracts, and then examining the ratchet effect within cropshare contracts alone.

---

[7] We make these assumptions to focus on the ratchet effect. The ratchet effect, however, does not depend on any of the classic principal-agent assumptions. In particular, risk aversion is not necessary. A ratchet effect can exist in more complicated multiple moral hazard models and models of adverse selection without the assumption of risk aversion. For an example of a ratchet effect model with moral hazard and no risk aversion, see Meyer and Vickers.

[8] This is a reasonable assumption in the context of farming. For the two states that we examine, farmers are demographically very similar. Also, the use of tractors and other types of farm machinery tends to equalize the ability to farm, as sheer physical strength is less of a factor. We recognize that farmers are literally not identical and that, as a result, some learning will take place over time for the landowner regarding the farmer.

[9] A share contract often requires the farmer to pay a fraction of the nonlabor input costs such as seed and fertilizer (Allen and Lueck 1993). A cash rent contract requires the farmer to pay for all inputs.

Table 1. Summary of Dynamic Contracting Cases

Contracting Case	Landowner committed to consistent contract?	Constant effort and incentives each period?	Presence of ratchet effect?	Empirical Implementation
Case I	Yes	Yes	No	Same agent in both periods
Case II	No	No	Yes	Different agent in each period

Cash Rent versus Cropshare Contracts

In agricultural land leasing where farmers and landowners contract over the use of land and where the choice is between share contracts and cash rent contracts, the principal-agent model with ratchet effects suggests that new farmers are more likely to lease land with cash rent contracts, since cash rent contracts are higher powered; that is, they have stronger agent incentives. When cash rent contracts are used with *new* farmers, landowners can exploit the information obtained over past seasons with *previous* renters and still maintain the reservation income of those who currently work the land.[10]

To show this, assume the contract between the farmer (agent) and landowner (principal) generates the following income function for the farmer in each period:

$$Y = \alpha Q - \beta - C(e) \geq \overline{Y}, \tag{1}$$

where Y is the income to the farmer, $\overline{Y}$ is the farmer's reservation income from another plot of land, α is the farmer's share of output Q, β is a side payment to the landowner, $C(e)$ is the farmer's effort cost function, and the price of output is normalized to one. In each period $i \in \{1, 2\}$, observed output is $Q_i = e_i + \theta_i$, where e_i is the unobservable effort of the farmer, and $\theta_i \sim (0, \sigma^2)$ is a random input, caused by nature.[11] A cash rent contract implies $\alpha = 1$ and $\beta > 0$, while a share contract implies $\alpha \in [0, 1]$ and $\beta \in (-\infty, \infty)$. A cash rent contract is a pure *high-powered* contract, because the farmer is the complete residual claimant. A share contract has *lower-powered* incentives since $\alpha < 1$.

We examine two moral hazard models that generate the second-best outcomes summarized in table 1. In Case I, the landowner commits to maintaining the contract over two periods, while in Case II there is no such commitment. Case I corresponds to the situation of an ongoing landowner-farmer relationship, while Case II corresponds to a new farmer dealing with an established landowner in period 2. In both cases, farmers exert less than the first-best level of effort, and the optimal share is less than one. Compared to the first-best optimum, there is less effort because the farmer does not own the entire output and there is moral hazard.

[10] The ratchet effect appears to grind against Spillman's 1919 "ladder hypothesis" that implies young farmers start with cropshare contracts, move on to cash rent contracts, and eventually have sole ownership of the farm. However, the two concepts are not necessarily at odds. With models that incorporate the ratchet effect, a *new* tenant farmer is not the same as a *young* tenant farmer.

[11] This simple production function allows us to focus on the ratchet effect without adding superfluous complications. See Meyer and Vickers for a similar setup.

Case I: Dynamic Commitment

First, consider the case where the landowner ignores any new information when deciding what incentives to set in period 2, so there is no possibility of a ratchet effect. This is equivalent to having (dynamic) commitment to the terms of the contract over the two periods. Given the assumption of no wealth effects, the optimal contract maximizes the total certainty equivalent income of the farmer and the landowner, subject to the incentive-compatibility constraints for each period.[12] As a result, the optimal contract follows from:

$$\max_{e_1,e_2} TCE = Q(e_1) + Q(e_2) - C(e_1) - C(e_2) - \tfrac{1}{2} r \mathrm{Var}(\alpha_1\theta_1 + \alpha_2\theta_2), \tag{2}$$

$$\text{s.t.: } \alpha_1 = C'(e_1) \text{ and } \alpha_2 = C'(e_2),$$

where r is the constant coefficient of absolute risk aversion. Since the problem is symmetric across periods, and since by assumption $\mathrm{Var}(\theta_1) = \mathrm{Var}(\theta_2)$, the optimal solution requires $\alpha_1 = \alpha_2$, and $e_1 = e_2$. This means that the contract has identical incentives and work effort of the farmer in each period.

