Incomplete Contracts and Holdup: Land Tenancy and Investment in Rural Pakistan

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Abstract

When contracts are incomplete, relationship specific investments may be under-provided due to the threat of opportunistic expropriation or holdup. This paper finds evidence of such underinvestment on tenanted land in rural Pakistan. Using data from households cultivating multiple plots under different tenure arrangements, the paper shows that land-specific investment is lower on leased plots. This result is robust to the possible effects of asymmetric information in the leasing market. Greater tenure security also increases land-specific investment on leased plots. Moreover, variation in tenure security appears to be driven in part by heterogeneity across landlords, suggesting that reputation may be important in mitigating the holdup problem.

Keywords: *Incomplete Contracts, Holdup, Land Tenancy*

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1 Introduction

Relationship specific investments are important in a wide variety of economic transactions. As has long been recognized, when contracts are incomplete, specific investments may be undersupplied due to the threat of opportunistic expropriation by one of the trading partners. The holdup problem underlies a number of prominent theories of institutions, in which particular organizational forms, such as firms or governments, are rationalized as means of curbing ex-post opportunism (see, e.g., Klein, Crawford, and Alchian, 1978; Grossman and Hart, 1986; Hart and Moore, 1990; Williamson, 1975; and North and Weingast, 1989). 'Cooperative' investments, i.e., those that directly benefit the other trading partner – as when a tenant undertakes an improvement of his landlord's property – are particularly susceptible to holdup (Che and Hausch, 1999). In such cases, when commitment by the parties not to renegotiate ex-post is impossible, no contract may be able to protect the investor (see also Hart and Moore, 1999, on commitment).

Despite the centrality of the holdup problem in economics, there is remarkably little direct evidence on its quantitative importance, nor on the extent to which commitment mechanisms mitigate holdup.[1] This paper begins to fill these lacunae by examining cooperative investment within the classic principal-agent relationship, that between landlord and tenant. In this context, we ask two basic questions: (1) Does the threat of holdup significantly constrain specific investment? and (2) Is lack of commitment ubiquitous, or are some relationships characterized by greater commitment, and hence a lower holdup threat, than others?

Banerjee, et al. (2002) also emphasize contractual incompleteness in their investigation of the impact of tenancy reform on farm productivity in one Indian state. However, because they lack data on investments potentially subject to holdup, they cannot distinguish the investment channel from other effects of tenancy reform. There are, to be sure, micro-level studies showing that insecure property rights in land create a disincentive to invest (e.g., Besley, 1995; Jacoby, et al., 2002), but without information on the extent of commitment this evidence says little about how land *tenancy* affects investment. The setting for our investigation is rural Pakistan, where land-leasing under both crop-sharing and fixed rental arrangements is pervasive. The empirical analysis compares land-specific investment on owned versus leased land. If landlords cannot credibly commit to long-term

[1] Joskow (1987) finds that longer term contracts are more common as the degree of relationship specific investment increases, but in a context where long-term contracting is feasible. His paper does not examine the investment decision *conditional* on contractual form. See also Chiappori and Salanié (2000) for a broad survey of empirical research on contract theory.

contracts, then certain types of land specific investment will be underprovided by tenants, whereas investment in owned land is obviously immune to holdup.

This is not the first paper to compare farming practices on leased and owned land, but it is the first paper of its type to study investment behavior. Seminal work by Shaban (1987) is concerned with static efficiency; i.e., with moral hazard in current production effort that can arise in share-tenancy. Our approach, by contrast, is to examine the use of an input, farmyard manure, that enhances productivity over more than one agricultural season (Besley, 1995, and Jacoby, et al., 2002 also exploit this feature of manure). While manuring improves soil quality over an extended period, it is an extremely labor intensive activity, one that, in rural Pakistan, is virtually never entrusted to a hired worker. Thus, manuring is for all practical purposes a non-contractible investment. Whether manure will be under-applied on tenanted land relative to owned land depends on the extent to which landlords can commit to rewarding the tenant for his investment. In a world of no commitment, tenants will apply manure only to the point were the marginal return in the *current* period (i.e., the period of the contract) equals the shadow price, and this dynamic inefficiency will be common to both share tenants and fixed rent tenants, even though the latter are full residual claimants.

Security of tenure does not appear to be entirely lacking in rural Pakistan. Despite the absence of enforceable long-term contracts, annual tenancy contracts are typically renewed. Consequently, tenants often stay with the same landlord for a number of years, although the duration of tenancy is highly variable. Our evidence will show that a considerable portion of this tenure heterogeneity is generated by variation in landlord behavior toward their tenants. This, in turn, allows us to ask whether differences in the degree of commitment lead to differences in investment across tenants. If all tenants are equally insecure, then the duration of tenancy would indicate nothing about a tenant's incentive to invest. The alternative hypothesis, against which we would like to test this null, is that the duration of a tenancy is a signal of the degree of commitment in a relationship, albeit an imperfect one. Longer durations should therefore be associated with greater investment.[2]

Our main econometric challenge lies in dealing with the endogeneity of tenurial arrangements. Past work has stressed the importance of controlling for unobserved characteristics

[2] Laffont and Matoussi (1995) find that longer duration *share* contracts are associated with higher farm *output* in Tunisia. However, because they do not examine investment directly, nor (crucially) allow contract duration to affect output of fixed renters, one cannot use their results to distinguish the holdup problem from moral hazard in effort.

of the tenant so as to avoid the problem of self-selection into leasing or into different types of leasing contracts. Thus, for example, tenants may invest less than landowners merely because they are less wealthy. A solution to this problem, pioneered by Bell (1977), is to compare outcomes across plots *within* the same household in a sample of owner-cum-tenants. A limitation of this approach is that it assumes that the leasing decision is not correlated with unobserved attributes of the plot. This assumption may be violated if there is asymmetric information in the leasing market.

We take a two-pronged strategy to address this potential endogeneity problem. First, we use the fact that landlords who do not cultivate any land themselves (the majority of landlords in our sample) are unable to withhold their poor quality land from the leasing market. Plots leased from these landlords, therefore, should not be subject to adverse selection. Second, we use the proximity of the plot to its *owner*, which our data set provides even if the plot is leased in, as an instrument for leasing status. More remote plots are much less likely to be self-cultivated and proximity to owner is plausibly excludable. Both of these independent identification strategies lead to the same conclusion: The hypothesis of full commitment can be decisively rejected in rural Pakistan.

The next section of the paper provides the context for our study and sets out a simple two-period model of tenancy, moral hazard, and land-specific investment. Section 3 presents the estimation and identification strategy as well as our evidence for a leasing effect on investment. The analysis of the tenure security effect follows in section 4, along with conclusions and implications in section 5.

2 Tenancy and Land Specific Investment

2.1 Context and data

Ownership of agricultural land is highly concentrated in rural Pakistan, where about half the population is landless. As a result, land lease markets are quite active. According to the latest agricultural census (2000), about a third of total cultivated area was tenant operated, mostly (roughly two-thirds) under crop-sharing arrangements with the remainder under fixed rent. Land and tenancy reforms have been attempted at various times, but they have been largely ineffectual, leaving tenant cultivators with little legal recourse in the event of eviction.[3] Land ownership, however, is clearly established in rural

[3] Nabi (1986) reports data from a small 10 village survey in Pakistan's Punjab in which 46 percent of share-tenants said that their landlords could evict them 'easily' and 32 percent said that they or their

Pakistan and the risk of expropriation by the state or by powerful individuals is negligible.

Our empirical analysis draws upon a two-phase rural household survey undertaken in the two largest provinces of Pakistan, Punjab and Sindh, during 2004-05. The first phase of the (second) Pakistan Rural Household Survey (PRHS-II) follows up a sample of 1800 households from 94 villages that originally took part in the 2001 PRHS-I. Roughly sixty percent of the households surveyed in phase one operated or owned farmland and these households were asked about their activities over the two main agricultural seasons, *kharif* (May-November) 2003 and *rabi* (November-May) 2004.[4] The second phase of PRHS-II randomly sampled about 1600 households from an additional 77 villages, but with specific categories of household purposively over-represented. Specifically, only farm households were chosen, and certain types of tenant households (e.g., owner-cum-tenants) were oversampled. Phase two covers the *kharif* 2004 and *rabi* 2005 seasons.

2.2 Why farmyard manure?

To provide evidence on the holdup problem, we want to focus on an activity that is, in the first place, at least partly an investment. Moreover, we would like this investment to be relationship specific and noncontractible. Last, but not least, it must be relatively easy to measure. Farmyard manure (FYM) meets all of these criteria.

FYM, composed largely of cattle dung, provides variable amounts of the three principal soil nutrients, nitrogen, phosphorous, and potassium. Equally, if not more, important than its role as a nutrient source, FYM improves the quality of the soil by increasing aeration, water retention, structure, and ability to retain nutrients (Government of Pakistan, 1997; Gaur, 1992). Further, these benefits of FYM are long-lasting. Extended field trials in India cited by Gaur (1992) show that the marginal effects of FYM on grain yields persist for at least three years following the initial application; the effects in succeeding cropping seasons averaged 50-63% of the effect in the initial season. Chemical fertilizers, meanwhile, are used extensively in Pakistan, but they leach from the soil relatively quickly and hence their productivity effects are essentially limited to the season of application.

Because FYM, once applied and incorporated into the soil, is not portable, it is a relationship specific investment in the purest sense. By contrast, investments like experimentation with new farming techniques or seed varieties, which have an aspect of general

relatives had experienced eviction within the last two years. At the same time, however, most of these tenants had been leasing land of the same landlord for more than 10 years.

[4] The main cash crops, cotton, rice, and sugarcane, are grown in *kharif*, while the main food crop, wheat, is grown in *rabi*.

human capital, can be transferred, at least in part, to another landlord-tenant relationship. Still, there are other, larger scale, entirely specific investments that farmers undertake in rural Pakistan, such as constructing irrigation and drainage canals, clearing land, and digging wells. However, these fixed investments are, for the most part, contractible; the tenant or some other party can be paid to do them for the landlord. It is, to be sure, an interesting question as to whether contractible investment is underprovided on tenanted land, but it is not one that speaks directly to the holdup problem.

The attraction of FYM, from our perspective, is that it is noncontractible. Farmers rarely purchase FYM, but rather typically collect it as a by-product of their own livestock, load it onto carts or donkeys, transport it to the plot and then spread and incorporate it into the soil. Recommended quantities of FYM vary greatly by crop, but as much as 10-15 cartloads (8000-12000 kg) could be used for an acre of sugarcane (Government of Pakistan, 1997). Thus, the application process is extremely labor intensive and, as a result, costly to monitor. The extent and quality of FYM application is also not easily verified or observed ex-post, since weather and other sources of exogenous uncertainty make it difficult to extract this information from realized output alone.[5]

Noncontractibility in itself does not preclude an efficient level of investment. If the landlord is able to commit fully to retaining the tenant for the duration of the investment, a contract that makes the tenant the residual claimant to the returns on his investment would induce optimal investment. The landlord could then simply remove any surplus accruing to the tenant by appropriately increasing his rent. The classic holdup problem arises only when the investment is noncontractible *and* the landlord is unable to commit. The landlord stands to gain, in this case, by renegotiating the contract terms or contract renewal ex-post. The tenant, aware of this potential for opportunism on the part of the landlord, realizes that he is unlikely to recoup all the fruits of his investment. It is thus privately optimal for the tenant to underinvest. The remainder of this section sketches out a simple model to formalize this intuition.

[5] Direct evidence on the noncontractibility of FYM application is found in the 2001 PRHS-I, where agricultural jobs held over the past year are enumerated by task. A miniscule 0.08 % of all agricultural wage labor days fall under the category "collecting/spreading farmyard manure". By contrast, two-thirds of all paid labor days in agriculture involve harvesting, a task more readily contractible because productivity per hour is relatively easy to observe. While we do not have data from Pakistan that would allow us to compute the proportion of annual *family* labor devoted to FYM application, the corresponding figure from northeast China (which has a similar agricultural technology) is 8 % (Jacoby, et al. 2002).

2.3 Land specific investment under full commitment

To provide an organizing framework for our empirical work, we incorporate investment into a standard limited liability model of land tenancy.[6] While limited liability on the part of the tenant is just one of several ways to obtain sharecropping as a possible optimal contract (risk aversion, ex-ante financial constraints, and double-sided moral hazard are others), the implications for investment are similar across these tenancy models.

Each landlord owns a single unit of land that he cannot self-cultivate and therefore must give over on lease to one out of a large population of tenants. The tenant is the sole provider of two inputs that are unobservable to the landlord, current production effort and investment. Although our empirical work considers a recurrent investment, we strip the model down to two periods. Investment, $m \in [0, \overline{m}]$, takes place only in the first period, but yields returns in both periods. Since these returns are embodied in the landlord's property, the investment is cooperative in the sense of Che and Hausch (1999). We ignore discounting and depreciation; given our restrictions on the technology, the latter assumption is innocuous. Effort, $e \in [0, \overline{e}]$, is undertaken in both periods.

The production function $f(e, m)$ is increasing and concave in its arguments, whereas output, $Y = f(e, m) + \varepsilon$, depends also on an additive shock ε with bounded support such that $Y \in [0, \overline{Y}]$. The tenant's cost functions $c(e)$ and $q(m)$ are increasing and convex in e and m, and are assumed separable from each other (otherwise, the model would have to be solved recursively starting from the second period).

We take the landlord and tenant to be risk-neutral and consider linear contracts of the form $sY - r$, where s is the output share of the tenant and r is his fixed rental payment, which can be negative. Tenants have an exogenously given opportunity cost that determines their participation constraint and an exogenous pre-contract wealth that determines their limited liability constraint (i.e., the maximum they can be made to pay in any state of nature).

When the landlord can fully commit to a two period contract, the tenant's optimality conditions are

$$sf_e(e, m) = c_e(e) \qquad \text{and} \qquad 2sf_m(e, m) = q_m(m), \tag{1}$$

the factor of 2 arising in the second equation from the fact that the tenant reaps a return on his investment in both periods. Meanwhile, the first-best – the effort and investment

[6] Banerjee et al. (2002) and Banerjee and Ghatak (2004) also discuss this type of investment model. Other papers that have modelled tenancy in a limited liability setting include Shetty (1988), Basu (1992), and Mookherjee (1997), to name a few.

levels that maximize total surplus $2[E(Y \mid e, m) - c(e)] - q(m)$ – solves

$$f_e(e, m) = c_e(e) \qquad \text{and} \qquad 2f_m(e, m) = q_m(m). \tag{2}$$

Clearly, the first-best is achieved only when $s = 1$; that is, when the lease is given on fixed rent. A landlord who can fully commit is essentially 'selling' the property rights on land to the tenant for the duration of the contract. As residual claimant, the tenant is fully incentivized and both moral hazard problems consequently disappear. However, the landlord can only offer a fixed rent contract to those tenants with sufficiently high wealth. If the tenant cannot afford the rent, then the landlord, now facing a tradeoff between production efficiency and surplus extraction, may offer a share contract, $s \in (0, 1)$. Crop sharing gives rise to the familiar 'Marshallian' inefficiency, in which current production effort and, in our model, investment are provided below their first best level.