Case II: No Commitment over Time

Now consider the case in which two one-period contracts are made sequentially, and the landowner learns about the relative contribution of nature by observing the output in the first period. In this case, there is no commitment to the terms of the contract over the two periods. Following Milgrom and Roberts, we model the acquisition of information by assuming there is a positive correlation between the values of the random inputs (θ_1 and θ_2) in the two periods; that is, a high value of θ_1 suggests a high value of θ_2 is likely. This means that the landowner can use observed performance in the first period to get an estimate ($\hat{\theta}_2$) of the random input in the second period (θ_2). In turn, this estimate ($\hat{\theta}_2$) can be used to obtain a better estimate of the farmer's actual effort in the second period (e_2).[13]

Let the landowner's estimate of θ_2 be given by $\hat{\theta}_2 = \gamma(e_1 + \theta_1)$, where γ is an adaptive expectation of the landowner, used to estimate nature's contribution to farm output in the second period. The landowner's estimate of second-period output in terms of second-period effort becomes $\hat{Q}_2 = Q_2 - \hat{\theta}_2 = e_2 + \theta_2 - \hat{\theta}_2$. The landowner now uses this information to adjust the contract so that the farmer's compensation (gross income) over the two periods becomes:[14]

$$Y = \left[\beta_1 + \alpha_1 Q_1\right] + \left[\beta_2 + \alpha_2 \hat{Q}_2\right]. \tag{3}$$

---

[12] The certainty equivalent for the farmer is simply his average pay minus his risk premium and cost of effort.

[13] This simple specification of the correlation in random inputs can easily apply to agriculture where the effect of nature is often relatively straightforward. For example, a particular hay field may have poor drainage or slope which leads to poor drying conditions and reduced hay output. Knowledge of this information gained in the first period helps the landowner better estimate the drying contribution of nature in the second period. Although the role of nature is straightforward, we do not imply that the landowner can learn everything in a short period of time.

[14] Because we focus on gross income, the $C(e)$ term is gone. This simplifies the analysis without altering the predictions.

After substituting $\{Q_1 = e_1 + \theta_1\}$, $\{\hat{Q}_2 = e_2 + \theta_2 - \hat{\theta}_2\}$, and $\{\hat{\theta}_2 = \gamma(e_1 + \theta_1)\}$, and collecting terms, the compensation function (3) can be rewritten as:

$$Y = \left[\beta_1 + (\alpha_1 - \gamma\alpha_2)(e_1 + \theta_1)\right] + \left[\beta_2 + \alpha_2(e_2 + \theta_2)\right]. \tag{4}$$

It is clear that the *effective* share coefficient on first-period effort (e_1) is not the nominal contract amount (α_1) paid under the case of commitment, but a smaller net amount ($\alpha_1 - \gamma\alpha_2$). In terms of first-period compensation, the direct return to additional effort is α_1, but greater effort in the first period leads to a reduction in compensation for second-period effort by $\gamma\alpha_2$. This means the share in the first period is lower than the share in the second period.[15] *This is the ratchet effect.* The incentives for farmer effort are increased (or become more high powered) from period 1 to period 2. In other words, the farmer's share of output is "ratcheted up" over time as long as there is no commitment to contract terms and the landowner can learn about the value of the random input.[16] In the case where the farmer's incentive increases to the point where $\alpha_2 = 100\%$, the contract has switched from a share contract to a cash rent contract.

Thus far, the model has been specified in terms of the landowner's ability to commit to a contract or not. When there is commitment, there are constant incentives or shares across periods. When there is no commitment, there is the ratchet effect or rising shares over time. In order to operationalize this model, we consider commitment as equivalent to an *ongoing* relationship between a farmer and a landowner. When a farmer and landowner have an ongoing relationship, they have an incentive to avoid the ratchet effect, and we expect that they will commit to consistent contract terms over time. On the other hand, if there is a new tenant farmer, there is no commitment, and an opportunistic landowner will fully exploit his knowledge based on past information. In this case, incentives should be higher than with the past tenant farmer.

An additional implication of this reasoning is that if a *new landowner* is involved in the second-period contract, then constant incentives should be used because he will be unable to accurately measure the past performance on the farm. Over the two periods the ratchet effect will be absent because a change in landowners means that the principal is not able to acquire information about the agent's past performance. This leads to two predictions about the choice of a contract:

- PREDICTION 1. *New farmers contracting with established landowners are more likely to cash rent land.*

- PREDICTION 2. *New landowners contracting with either new or established farmers are more likely to cropshare.*

---

[15] This model does not imply the contract would have a complicated formula whereby the share in the second period would be 50% plus some fraction of the share in the first period. We would simply observe two sequential share contracts that might give the first farmer 50% of the crop in the first year, and then observe a second farmer getting 60% of the crop in the second year.

[16] The benefit of the acquired information is the reduction in the variance in the landowner's estimate of the value of random input; that is, $\mathrm{Var}(\theta_2 - \hat{\theta}_2) < \mathrm{Var}(\theta_2)$. When the landowner has a better measure of the random input, he has a more accurate picture of the farmer's contribution as well, and can better alter the contract to increase his returns. Hence, although the share to the farmer increases, the side payment to the landowner also increases, making the landowner better off.