2.4 Tenure Insecurity and Investment

When the landlord can only commit to a one-period contract, the tenant's optimality conditions become

$$sf_e(e, m) = c_e(e) \qquad \text{and} \qquad sf_m(e, m) = q_m(m), \tag{3}$$

so the marginal return on investment is half as large as in the full commitment case. This is true regardless of whether the tenant is the residual claimant. A fixed rent contract does not eliminate the dynamic inefficiency, although the marginal return on investment remains higher than under a share contract. Thus, we have

Proposition 1 *If investment is not itself contractible and the landlord cannot commit to a tenancy contract that lasts at least as long as the duration of the investment, then the tenant will undersupply land specific investment, even under a fixed rent contract.*

Holdup problems such as this may be mitigated by repeated interaction between landlords and tenants. A landlord may be reluctant to 'milk his reputation' by reneging on his current tenant, realizing that if he does so he will be 'punished' by future tenants playing the one-shot equilibrium, meaning suboptimal investment on his land. Any number of equilibria in the repeated game are possible depending on, among other things, the patience of the landlord, the extent to which the history of his actions is public information, and perhaps on his innate trustworthiness (more on this later). It is reasonable to suppose that landlord reputation – avoidance of the one-shot equilibrium – is heterogeneous and is known to some degree by potential tenants.[7] Assume, then, that the tenant believes his contract will be renewed in the second period with probability θ. Full commitment is the case where $\theta = 1$ and no commitment is the case where $\theta = 0$. Clearly, $\theta > 0$ will increase investment relative to the no commitment case, so that

Proposition 2 *As the degree of tenure uncertainty increases, the tenant will reduce his land specific investment.*

There are other potential sources of heterogeneity in tenure security besides the behavior of landlords. Tenants may have different search or moving costs or face different distributions of outside opportunities. In these cases, we may find that some tenants underinvest relative to others even if all landlords can fully commit to long term contracts. It is, in effect, the tenant here who cannot commit to staying long enough to recoup his investment. Our empirical analysis will show, however, that tenant heterogeneity, while of potential importance, is not the whole story.

Finally, we have assumed up to now that a landlord who can commit to a multi-period contract will retain his tenant indefinitely, or at least long enough for the latter to realize the investment. But landlords with the ability to commit may also have an incentive to evict their tenants for failure to meet an output standard.[8] In this case, since output is stochastic, eviction occurs in equilibrium when the tenant is 'unlucky'. With or without an eviction threat, however, long duration tenancies will still be associated with landlords who are more willing to commit.

3 The Leasing Effect

3.1 Econometric specification and identification

Our test of Proposition 1 is based on a regression of per-acre FYM use, M_{ci}, by cultivator c on plot i

$$M_{ci} = \alpha L_{ci} + \beta S_{ci} + \omega' X_{ci} + \nu_c + \varepsilon_{ci}, \tag{4}$$

[7] See Banerjee and Duflo (2000), and the references cited therein, for a discussion and evidence of reputation effects in the context of firm behavior.

[8] Banerjee and Ghatak (2004) have recently shown, in a similar limited liability set-up, that a landlord can increase a (share) tenant's noncontractible investment by threatening eviction. Even though this threat reduces tenure security, it raises the tenant's cost of not investing. If the tenant is sufficiently patient or if the marginal product of investment is sufficiently high, then the second effect will dominate.

where L_{ci} is an indicator of whether the plot is leased, S_{ci} is an indicator of whether the plot is sharecropped, and X_{ci} is a vector of exogenous plot characteristics.[9] Holdup implies that the average leasing effect $\alpha + \beta E[S_{ci}|L_{ci} = 1] < 0$, while β, the impact of sharecropping over and above fixed rental, should also be negative according to the model in section 2.4 because of Marshallian inefficiency.

The error term ν_c captures unobserved factors common to a given cultivator, such as wealth, access to credit, risk aversion and the discount rate, farming knowledge, average land quality, and the available stock of FYM as well as of other farm assets. The plot-specific error term ε_{ci} reflects measurement error in FYM use and unobserved attributes of the plot. Most models of contractual choice in agriculture imply a correlation between L_{ci} (S_{ci}) and ν_c. To deal with this endogeneity problem, we follow earlier work by restricting attention to owner-cum-tenant (OCT) households; i.e., those that cultivate at least one owned and one leased plot. If positive amounts of FYM are used on all plots, one can estimate the leasing effect from the linear regression

$$\Delta M_c = \alpha \Delta L_c + \beta \Delta S_c + \omega \prime \Delta X_c + \Delta \varepsilon_c \tag{5}$$

where Δ denotes pairwise differencing between plots of a given cultivator. The fact that OCT households might be a selective sample in the sense that $E[\nu_c|OCT] \neq 0$, does not affect the estimates because ν_c differences out of equation 5.

Ignoring the control variables, it is easily seen that the OLS estimate of the average leasing effect from equation 5 is

$$E[\Delta M_c|\Delta L_c = 1] - E[\Delta M_c|\Delta L_c = 0] - \{E[\Delta \varepsilon_c|\Delta L_c = 1] - E[\Delta \varepsilon_c|\Delta L_c = 0]\} \tag{6}$$

where, without loss of generality, we have organized the data such that the first plot in the pair (if any) is always the leased plot. $E[\Delta \varepsilon_c|\Delta L_c] = 0$ thus insures unbiasedness and consistency, but may fail to hold if there is asymmetric information in the leasing market. Aspects of plot fertility unobserved by the tenant could be correlated with leasing choice due to adverse selection. In particular, landlords may have an incentive to lease out low quality land rather than cultivate it themselves. Moral hazard can lead to a similar effect if, for example, plots vary in their sensitivity to soil degradation. Landlords may

[9] Shaban (1987) states the precise restrictions on technology necessary to move from the tenant's first-order conditions under different tenure types to a regression of input intensity on tenure type. We suppress an analogous discussion here for the sake of brevity.

then be reluctant to lease out their more sensitive plots, since these are more susceptible to unmonitorable tenant abuse. In either case, the presence of asymmetric information does not, in and of itself, lead to inconsistency; the relevant component of plot quality (i.e., unobserved fertility or sensitivity to abuse) must also shift the returns to FYM application.

Consistency and unbiasedness of the OLS estimate of the sharecropping effect (β),

$$\frac{E\left[\Delta M_c|\Delta S_c=1\right]-E\left[\Delta M_c|\Delta L_c=1\right]-\left\{E\left[\Delta\varepsilon_c|\Delta S_c=1\right]-E\left[\Delta\varepsilon_c|\Delta L_c=1\right]\right\}}{1-E\left[\Delta S_c|\Delta L_c=1\right]}, \quad (7)$$

is guaranteed by the restriction $E\left[\Delta\varepsilon_c|\Delta S_c\right]=E\left[\Delta\varepsilon_c|\Delta L_c\right]$. We first consider two alternative strategies for tackling the endogeneity of leasing under the assumption that this restriction holds. Having dealt with the endogeneity of leasing, and recognizing that estimates of the *average* leasing effect do not depend on the validity of this restriction (see expression 6), we then test it in section 3.4.