The Terms of Share Contracts

A ratchet effect might also lead to changes in the terms of a cropshare contract, without causing a switch to cash rent contracts. Because the formal analysis in this context is similar to the contract choice model, we explicitly analyze only Case II (no commitment). To begin, we simplify by replacing the side payment with an input cost share. Although modern share contracts do not often have side payments, they routinely share nonlabor input costs (Allen and Lueck 1993). As a result, the income for a farmer with a share contract becomes:

$$Y = \alpha Q - \delta K - C(e) \geq \overline{Y}, \tag{5}$$

where $\delta \in (0, 1)$ is the share of input costs borne by the farmer, K represents aggregate nonlabor input costs (e.g., fertilizer, seed), and $Q_i = e_i + K_i + \theta_i$ in each period to include noneffort inputs.[17]

The farmer's two-period compensation without commitment is now:

$$Y = \left[\alpha_1 Q_1 - \delta_1 K_1\right] + \left[\alpha_2 \hat{Q}_2 - \delta_2 K_2\right], \tag{6}$$

where δK replaces the side payment β. As above, a series of substitutions—$\{Q_1 = e_1 + K_1 + \theta_1\}$, $\{\hat{Q}_2 = e_2 + K_2 + \theta_2 - \hat{\theta}_2\}$, and $\{\hat{\theta}_2 = \gamma(e_1 + K_1) + \theta_1\}$—allows us to rewrite the compensation function as:

$$Y = \left[(\alpha_1 - \gamma\alpha_2)(e_1 + K_1 + \theta_1) - \delta_1 K_1\right] + \left[\alpha_2(e_2 + K_2 + \theta_2) - \delta_2 K_2\right]. \tag{7}$$

Since the structure of this problem is identical to the contract choice problem, the structure of the solution is also identical. As before, it is clear that the effective share coefficient on first-period effort (e_1) is not the nominal contract amount (α_1), but a smaller amount ($\alpha_1 - \gamma\alpha_2$). This implies that effort and the actual shares increase over time. Again, this is the ratchet effect. When there is no commitment, output shares (α) will be higher for new farmers. Notice that equation (7) also implies that the input cost shares remain *constant* over time. In contrast, if a new landowner is involved in the contract, he has no knowledge of past performance, and consequently that landowner should not provide the farmer with higher-powered incentives. The ratchet effect, therefore, plays a similar role within share contracts in terms of incentives increasing over time, which leads to the second set of predictions:

- PREDICTION 3. *New farmers should receive a higher output share than farmers with ongoing contracts; however, input cost shares should remain constant.*

- PREDICTION 4. *New landowners should not change the output shares to their farmers compared to established landowners.*

[17] We assume, for simplicity, that the inputs K_i are observable. This leads to a strong prediction about input shares over time. This prediction, however, is not found elsewhere in the ratchet literature, and does not hold if inputs are assumed unobservable. Our purpose here is to focus on output shares.

Empirical Analysis

To test our four predictions, we use contract data from the "1986 Nebraska and South Dakota Leasing Survey" (see Johnson et al.). A description of the data, as well as definitions and means of the variables used, can be found in the appendix. Each observation represents a single farmland contract between a farmer and a landowner for a given plot of land. There are 3,432 contracts in total, of which 2,424 are cropshare and 1,008 are cash rent. Of these, 264 cropshare contracts and 29 cash rent contracts had new farmers within five years of the survey. In addition, 115 cropshare and 38 cash rent contracts had new landowners within five years of the survey. The data set provides information on whether input and output shares changed, and the direction of the change for output shares.

Ideally, to test the ratchet effect, we would like a panel data set containing information on contract terms as well as farmers and landowners. However, because our cross-section data include retroactive information, they are well suited to test the predictions from the ratchet effect model. In particular, the data contain information on the history of tenant farmers over the five years prior to the survey. This is the critical piece of information that allows us to test for ratchet effects because we know whether or not there has been a change in the tenant farmer or the landowner. Hence, the two periods in our model correspond to the periods with the old and new farmer, i.e., period 1 corresponds to the old farmer, and period 2 corresponds to the new farmer.

We use these data to test the predictions of our model by estimating the effects of new farmers and landowners on contract choices and on the terms of cropshare leases. In general, the ratchet effect predicts that cash rent contracts should be more common, and output shares should be higher in the second period. For this estimation we also use the variables *ACRES*, *AGE*, *FAMILY*, *HAY*, *INPUTS CHANGED*, *IRRIGATION*, *POP DENSITY*, *ROW CROP*, and *YEARS* to control for farm size, farmer's age, whether or not contracts are between family members, the presence of hay, whether the number of inputs changed, the presence of irrigation, local population density, the type of crop, and the number of years the landowner and farmer have contracted with each other. These variables are chosen based on past work which not only provides a theoretical rationale for including them, but also shows that they are empirically relevant (Allen and Lueck 1992a, 1992b, 1993). In particular, including *AGE* allows us to control for the effects of farming experience, and assures that our *NEW FARMER* variable is representing farmers who are new to the plot of land. We test these predictions using the entire contract sample, as well as several subsamples.

Cash Rent versus Cropshare Contracts

To test Predictions 1 and 2, we use a sample that contains both cropshare and cash rent contracts.[18] Table 2 presents the results of several logit regressions on the choice of contract. The dependent variable in all cases is one if the contract is cropshare, and zero

[18] Cropshare contracts usually do not contain a side payment. Nevertheless, we can still use these data to test the ratchet effect model, because inputs are shared and adjustments can be made to input shares that are equivalent to adjusting fixed payments. The second model in this study demonstrated how simply the model can be adjusted along these lines.

Table 2. Logit Estimates on Contract Choice (dependent variable = 1 if share contract, 0 if cash rent contract)

Independent Variables	Estimated Coefficients: Full Sample	Non-family Sample	Oral Sample	Annual Sample	Predicted Sign
Ratchet Effect Variables:					
NEW FARMER	0.24	0.25	0.23	0.23	–
	(1.48)	(1.12)	(0.98)	(0.65)	(Prediction 1)
NEW LANDOWNER	0.06	-0.14	-0.16	-0.44	+
	(0.30)	(-0.47)	(-0.58)	(-1.06)	(Prediction 2)
Control Variables:					
ACRES	0.42	0.75	0.80	1.00	
	(0.45)	(1.42)	(4.39)	(0.74)	
AGE	0.10	0.09	0.13	0.14	
	(3.60)	(2.31)	(3.52)	(2.49)	
FAMILY	-0.02	—	-0.33	-0.003	
	(-0.26)		(-2.65)	(-0.03)	
HAY	-0.36	-0.40	-0.54	-0.65	
	(-3.01)	(-2.41)	(-3.36)	(-2.57)	
INPUTS CHANGED	-0.26	0.20	-0.08	0.83	
	(-1.03)	(0.49)	(-0.20)	(0.76)	
IRRIGATION	-0.96	-1.16	-1.00	-1.35	
	(-8.22)	(-6.89)	(-6.44)	(-5.26)	
POP DENSITY	-0.001	-0.001	-0.001	-0.001	
	(-1.98)	(-0.91)	(-1.94)	(-1.56)	
ROW CROP	2.76	3.20	2.54	2.86	
	(28.30)	(22.40)	(19.42)	(13.67)	
YEARS	0.03	0.03	0.02	0.02	
	(6.50)	(4.23)	(2.53)	(2.07)	
Constant	-0.50	-0.92	-0.57	-0.41	
	(-4.14)	(-4.06)	(-2.39)	(-1.18)	
-2 Log Likelihood	4,155	2,358	2,218	986	
Percent Correct Predictions	81.56	83.58	81.81	83.42	
No. Observations	3,432	1,912	2,067	947	

Note: Numbers in parentheses are asymptotic *t*-statistics.

if the contract is cash rent. The first column of numbers presents the results using the entire contract sample. The other logit estimates are undertaken for three additional subsamples: contracts for which the farmer and landowner are unrelated (column 2), only oral contracts (column 3), and annual or short-term contracts (column 4).

Each of these subsamples allows us to control for various factors that might influence the magnitude of the potential ratchet effects. In each case, the ratchet effect is expected to be larger than the full sample case. For example, it might be expected that the ratchet effect is stronger with unrelated individuals because more information is known about

Table 3. Summary Statistics for New Farmers and New Landowners Within Share Contracts

	Only a New Farmer		Only a New Landowner	
Variables	Number	Percent	Number	Percent
Total Sample	264	100.0	115	100.0
Share of inputs changed	47	17.8	18	15.7
No. of shared inputs changed	37	14.0	8	7.0
Lease changed to cropshare	36	13.6	10	8.7
Farmer's share decreased	15	5.7	10	8.7
Farmer's share increased	20	7.6	5	4.3

family members to begin with, and ratcheting-up incentives on relatives may be frowned on within a family. Conversely, oral contracts involve less commitment, and as a result, ratchet effects should be more common. Likewise, shorter annual contracts may imply less commitment and a higher likelihood of ratchet effects.

We test for ratchet effects by including the variables *NEW FARMER* and *NEW LANDOWNER* in the logit regressions. In all cases, Prediction 1 implies a negative coefficient for the *NEW FARMER* variable, yet the estimated coefficient for *NEW FARMER* is positive and statistically insignificant (table 2). This indicates that in contracts where we use the variable *NEW FARMER* to identify situations of a lack of commitment, there is no ratchet effect. Prediction 2 implies that the presence of a new landowner should increase the probability of a share contract. Although the estimated coefficient for *NEW LANDOWNER* has the expected sign in the full sample, it is also statistically insignificant. These insignificant results hold not only in the full sample case, but also in each of the subsample cases where ratchet effects should have been more likely to occur. Overall, then, the estimates shown in table 2 fail to reject the null hypothesis of no ratchet effects, and suggest that the threat of a ratchet effect has virtually no impact on the choice of land leasing contract.