3.1.1 Identification Strategy 1: Using the landlord's cultivating status

Asymmetric information creates a problem insofar as landowners select which of their plots to cultivate themselves and which to lease out. But landlords who do not cultivate at all have no scope for holding their relatively fertile or sensitive land off of the leasing market. This suggests a simple strategy for isolating the causal effect of leasing: Focus on plots leased in from landlords who do not cultivate.

Specifically, let d_k be an indicator for whether the owner of plot k cultivates or not, and let $D_{ck}=d_k L_{ck}$. Our identifying restriction is

$$E\left[\Delta L_c\Delta\varepsilon_c|\Delta D_c=0\right]=0. \quad (8)$$

To illustrate how this restriction works, suppose that each OCT household has exactly two plots, the first of which is leased in on fixed rent, so that $\Delta L_c=1$, $\Delta S_c=0$, and $\Delta D_c=d_i$. Equation 8 then becomes $E\left[\Delta\varepsilon_c|d_i=0\right]=0$, which says that the average unobserved quality differential between the leased and owned plot is zero if the landlord of the leased plot does not cultivate. Ignoring observed plot characteristics, this implies $E\left[\Delta M_c|d_i=0\right]=\alpha+E\left[\Delta\varepsilon_c|d_i=0\right]=\alpha$, the leasing effect. More generally, OLS estimates of equation 5 augmented by ΔD_c 'partials out' the effect of selection on unobservable attributes of leased plots, delivering unbiased estimates of the average leasing effect. Including ΔX_c in the regression controls for any observed differences in land leased from cultivating and non-cultivating landlords. Having the market value of the plot among these controls also accounts for unmeasured (by us) plot attributes that influence its per acre price.[10]

3.1.2 Identification Strategy 2: Using the landowner's proximity to the plot

An alternative approach is to find a suitable instrument, a variable strongly influencing contractual choice but orthogonal to unobserved plot characteristics. A natural candidate is the distance of the plot from its *owner's* residence, as more remote plots are obviously more costly to self-cultivate. In PRHS-II, tenants report the proximity of their landlord, so we know distance to owner for both leased and owned plots. Thus, equation 5 can be estimated using ΔZ_c, the difference in owner proximity across plots, as an instrument for ΔL_c.

There remains the question of instrument excludability: Might distance to the landowner reflects something about plot quality? Landlords, for instance, may purchase poor quality land far away from their homes with the intention of leasing it out. While this would lead to an unconditional correlation between distance to owner and plot quality, it should not lead to correlation *conditional on plot value*, which, as already mentioned, is included in the second stage regression. Given that the location of the plot relative to its owner is easily observed, any average quality differential based on owner proximity would have to be reflected in the plot's market value.

One might take issue with this argument on the grounds that plot values, at least as reported by tenants, may correspond rather loosely to true market values. Table 1, therefore, presents an analysis of land rents based on the nearly 600 plots leased on fixed rent in the PRHS-II. These rents are not estimates based on hypothetical market transactions, but are actual cash amounts paid by tenants. Furthermore, since fixed renters are, on average, wealthier than sharecroppers (e.g., among households that lease one or more plot on fixed rent, landlessness is 19% and mean landholdings is 3.9 acres, compared to 56% and 1.7 acres, respectively, among households that lease only on a share basis) and consequently much sought after as tenants, they are likely to have considerable

[10] In particular, differences in landowner cultivating status, since they are publically observable, should be impounded in land prices and rents to the extent that they signal quality differentials. However, in analyses not reported here for sake of brevity, we find no significant differences in land values between plots owned by cultivators and non-cultivators (conditional on other observed characteristics) and no significant differences in land rents paid by tenants leasing from cultivating and non-cultivating landlords.

bargaining power *vis a vis* landlords. It is reasonable, then, to ask whether such tenants, knowing that land leased from distant landlords tends to be of lower average quality, bid down the rent on such plots relative to that on observationally equivalent land leased from nearby landlords.

To uncover a compensating differential for landlord proximity, we estimate a parsimonious log-rent equation, controlling only for the key plot characteristics and 23 *tehsil* or subdistrict dummies. Proximity is defined by two dummies, one indicating that the landlord lives outside the village and another indicating that he lives outside the village and 5 or more kilometers away from the plot. Whether we exclude plot value, in column (1), or include it, in column (2), landlord proximity has no impact on rents. The significance of plot value in column (2) indicates that estimated market prices and actual rents contain common information not captured by the other plot characteristics. In any event, there is no evidence here that more remote plots are of worse *average* quality. Thus, even if tenant-reported plot value does not fully reflect underlying quality differentials, it will make little difference to our test of the leasing effect.

A second possible source of correlation between our instrument and the error term in equation 5 arises from the fact that landowners who live far from their plots tend to have larger landholdings. Recall that, under adverse selection, landowners will lease out their relatively poor quality land and keep their better land for self-cultivation to the extent that they cultivate at all. Since large landowners must lease out a larger fraction of their land, it follows that, when the owner of a particular plot has larger landholdings, that plot is more likely to be of low quality.[11] Fortunately, having information on the landholdings of the plot owner whether or not the plot is leased allows us to control for this variable directly in the second stage.

3.1.3 Estimation with Censoring

Partly due to the carryover effect, making it uneconomical to apply every year, annual FYM use is heavily censored at zero. In our sample, described in detail in the next subsection, manure is applied to only 36% of plots overall and by 49% of OCT households. Moreover, nearly half of the OCT households that use FYM apply it to some of their plots but not to others. To handle this censoring in the context of a fixed effects model, while allowing for endogenous covariates, we use the semiparametric estimator suggested by

[11] This can occur even if, *on average*, large landowners have the same quality land as small landowners. We are grateful to a referee for bringing this subtle issue to our attention.

Honore and Hu (2004). For identification strategy 2, with $\psi\prime\Delta W_c = \beta\Delta S_c + \omega\prime\Delta X_c$, GMM-IV estimation is based on the unconditional moment conditions

$$E\left[\rho_c(\alpha,\psi)\Delta W_c\right] = 0 \quad (9a)$$

$$E\left[\rho_c(\alpha,\psi)\Delta Z_c\right] = 0 \quad (9b)$$

where $\rho_c(\alpha,\psi) = \max\{M_{ic} - \alpha\Delta L_c - \psi\prime\Delta W_c, 0\} - \max\{M_{jc} + \alpha\Delta L_c + \psi\prime\Delta W_c, 0\} + \alpha\Delta L_c + \psi\prime\Delta W_c$ for plot pair (i,j) of cultivator c. The procedure is essentially the same for identification strategy 1, except that ΔL_c replaces ΔZ_c in 9b.

Under suitable regularity conditions and assuming that ε^*_{ic} and ε^*_{jc} (the errors in the equation for *latent* FYM use) are identically distributed conditional on $(W_{ic}, W_{jc}, Z_{ic}, Z_{jc}, \nu_c)$, the estimate of (α,ψ) is consistent and asymptotically normal. We use the continuously updating GMM algorithm, as suggested by Honore and Hu (2004). To account for correlation in the errors across plots within the same household, we also adjust the covariance matrix for clustering at the household level.

3.2 Estimation sample and controls

Our estimation sample consists of 2450 plots cultivated by 1058 households during either the 2003-04 or 2004-05 agricultural year. Only households cultivating more than one plot are used in the estimation, but not all of these households are *OCTs*. There are 528 *OCT* households contributing 1237 plots and another 530 multi-plot households (i.e., with all their plots either leased or owned) whose plots comprise the remaining half of the sample. While the leasing effect is identified exclusively from the *OCT* plots, including the other plots helps estimate the effects of the control variables and thus improve overall efficiency. The 960 leased plots in the non-*OCT* subsample also contribute to estimating the tenancy duration effect, as discussed below. Descriptive statistics for the various subsamples are reported in Appendix Table A.1.