Changes in Share Contracts

The second set of empirical tests examines the determinants of particular sharing rules within cropshare contracts in order to test Predictions 3 and 4. Table 3 reports some summary statistics for cases in which a new landowner or farmer is involved in the cropshare contract. The data in table 3 are generally inconsistent with ratchet effects existing *within* the set of all share contracts. First, when there is a new farmer, both input cost shares and the number of inputs changed, refuting Prediction 3 which states they should remain constant. However, the output share to the farmer increased more often than it decreased, which is consistent with Prediction 3. Furthermore, when there is a new landowner, input cost shares changed less often, and output shares decreased more often than they increased. These summary statistics are generally inconsistent

with a ratchet effect; however, the difference in proportions between the two samples is *not* statistically significant.[19]

To further test Predictions 3 and 4, we use several samples containing only share contracts to estimate the following model:

$$\ln(\alpha/(1 - \alpha)) = \mathbf{Z}\phi + \varepsilon, \tag{8}$$

where α is the farmer's share of the output, $\mathbf{Z}$ is a row vector of explanatory variables, ϕ is a column vector of unknown coefficients, and ε is an error term.[20] This equation has two relevant variables: *NEW FARMER* and *NEW LANDOWNER*. Under Prediction 3, the expected sign for the estimated coefficient of *NEW FARMER* is positive, since a higher share means the contract has higher power. Prediction 4 implies a negative sign for the estimated coefficient of *NEW LANDOWNER*. Table 4 presents the results from four OLS estimations of equation (8). As with the regression results from table 2, there is no consistent support for the ratchet effect within share contracts. The estimated coefficients for *NEW LANDOWNER*, although negative as predicted by Prediction 4, are statistically insignificant. The estimated coefficients for *NEW FARMER* are statistically insignificant at the 5% level, and have the wrong sign in two cases.

Predictions 3 and 4 also can be tested by estimating the probability that a farmer's cropshare changed in the recent past. Table 5 shows the estimated coefficients from a logit regression in which the dependent variable is one if the farmer's share increased within the last five years. The estimates show limited support for the presence of ratchet effects. First, the estimated equation shows that *NEW FARMER* is positively related to rising farmer shares, consistent with Prediction 3. Second, the estimated equation also shows that *NEW LANDOWNER* is positively related to rising farmer shares, inconsistent with Prediction 4.

Discussion: Economic Significance and Other Variables

Two separate tests of ratchet effects have been conducted. The first examined whether contracts would be switched from low-powered share contracts to high-powered cash rent contracts, and the second looked at whether shares would be increased when a new farmer started farming the land. In both cases, virtually no evidence of a ratchet effect was found. Furthermore, the magnitude of the estimated coefficients for the two variables *NEW LANDOWNER* and *NEW FARMER* were dwarfed by the size of the estimated coefficients of the other variables in the regression, suggesting that ratchet effects have little economic significance. From table 2, we see that several nonratchet variables have much larger coefficients. In particular, the coefficient on the binary variable *ROW CROP* is almost 11 times larger than the coefficients for the binary ratchet variables. From table 4, even in the full sample case where output shares do rise

[19] Allen and Lueck (1993) conducted one of the few empirical studies on input shares in cropshare contracts. They found a strong positive relationship between the number of inputs shared and the farmer's output share, as well as a strong positive relationship between the size of the farmer's input cost share and the farmer's output share.

[20] We use the log of the odds ratio to create a nonlimited dependent variable, since the share is naturally bounded from zero to one.

Table 4. OLS Estimates of Output Share in Share Contract Sample (dependent variable = ln[*SHARE*/(1 – *SHARE*)])

Independent Variables	Estimated Coefficients: Full Sample	Non-family Sample	Oral Sample	Annual Sample	Predicted Sign
Ratchet Effect Variables:					
NEW FARMER	0.05	0.07	-0.02	-0.06	+
	(1.19)	(1.69)	(-0.38)	(-1.32)	(Prediction 3)
NEW LANDOWNER	-0.02	-0.04	-0.05	-0.04	–
	(-0.42)	(-0.68)	(-0.82)	(-0.56)	(Prediction 4)
Control Variables:					
ACRES	-0.00001	-0.00002	-0.00004	-0.00003	
	(-1.04)	(-1.43)	(-1.13)	(-1.57)	
AGE	0.01	0.01	0.004	0.007	
	(1.57)	(0.79)	(0.025)	(0.77)	
FAMILY	0.03	—	-0.04	0.02	
	(1.20)		(-1.44)	(0.65)	
HAY	0.05	0.05	0.06	0.04	
	(1.74)	(1.40)	(1.83)	(1.11)	
INPUTS CHANGED	0.002	-0.05	-0.02	0.07	
	(0.004)	(-0.73)	(-0.23)	(0.93)	
IRRIGATION	0.04	-0.002	0.02	0.04	
	(1.34)	(-0.06)	(0.62)	(1.12)	
POP DENSITY	-0.0003	-0.0004	-0.0003	-0.0005	
	(-2.39)	(-2.39)	(-1.73)	(-2.10)	
ROW CROP	-0.23	-0.19	-0.13	-0.20	
	(-6.70)	(-4.67)	(-3.25)	(-4.27)	
YEARS	0.004	0.003	0.004	0.005	
	(2.86)	(2.36)	(3.14)	(3.34)	
Constant	0.48	0.49	0.50	0.47	
	(8.96)	(8.00)	(7.68)	(6.67)	
Adjusted R^2	0.025	0.027	0.014	0.021	
F-Statistic	6.71	4.71	3.01	4.11	
[d.f.]	[11, 2,412]	[10, 1,314]	[11, 1,584]	[11, 1,606]	
No. Observations	2,423	1,324	1,595	1,617	

Note: Numbers in parentheses are *t*-statistics.

with the presence of new farmers, the effect of *NEW FARMER* and *NEW LANDOWNER* is not as large as that associated with the choice of crop.[21] Hence, in addition to the lack of statistical significance, the small coefficient size also suggests that these two variables have a small economic impact, and that the ratchet effect is unimportant in the context of this contracting example.

[21] Allen and Lueck (1992b, 1993) found that the choice of a row crop where the soil is worked intensively was the single most important variable explaining the choice of contract.

Table 5. Logit Estimates of Changes in Share Contracts (dependent variable = *SHARE-UP*)

Independent Variables	Estimated Coefficients	Predicted Sign
Ratchet Effect Variables:		
NEW FARMER	0.55	+ (Prediction 3)
	(1.77)	
NEW LANDOWNER	0.16	– (Prediction 4)
	(0.33)	
Control Variables:		
ACRES	0.00	
	(0.46)	
FAMILY	0.00	
	(0.02)	
HAY	-0.18	
	(-0.58)	
INPUTS CHANGED	2.91	
	(9.50)	
IRRIGATION	-0.25	
	(-0.75)	
POP DENSITY	0.00	
	(0.69)	
ROW CROP	-0.84	
	(-2.59)	
YEARS	-0.01	
	(-1.13)	
Constant	-3.15	
	(-8.03)	
-2 Log Likelihood	612.9	
Percent Correct Predictions	97.19	
No. Observations	2,424	

Note: Numbers in parentheses are asymptotic *t*-statistics.

Although the two variables for new farmers and landowners most directly test for ratchet effects, the positive estimated coefficient on the *YEARS* variable in table 2 could be interpreted as consistent with the ratchet effect. This positive relationship shows that long-time contracting parties are more likely to choose share contracts over cash rent contracts and, as such, the variable *YEARS* could be considered as a proxy ratchet variable. The longer two parties contract with each other, the more likely the contract involves commitment and lower-powered incentives, despite the learning experienced over time by the landowner. Again, the effect is small both in absolute size and relative to other variables. The estimates in table 2 imply that an additional year to the relationship, calculated around the mean of the dependent variable, leads to just a 0.61%

increase in the probability of a share contract. Compared to the effect of having a row crop, which increases the probability of a share contract by 56% at the mean, this effect is economically unimportant. In the context of tables 3 and 4, one might consider the *YEARS* coefficient along the same lines. In these cases, however, the estimated coefficients for *YEARS* are *not* consistent with the ratchet effect. In table 4, the coefficient is positive and statistically significant, indicating that longer-term relationships have greater share terms. This is not only inconsistent with Prediction 3, but also suggests that landowners do not commit to terms with ongoing farmers. Finally, in table 5, the estimated coefficient for YEARS is insignificantly different from zero. Taken together, the effect of YEARS on contract design offers little support for the existence of economically important ratchet effects in agriculture.[22]

Conclusion

The literature on contract theory has flourished in the past 20 years, but empirical tests have been limited.[23] The ratchet effect literature is a classic example of this trend. Though the hypothesis arose in the context of Soviet manufacturing, it has subsequently been applied to private contracting. By our count, there are over 20 papers dealing with ratchet effects, along with an entire chapter in an important text (Laffont and Tirole). To our knowledge, the present study is the first empirical analysis of the ratchet effect. The reason for the lack of empirical work is that evidence to test for the presence of ratchet effects is generally unavailable. Data on both sides of the contract—farmer and landowner in our case—as well as contract history are required. Our data are unique in meeting these requirements and allowing for testing.

Because agriculture and share contracting are important theoretical applications of the principal-agent model, and because our data meet the conditions laid out in the theoretical literature, this study provides an important test. Our evidence suggests that the ratchet effect is generally unimportant in modern agricultural land contracts. We did find that within cropshare contracts there is limited evidence that input and output shares move in ways consistent with ratchet effects, although the effects are relatively small. We find virtually no evidence to support the ratchet effect in the determination of contract choice compared to other explanatory variables. Overall, our estimates show that even in the limited cases in which there is support for a ratchet effect in private agricultural share contracts, these effects tend not to be economically significant.