To obtain the traditional lognormal model for the uncensored values of FYM, our dependent variable is $\log((M+k)/k)$, where M is in kilograms per cultivable acre. In the presence of zeros, there is no way to let k be a free parameter in the estimation, so the choice of k is largely arbitrary (we set it to 0.1 times the minimum nonzero value of M in the sample). Furthermore, the estimated coefficients are not invariant to the choice of k, which means that the magnitudes of these coefficients are only relevant in making comparisons across specifications. Given our focus on hypothesis testing, however, this is not a problem, as the t-statistics of interest *are* essentially invariant to the choice of k.

We control for the following plot characteristics: log area, proximity to cultivator's domicile, irrigation (access to canal, access to good groundwater, access to brackish groundwater), soil type/quality, and log plot value.[12] Detailed descriptive statistics are reported in Appendix Table A.2. In terms of proximity, 87% of plots are located within the cultivator's village (90% of owned plots compared to 86% of leased plots). Of those plots located outside the village, 78% are 4 kilometers or less from the farmer's home (with nearly identical percentages for owned and leased plots). Most plots in the sample (87%) have access to irrigation in one form or another, and 81% are canal irrigated, a dimension along which leased plots look better than owner-cultivated plots (84% versus 74%). Irrigation and the other plot attributes explain 42% of the variance in reported (log) plot values, so the latter variable appears to convey considerable information.

3.3 Main results: The leasing effect

Table 2 presents alternative estimates of the leasing effect. We first run a household *random* effects (parametric) tobit model that includes, in addition to the plot characteristics, a set of 28 *tehsil* dummies. All the rest of the specifications in Table 2 account for household fixed effects using the semiparametric GMM estimator. Restricting β to zero initially, there is little to choose from amongst the estimated leasing effects in columns (1)-(3); all are negative and highly significant. The random and fixed effects estimates (with controls) are virtually identical, which means either that households are not strongly selected into land leasing or that whatever unobservables they are selected upon do not shift FYM use. A comparison of columns (2) and (3) reveals that observed plot characteristics, while jointly significant, are not highly correlated with leasing status. Allowing investment effects to differ by tenancy contract type in column (4) changes little, there being no significant difference in FYM use between sharecropped and rented plots.

Of course, *unobserved* plot characteristics may be correlated with leasing status and FYM use. We next turn to estimators that correct for bias due to asymmetric information. Specification (5) controls for the cultivating status of landlords of leased plots as per identification strategy 1. Only about one quarter of leased plots in the sample are owned by cultivating landlords, though more relevant is the corresponding figure of 31%

[12] It is highly unlikely that plot value reflects the extent of past manuring, since the effects of FYM are far from permanent. At any rate, the exclusion of this variable from the regressions has a negligible impact on the estimates of interest.

for plots leased to OCT households. The cultivating landlord variable, ΔD_c, attracts a significantly negative coefficient, so plots leased from such landlords appear to be systematically different from other leased plots. However, the 'selectivity corrected' estimate of the leasing effect is only about one standard error lower than that in column (4); still negative and highly significant.

The remainder of Table 2 pursues the IV strategy of subsection 3.1.2. The two instruments are, first, a dummy for whether the plot is located outside the village of the owner and, second, a dummy for whether, if outside the village, the plot is 5 or more kilometers away (note that we are already controlling in the second stage for precisely the same proximity indicators with reference to the *cultivator*).[13] These instruments are highly relevant. A 'first-stage' fixed-effects regression yields a joint (robust, household clustering adjusted) F-statistic for the excluded instruments of 83. As a consequence of this explanatory power, the standard error on the GMM-IV estimate of the leasing effect in column (6) is only about twice the size of its counterpart in column (4). The corresponding leasing coefficients are practically identical, and the sharecropping effect remains insignificant.

Specification (7) adds the log of the plot *owner's* landholdings to the second stage. As discussed, the purpose of doing this is to control for a potential correlation between our instrument, plot owner proximity, and unobserved plot quality. The result of this exercise is mainly to raise the standard error of the leasing coefficient. This is not surprising, given that the landholdings of the plot owner is correlated both with the leasing status of the plot and with the proximity of the plot owner. In any event, the added landholdings variable is insignificant while the other estimates are not appreciably affected by its inclusion.

To summarize, we can resoundingly reject full commitment in our data. Less FYM is used per acre on leased plots than on owned plots with the same observed characteristics and cultivated by the same household. This result is robust to the presence of asymmetric information in the leasing market, as indicated by two alternative tests based on imposing independent moment restrictions.

3.4 Share versus fixed rent tenancy

As we have seen, the potential for holdup exists regardless of whether the tenant has taken the land on fixed rent or on a share contract. The results in Table 2 strongly confirm

[13] Of the 1645 leased plots in the estimation sample, 38% are located outside the landlord's village and, of these, 71% are at a distance of 5 or more kilometers from the landlord's residence.

this prediction. In particular, the leasing effect is not just confined to sharecropped land, on which FYM may be underutilized merely because of 'static' moral hazard in effort. Rented plots also receive less FYM than owned plots.

Thus far, however, we have assumed (cf. expression 7) that $E[\Delta\varepsilon_c|\Delta S_c] = E[\Delta\varepsilon_c|\Delta L_c]$, which amounts to saying that asymmetric information in the leasing market shifts the average quality of sharecropped land by as much as it shifts the average quality of all leased land. Under adverse selection, this is intuitively plausible; the ability of a landowner to pass off low quality land to his tenants should not be related to the form of the incentive contract between them. The story may be different, however, under moral hazard. Allen and Lueck (1992), for example, argue that landlords prefer to lease their more sensitive land to sharecroppers rather than to fixed renters, since sharecroppers have less incentive to deplete the soil. If FYM use is, in turn, related to land sensitivity, then $E[\Delta\varepsilon_c|\Delta S_c] \neq E[\Delta\varepsilon_c|\Delta L_c]$ and our estimates of β in Table 2 (but *not*, as already emphasized, our estimates of $\alpha + \beta E[S_{ci}|L_{ci} = 1]$) could be biased.

To deal with this case, we exploit regional variation in contractual arrangements. In parts of Pakistan, notably Sindh province, fixed rent contracts are rare, mainly because there are few tenants around who can afford to pay rent up front. Based on more than 2,100 leased plots in the PRHS-II, there are 52 villages in which not a single leased plot is taken on fixed rent; three-quarters of these village are located in Sindh, compared to one-third of the villages in the sample as a whole. It is reasonable to suppose that landlords in these 52 villages could not find a fixed rent tenant even if they wanted one. Consequently, landlords in this sample are unable to allocate plots to fixed rent tenancy on the basis of land sensitivity or any other unobserved characteristic for that matter.

Table 3 presents GMM estimates of the overall impact of sharecropping, $\alpha + \beta$, for the full sample (based on specification (4) of Table 2) and for the subsample of around 800 plots from the 52 sharecrop-only villages. Whether landlord cultivation status is included or not, we obtain the same result: the overall sharecropping effect on FYM use is not substantially different between the full and restricted samples (because of limited variation, we had to drop the irrigation variables from the set of controls in the latter case). Thus, estimating β on a sample in which landlords generally have scope for choosing fixed rent contracts (i.e., the full sample) does not seem to bias our conclusions; in other words, the restriction $E[\Delta\varepsilon_c|\Delta S_c] = E[\Delta\varepsilon_c|\Delta L_c]$ cannot be rejected.