Although the purpose of this study has been to search for the presence of ratchet effects, our findings do raise the question as to why ratchet effects are so limited in these data. Several possibilities exist. First, if farmer heterogeneity is important, then adverse selection incentives in the absence of commitment (Freixas, Guesnerie, and Tirole; Salanié) could lead to other behavior that would not generate the ratchet effects in Predictions 1–4. This seems unlikely in the context of farming where farmers and

[22] This regression has an unusually high number of correct predictions. This occurs simply because there are very few positive responses. For most contracts, the terms of trade remain relatively stable over time.

[23] This is not to say there have not been significant empirical findings in this literature beyond ratchet effect studies (e.g., notable are Joskow; Crocker and Masten; Lafontaine; and Leffler and Rucker). See Shelanski and Klein for a survey of the empirical contract literature, and Knoeber for a survey of the empirical agricultural literature on contracts.

landowners are relatively homogeneous. Second, if information about farmers and landowners is sufficiently cheap to produce, then the landowner may face reputation costs, even across agents, which would limit his ability to change contracts when dealing with a new farmer. Third, in our past work (Allen and Lueck 1992b, 1993), we found that multiple-task moral hazard is important in determining contract choice. This explains the dominance of row crops in our estimates. Row crops require large amounts of soil manipulation, and share contracts are used to retard overexploitation. It may be the case that soil manipulation is so important that adjusting the shares for a ratchet effect leads to serious soil depletion. Unfortunately, our data do not allow us to separate out these different explanations.[24]

The failure of ratchet effects may be unique to agriculture, or it may be quite common. Ratchet effects can occur only when contract commitment is costly. To the extent that private contracts arise only when commitment is not costly, then ratchet effects should not be expected. Perhaps the best example is still government agencies where agent turnover is common, information poor, and reputations hard to establish—all making commitment difficult. In private contracts, there is a stronger incentive to curb any of the ratchet incentives and to make commitment more feasible. This, however, is speculation on our part. We leave it to future work on dynamic contracts to explore the implications of these and other issues.

[*Received December 1998; final revision received July 1999.*]

References

Allen, D. W., and D. Lueck. "The Back-Forty on a Handshake: Specific Assets, Reputation, and the Structure of Farmland Contracts." *J. Law, Econ., and Organization* 8(1992a):366–77.

———. "Contract Choice in Modern Agriculture: Cash Rent vs. Cropshare." *J. Law and Econ.* 35(1992b): 397–426.

———. "Transaction Costs and the Design of Cropshare Contracts." *RAND J. Econ.* 24(1993):78–100.

Baron, D., and D. Besanko. "Regulation and Information in a Continuing Relationship." *Information Econ. and Policy* 1(1984):267–302.

Berliner, J. S. *Factory and Manager in the Soviet Union.* Cambridge MA: MIT Press, 1957.

Crocker, K. L., and S. Masten. "Mitigating Contractual Hazards: Unilateral Options and Contract Length." *RAND J. Econ.* 19(1988):327–43.

Freixas, X., R. Guesnerie, and J. Tirole. "Planning Under Incomplete Information and the Ratchet Effect." *Rev. Econ. Stud.* 52(1985):173–91.

Ickes, B., and L. Samuelson. "Job Transfers and Incentives in Complex Organizations: Thwarting the Ratchet Effect." *RAND J. Econ.* 18(1987):275–86.

Johnson, B., L. Jannsen, M. Lundeen, and J. D. Aitken. *Agricultural Land Leasing and Rental Market Characteristics: A Case Study of South Dakota and Nebraska.* Report prepared for the Economic Research Service, U.S. Department of Agriculture. Washington DC: U.S. Government Printing Office, 1988.

Joskow, P. "Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets." *Amer. Econ. Rev.* 77(1987):168–85.

Kanemoto, Y., and W. B. MacLeod. "The Ratchet Effect and the Market for Secondhand Workers." *J. Labor Econ.* 10(1992):85–98.

[24] For example, if we could identify situations where there was a new technology shock or a new crop produced on the land, we could better isolate the effect of landowner information on the land.

Knoeber, C. "Land and Livestock Contracting in Agriculture: A Principal-Agent Perspective." In *Encyclopedia of Law and Economics*, eds., B. Bouckeart and G. DeGeest. Brookfield VT: Edward Elgar (forthcoming).

Laffont, J. J., and J. Tirole. *A Theory of Incentives in Procurement and Regulation.* Cambridge MA: MIT Press, 1993.

Lafontaine, F. "Agency Theory and Franchising: Some Empirical Results." *RAND J. Econ.* 23(Summer 1992):263–83.

Leffler, K. B., and R. R. Rucker. "Transactions Costs and the Efficient Organization of Production: A Study of Timber-Harvesting Contracts." *J. Polit. Econ.* 99(1991):1060–87.

Meyer, M., and J. Vickers. "Performance Comparisons and Dynamic Incentives." *J. Polit. Econ.* 105 (1997):547–81.