While it is clear, then, that the leasing effect is not being driven entirely by the Marshallian inefficiency of share-tenancy, the finding that share-tenants are not investing *less* than fixed rent tenants *is* inconsistent with the simple tenancy model laid out in section 2.3.[14] There are at least two ways to explain this apparent anomaly. The first is by a monitoring argument. Given moral hazard in current production effort, it may pay for a landlord to supervise his share-tenant's production activities. Indeed, share-tenants in Pakistan *are* typically heavily supervised (see Nabi, 1986; Jacoby and Mansuri, 2004), either directly by their landlord or by hired labor managers (*kamdars*). If there are economies of scope in supervision, then the cost of monitoring a tenant's investment effort (at least to some degree) is lower in sharecropping than in fixed rental arrangements. Such monitoring may counteract the greater disincentives faced by share-tenants.

A second explanation is that share-tenants expect to be in more durable relationships with their landlords than fixed rent tenants. There is, in fact, considerable divergence in tenancy duration by type of contract, with share-tenancies having lasted an average (median) of 9 (5) years compared to 6 (4) years for fixed rentals. Although we control for tenancy duration later, this variable may not fully capture intertemporal links between landlord and tenant. In Pakistan, for example, landlords often provide credit to their share-tenants. Such 'interlinked' credit transactions create incentives for landlords to retain tenants across multiple seasons. Unfortunately, supervision, interlinkage, and output sharing are all bundled together in share-contracts. Since there are no fixed rent contracts with these features, it is difficult to pursue these alternative explanations empirically. Suffice it to say, then, that plots held under both fixed rent and sharecropping arrangements receive less investment than owner-cultivated plots, a strong indication that lack of commitment and the threat of holdup pervade all types of tenancy relationships. The rest of this paper explores whether mechanisms exist for restraining such holdup.

4 The Tenure Security Effect

4.1 Econometric considerations

To test Proposition 2, we must operationalize tenure security. Let μ_{oc} represent the degree of tenure security, the dual subscripts indicating that this variable is specific to an

[14] Output shares for sharecropping contracts are no greater than 50% in the vast majority of cases. Although the raw means in Appendix Table A.1 do show subtantially lower use of all inputs (FYM, nitrogen fertilizer, and traction) on sharecropped plots as compared to rented plots, this should not be ascribed to Marshallian inefficiency. Most of the difference can be explained by the fact that sharecropping is more prevalent in poorer areas where input use would otherwise be lower. Among other things, our household fixed effect estimates eliminate such regional differences.

owner (landlord)-cultivator (tenant) match. In terms of the model in section 2.4, we may think of μ as the objective probability of contract renewal, in contrast to the subjective (on the part of tenant) probability θ; in other words, θ is the tenant's prior on μ. For μ to affect investment behavior, the tenant's prior must be informative. Without loss of generality, we may set $\mu_{oc} = 1$ for owner-cultivated plots, on which tenure security is presumably absolute and unvarying. Introducing the term $\Delta(L_c \times \mu_{oc})$ into equation 5 allows a test of the null hypothesis that its coefficient, γ, is equal to zero; i.e., tenure security does not influence investment on leased plots *vis a vis* owned plots. The alternative hypothesis, $\gamma > 0$, is that investment incentives are stronger in more secure tenancies.

This test requires information on μ_{oc}, which is not directly observed. But notice that the ongoing duration of a tenancy, t_{oc}, is a (noisy) indicator of the underlying security of tenure. In Jovanovic's (1979) job-matching model, for example, the hazard rate of job separation in the presence of specific investment is a function of *elapsed* job duration and of match quality. If workers (tenants) have different costs of search and firms (landlords) have different retention policies, then the separation hazard also depends on these additional exogenous sources of turnover. Since this hazard rate uniquely defines the distribution of tenancy duration, we may write $\log(t_{oc}) = E\left[\log(t_{oc})|\mu_{oc}\right] + \xi_{oc}$, where ξ_{oc} is random 'luck'.[15] Taking a linear approximation to the conditional expectation delivers

$$\log(t_{oc}) = \mu_{oc} + \xi_{oc}, \tag{10}$$

which is exact if elapsed duration is distributed as a Weibull. Equation 10 suggests using log duration interacted with the dummy variable L_{ci} as a proxy for $L_{ci} \times \mu_{oc}$. It also implies that doing so leads to an errors-in-variables problem, because of ξ_{oc}. Since the resulting estimate of γ is biased toward zero, we will tend to find weaker evidence against the null (that $\gamma = 0$) than if we observed μ_{oc} directly.

Tenancy duration might also be endogenous for reasons other than measurement error, imparting a bias in γ *away* from zero. In particular, tenants may stay longer on better quality plots on which the return to FYM may also happen to be higher. Why would tenants stay longer on 'better' plots? One reason might be that, under adverse selection, the tenant does not know initially whether the quality of his plot is above or below the average for leased land. Presumably, the longer the tenant cultivates the plot the more he learns about its underlying fertility. Assume that landlords cannot commit to more

[15] Recall that bad luck may consist in getting evicted due to substandard output despite a high level of investment or other type of unobservable effort.

than one-year contracts. Thus, after the first year of tenancy, the landlord and tenant renegotiate. Suppose that the landlord offers the tenant the same rent as in the previous year. The tenant will only stay on for a second year if his posterior estimate of plot quality is at least as high as his prior (assuming zero cost of changing landlords). Therefore, *holding rent constant*, tenants will remain longer on better plots. Of course, there is no reason to suppose that the landlord will offer the same rent, since he knows that the tenant has learned something about the plot's quality. If the landlord has a relatively good plot, then he would want to raise the rent, but not to the point where the incumbent tenant would leave. This 'informed' tenant is more valuable to him than an uninformed tenant and needs to be given some incentive to stay on. The opposite is true for a landlord with a below average quality plot; he would want to replace the incumbent tenant with an ignorant one. In sum, the model implies: (1) Tenants remain longer on better plots; and (2) Rent rises with tenure.

The evidence from Table 2 already belies the empirical relevance of this story. Lack of (upward) endogeneity bias in the leasing coefficient implies that asymmetric information in the land leasing market and returns to FYM use that increase in unobserved plot fertility are not *jointly* present in rural Pakistan. Therefore, tenancy duration should not be acting as a proxy for unobserved plot quality in the FYM regressions. But we can also check whether land rents rise with tenure. The last two regressions in Table 1 show that the log of tenancy duration has no significant impact on rents, whether or not we condition on reported plot value. Despite this absence of support for a duration-quality nexus, we also use instrumental variables in section 4.3 to deal directly with endogeneity.

4.2 Evidence from landlords

For our test of the tenure security effect to have power, there must be a reasonable amount of variation in tenancy duration. But variation in t_{oc} does not necessarily imply variation in μ_{oc}, or in θ for that matter. To see why, take the case where θ, the subjective probability of retention, does not vary across tenants. Since actual contract renewal is a stochastic process, we would still observe a nondegenerate distribution of elapsed tenancy durations, but no relationship between duration and investment. It is thus important to assess the extent to which variation in tenancy duration reflects heterogeneity in the objective factors underlying μ_{oc}, such as tenant mobility and landlord behavior.

PRHS-II collects data from landlords on a range of their tenant's characteristics, including the duration of the tenancy on the specific plot. For reasons that will become apparent shortly, we focus only on those landlords who lease out at least two plots, each to a *different* tenant. This gives us a sample of 342 tenanted plots owned by 122 landlords. The mean elapsed tenure in this sample is 8 years and the median is 5 years.

Column (1) of Table 4 reports a regression of log duration on tenant, landlord, and plot characteristics, as well as 21 *tehsil* dummies; 46% of the total variance in log duration is explained by these covariates. Among the landlord variables, only schooling seems to matter, with educated landlords keeping their tenants longer. The regression in the second column of Table 4 includes landlord fixed effects. All the landlord characteristics and *tehsil* dummies consequently drop out. Remarkably, this regression explains 87% of the variance in log duration. So, landlord-specific unobservables account for 41% of the variation in tenancy durations in our sample.

Some of the explanatory power of the landlord-specific effect is undoubtedly due to the presence of tenant *unobservables*, since assortative matching of landlords and tenants would indicate that these unobservables are positively correlated among tenants of the same landlord. To get a handle on how important tenant unobservables might be, we use tenant observables as a guide, in the spirit of Altonji et al. (2005). If we drop all of the variables representing tenant human capital, assets, and relation to landlord from the log duration regression in column (1) of Table 4, we get an R^2 of 0.33; doing the same for the landlord fixed effects regression in column (2) gives an R^2 of 0.81. Thus, not controlling for *anything* about the tenant raises the R^2 gap from 41% to 48%. Suppose, now, that tenant unobservables explain the *same* fraction of the duration variance as tenant observables (i.e., 13%), and that tenants are equally assortative on unobservables as they are on observables. The residual variance explained by landlord behavior would then have to fall by 7 percentage points, to about a third of the total variance in log duration. So, as long as tenant observables explain at least as much of log duration as tenant unobservables, landlord behavioral heterogeneity must explain at least one-third of the total variation.

One interpretation of this apparent behavioral heterogeneity is that there are some landlords who – perhaps by not opportunistically evicting their tenants – are able to acquire a reputation for 'trustworthiness'. While the notion of trustworthiness is difficult to model formally, emerging empirical evidence from experimental economics indicates that this trait is innate, varies considerably across individuals, and can be a significant determinant of economic outcomes, such as debt repayment (see Karlan, 2005). Whether the same holds true in our particular setting must await future research. The upshot of this analysis is that proposition 2 is testable using data on tenancy duration and that any tenure security effect is due, at least in part, to landlord commitment problems.

4.3 Main results: The tenure security effect

Results for the tenure security effect are reported in Table 5. To maintain comparability across the estimated leasing effects, we demean log duration using the average over OCT plots. Log duration is initially assumed exogenous conditional on the household fixed effect. In addition, since we failed to find evidence to the contrary in Tables 2 and 3, we treat the leasing and sharecropping dummies as exogenous.[16] Specification (1) in Table 5 confirms the presence of a tenure security effect. The negative impact of leasing on FYM use declines significantly with plot tenure. Moreover, this effect cannot be attributed solely to the length of time that the household has exploited the plot, irrespective of whether it is leased. Specifically, when we include the (log) years since plot was acquired interacted with a plot ownership dummy in specification (2), we find no corresponding positive impact on FYM use.

Next we relax the assumption of exogenous tenancy duration. Our basic set of instruments is as follows: log of the tenant's overall farming experience (indicates his maximum potential duration), a dummy for whether the tenant actively searched for a tenancy *before* beginning the current one (indicates tenant's outside opportunities), and the village 'leave-out' mean of log tenancy duration based on the full tenant sample (including those cultivating a single plot) and excluding all plots cultivated by the household in question. Average duration in a village should be correlated with plot-specific duration to the extent that the duration of tenancies are determined by village leasing market conditions. Moreover, village-average duration should not be correlated with the unobserved (to the tenant) quality of a given plot; in particular, any plot quality information reflected in village-average duration should be common knowledge in the village.

All three of these variables are interacted with the leasing dummy to form instruments before implementing GMM-IV estimation. The F-statistic on the instruments in the hypothetical first-stage is high, at 32.3, and the GMM overidentification test statistic fails to reject the null. The results in column (3) show that not taking into account

[16] Note that if $\gamma \neq 0$ and ΔZ_c is correlated with log duration, then the orthogonality condition $E[\Delta\varepsilon_c \Delta Z_c] = 0$ used to obtain the GMM-IV estimates in Table 2 would not hold because it is wrongly assumed that $\gamma = 0$. In fact, however, including log duration in column (6) of Table 2 yields a leasing effect of -3.38 (0.67), which is practically identical to its uninstrumented counterpart in Table 4, column (1). Evidently, ΔZ_c is *not* correlated with log duration.

endogeneity has led to a large *downward* bias in the tenure security effect, consistent with the measurement error story in subsection 4.1. The IV coefficient on log duration is around five times larger than its uninstrumented counterpart in column (1), as is its standard error. The tenure security effect, though, remains significantly positive.

To sharpen precision, we augment the basic instrument set with three landlord variables: log age (indicates potential length of relationship with tenant), a dummy for whether landlord lives outside of local area,[17] and a dummy for whether he has post-secondary schooling (results in Table 4 show that more educated landlords have longer duration tenants). Column (4) records a 23% reduction in the standard error of the log duration coefficient (the first-stage F-statistic is 20.9), and a smaller percentage drop in its magnitude. Again, we strongly reject the hypothesis of no tenure security effect and conclude that tenancy duration is a noisy indicator of landlord commitment.

As a final check, we include the landlord's cultivating status in the second stage. Recall from Table 2 that this variable, which corrects for selection due to asymmetric information in the leasing market, attracted a significantly negative coefficient. One might worry that some of the landlord characteristics used as instruments in the last regression could be correlated with landlord cultivating status, although this concern is belied by the insignificance of the GMM overidentification test. Specification (5) confirms that such worries are indeed unwarranted. The coefficient on landlord cultivating status, though still negative, is no longer significant. This result may be due to the correlation that exists between landlord cultivating status and tenancy duration. At any rate, the important point is that our key findings are robust to the inclusion of this selection control.

Lastly, note that we still cannot reject the hypothesis of equal FYM use across fixed rent and sharecropped plots even after controlling for differences in tenancy duration, which, as noted earlier, are substantial. The estimated sharecropping effect remains stable across all specifications in Table 5.

4.4 Tests using static inputs

Our final set of tests are based on the observation that only noncontractible investments should exhibit a tenure security effect. By contrast, the use of static inputs should be unrelated to tenancy duration. An alternative story, however, is that longer-lived

[17] In light of our earlier monitoring argument, we checked whether the landlord location dummy was legitimately excludable, since absentee landlords of sharecroppers may be less likely to monitor (although they could just as well hire *kamdars*). But including this instrument in the second stage has negligible effects on the results.

landlord-tenant matches are more productive and hence involve more intensive use of a whole range of inputs, including those with no carryover across seasons or years. Here we focus on two such static inputs: nitrogen fertilizer and traction.

Table 6 presents results for nitrogen, measured in kilograms per cultivable acre. Nitrogen is the most important chemical fertilizer in Pakistan, whether mixed with phosphate or applied separately, and is used on 90% of plots in our sample. Given that the censoring problem is not serious and that, in the absence of censoring, linear fixed effects regression is more efficient than the semiparametric estimator used for FYM, we revert to the former procedure. Before considering tenancy duration, we go through an abbreviated series of tests for the endogeneity of leasing. A comparison of columns (1)-(3) indicates that, as before, asymmetric information does not lead to serious biases in the estimated leasing effect. While the leasing effect here is positive, which may indicate that nitrogen is a substitute for FYM, statistical significance is marginal at best.[18]

Turning next to the specifications that include log duration in columns (4) and (5), we find no significant tenure security effect for this static input, either when treating duration as exogenous or as endogenous. Also noteworthy is the absence of a sharecropping effect on nitrogen use. This finding is not surprising given that, in most cases, fertilizer costs are shared between landlord and share-tenant at the same rate as is output and, hence, there is no direct Marshallian inefficiency (Shaban, 1987, obtains similar results for chemical fertilizer use in India).