Milgrom, P., and J. Roberts. *Economics, Organization, and Management.* Englewood Cliffs NJ: Prentice-Hall, 1992.

Olsen, T., and G. Torsvik. "The Ratchet Effect in Common Agency: Implications for Regulation and Privatization." *J. Law, Econ., and Organization* 9(1993):136–58.

Salanié, B. *The Economics of Contracts.* Cambridge MA: MIT Press, 1997.

Shelanski, H., and P. Klein. "Empirical Research in Transaction Cost Economics: A Review and Assessment." *J. Law, Econ., and Organization* 11(1995):335–61.

Spillman, W. J. "The Agricultural Ladder." *Amer. Econ. Rev.* 9(1919):170–79.

U.S. Department of Commerce, Bureau of the Census. *County and City Data Book, 1987.* Washington DC: U.S. Government Printing Office, 1987.

Weitzman, M. "The Ratchet Principle and Performance Incentives." *Bell J. Econ.* 11(1980):302–08.

Appendix: Data Development and Sources

Data for the landowner-farmer contracts come from the "1986 Nebraska and South Dakota Leasing Survey." The leasing survey was conducted by Bruce Johnson of the University of Nebraska and Larry Jannsen of South Dakota State University. The survey was funded by the Economic Research Service of the U.S. Department of Agriculture (USDA). A summary of the study and the survey procedures can be found in Johnson et al.'s 1988 report prepared for the USDA/Economic Research Service, *Agricultural Land Leasing and Rental Market Characteristics: A Case Study of South Dakota and Nebraska.*

In conducting their 1986 leasing survey, Johnson and Jannsen obtained a list of landowners and farmers (from the Agricultural Stabilization and Conservation Service's list of producers) in each county in Nebraska and South Dakota who participate in, or are eligible to participate in, federal commodity programs. (According to Steven Munk, USDA Extension Agent for Minnehaha County in Sioux Falls, South Dakota, essentially all farmers in these two states are eligible for federal programs. Consequently, we do not have any sample selection bias in the data.)

From the farmer-landowner list, a random sample of names was chosen; the survey was sent to 6,347 individuals in Nebraska and 4,111 in South Dakota. The response rate was 32% for Nebraska and 35% for South Dakota. In the data set, the number of usable responses was 1,615 for Nebraska and 1,155 for South Dakota. Each observation represents a single farmer or landowner for the 1986 crop season. To conduct our tests, we reorganized the data so that each observation is a single farmland contract between a farmer and a landowner. Because many individuals had more than one contract, this increased the sample size by 20% and resulted in 2,101 observations for Nebraska and 1,331 for South Dakota, yielding a total of 3,432 observations for our full sample.

The leasing survey data contain information on the general attributes of the farmer and landowner, the number of acres owned and leased, the type of contract, the shares and cash rent, the type of crop grown, and other similar information. The data set has no information on the levels of inputs used in farming. There are several questions on pasture/range leases, but due to differences in the type of questions, the pasture lease data are not comparable to those for the cropshare or cash rent contracts.

There are relatively few pasture leases as well. The leasing survey data were combined with county-level data on population per square mile taken from the *County and City Data Book 1987*, published by the U.S. Department of Commerce, Bureau of the Census. This information was used to calculate the *POP DENSITY* variable used in our regressions.

Definitions of the variables used in our analysis, and their means, are presented in table A1 below.

Table A1. Variable Definitions and Means

Variables		Definition	Means: All Contracts	Means: Share Contracts Only
DEPENDENT VARIABLES:				
SHARE CONTRACT	=	1 if contract is share contract; 0 if contract is cash rent contract	0.71	NA
SHARE	=	Percent cropshare to farmer	NA	59.20
SHARE-UP	=	1 if share to farmer increased in past 5 years; 0 if share has not changed in past 5 years	NA	0.03
INDEPENDENT VARIABLES:				
▸ **Ratchet Variables**				
NEW FARMER	=	1 if farmer is new within past 5 years	0.11	0.13
NEW LANDOWNER	=	1 if landowner is new within past 5 years	0.05	0.05
▸ **Control Variables**				
ACRES	=	Number of acres covered by contract	445	433
AGE	=	Categorial age of farmer: 1 if <25 years 2 if 25–34 years 3 if 35–44 years 4 if 45–54 years 5 if 55–65 years 6 if >65 years	4.26	4.34
FAMILY	=	1 if landowner and farmer are related	0.44	0.45
HAY	=	1 if alfalfa, brome, or native hay	0.33	0.33
INPUTS CHANGED	=	1 if more inputs were shared in past 5 years	0.04	0.04
IRRIGATION	=	1 if land is irrigated	0.36	0.32
POP DENSITY	=	Population per square mile in the county of farm operation	30.20	30.60
ROW CROP	=	1 if corn, sugar beets, soybeans, or sorghum	0.66	0.83
YEARS	=	Number of years over which the two parties have contracted	11.50	12.40