Table 7 repeats these steps for traction. Virtually every plot in our sample (99%) is plowed using either tractors or bullocks (mostly the former), so censoring is not an issue. Since tractors are more efficient, we aggregate tractor and bullock hours using an appropriate conversion factor. In Pakistan, traction differs from chemical fertilizer in one salient respect: Generally, this input is entirely the share-tenant's responsibility. Therefore, any disincentives arising from output sharing should be strongly reflected in traction. In the event, evidence that sharecroppers underutilize traction is weak. *OCT* households use 5-10% fewer hours of traction per acre on their sharecropped plots than on their owned plots, but these differences are never significant. This result is consistent with other evidence showing minimal productivity differences between owned and sharecropped land in rural Pakistan (see Jacoby and Mansuri, 2004; Nabi, 1986). Putting aside the sharecropping issue, our chief concern in Table 7 is with the coefficients on tenancy duration in columns (4) and (5), which are both *negative* but insignificant. Once again,

[18] If nitrogen and FYM are indeed substitutes, then *less* nitrogen may be used on leased plots with greater tenure security. There is, however, no evidence of this indirect tenure security effect in Table 5.

these findings support our interpretation of the positive log duration coefficient in the case of FYM as a tenure security effect.

5 Conclusion

Although commitment and holdup problems lie at the core of incomplete contract theory, their quantitative significance has rarely been assessed directly. This paper finds striking evidence of a holdup threat in a setting where theory suggests it should be prevalent, namely where investment is cooperative (in our case, the tenant's investment benefits the landlord). In rural Pakistan, specific investment is lower on leased land than on owned land cultivated by the same household, even after accounting for the potentially confounding effects of asymmetric information in the leasing market. Further, this leasing effect is not confined to sharecropped land, on which we might expect inputs to be used less intensively in general; land taken on fixed rent receives too little investment as well

We also find that security of tenure, and hence the incentive to invest, varies considerably across tenancies. This means that the mere potential for holdup does not necessarily lead to an unravelling of all investment. What is the mechanism for restraining ex-post opportunism? Our data show important differences across landlords in their propensity to retain their tenants, suggesting that some landlords might value reputation more than others. One can imagine an equilibrium in which 'trustworthy' landlords, who can credibly commit to not appropriate their tenants' investment returns, coexist with 'untrustworthy' landlords on whose land tenants never invest. From the policy perspective, the finding that the degree of commitment varies across tenancies means that there is scope for effective tenancy reform. Put differently, if tenure insecurity arises purely from inherent differences in tenant mobility, not from landlord behavior, then legislation binding landlords to long term contracts would do little to encourage investment.

Finally, it is worth asking about the economic significance of underinvestment on tenanted land. Of course, the full extent of the dynamic inefficiency cannot be assessed without accounting for all the different types of land-specific investment. This paper focuses on just a single investment, albeit an important *noncontractible* one, the use of farmyard manure. Nevertheless, it is still instructive to ask, based on our estimates, how yields would be affected by giving land ownership rights to tenants. Fortunately, we have access to results from a large number of agricultural experiments in India compiled by

Gaur (1992) showing the effect of FYM use on the yields of major crops;[19] these should also be approximately valid for neighboring Pakistan. In the year of application, one metric ton of FYM per acre would increase the yields of any of the four major crops (wheat, rice, cotton, and sugarcane) by 1.5-1.75 %. Based on the leasing effect from an untransformed model, leased plots receive on average 2.5 metric tons less FYM per acre than owned plots. Therefore, by converting a leased plot into an owned plot, major crop yields would rise by about 4% in the first year alone, a substantial impact on gross productivity.

These are rough calculations, to be sure, but they do give some sense of the magnitudes involved. Banerjee et al. (2002) find that a tenancy reform in India, one that fell far short of giving share-tenants full ownership rights, increased crop yields on the order of 50-60 %. At least part of this increase, they argue, can be attributed to higher investment due to improved tenure security. Our findings suggest that investment – more precisely, noncontractible investment – may only be a small part of the story. However, we reiterate, this conclusion rests critically on what other noncontractible investments (e.g., land maintenance activities) tenants can potentially undertake and how responsive these investments are to changes in the security of tenure. Filling in these gaps in our knowledge is an important area for future research.

[19] These estimates are more accurate than could ever be obtained from economic data because they are quite literally taken from experiments, in which everything else is held constant. The experimental effects reported are for FYM use on top of a standard application of chemical fertilizer.

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Table 1: Analysis of Land Rents

	(1)	(2)	(3)	(4)
Plot outside landlord's village	0.076 (0.091)	0.053 (0.090)	---	---
Outside plot ≥ 5 km from landlord's home	-0.072 (0.095)	-0.039 (0.096)	---	---
Log(duration of tenancy)	---	---	0.044 (0.036)	0.037 (0.035)
Log(plot value per acre)	---	0.257** (0.082)	---	0.247** (0.077)
R^2	0.37	0.39	0.38	0.39

Notes: Standard errors adjusted for village level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). Dependent variable is log(cash rent per acre). Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. All regressions estimated by OLS and include 23 *tehsil* dummies. Sample consist of all plots under fixed rent as reported by tenants (*N* =594).

Table 2: Leasing Effect for FYM

	RE Tobit	GMM				GMM-IV	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average Leasing effect[a]	-3.45*** (0.27)	-3.62*** (0.27)	-3.52*** (0.32)	-3.39*** (0.33)	-3.07*** (0.36)	-3.20*** (0.69)	-3.01*** (0.84)
Sharecropped plot	---	---	---	0.78 (0.45)	0.75 (0.43)	0.63 (0.59)	0.65 (0.55)
Landlord cultivates	---	---	---	---	-1.31** (0.50)	---	---
Log plot owner's landholdings	---	---	---	---	---	---	0.28 (0.30)
Significance tests:							
Plot characteristics $\chi^2_{(10)}$	48.0***	---	32.7***	30.5***	27.2**	32.8***	32.9***
Tehsil dummies $\chi^2_{(28)}$	243.6***	---	---	---	---	---	---
Estimation Sample	2450	2450	2450	2450	2415	2450	2355

Notes: Standard errors adjusted for household level clustering (except in col. (1)) in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). See Appendix Table A.1 for sample description. Dependent variable is log(kg FYM per acre + *k*), where choice of *k* is discussed in section 3.2. Plot characteristics are detailed in Appendix Table A.2. RE tobit is a conventional parametric household random effects tobit estimator. GMM is a semiparametric household fixed effects estimator that accounts for censoring as described in section 3.1.3. GMM-IV also accounts for endogeneity of leasing decisions. Excluded instruments are as follows: (1) dummy for plot located outside village of owner's domicile (2) dummy for plot outside village and 5 or more kilometers away from owner's domicile.

[a] When sharecropping dummy is included, average leasing effect is $\alpha + \beta E\left[\Delta S \middle| \Delta L = 1, OCT\right]$.

Table 3: Leasing Effect for FYM on Restricted Sample

	Full Sample	Sharecrop-only villages	
Leasing effect on sharecropped plots $(\alpha + \beta)$	-3.00*** (0.44)	-3.49*** (1.02)	-3.46*** (1.05)
Landlord cultivates	---	---	-0.19 (1.66)
Estimation Sample	2450	828	819
No. of villages	160	52	52

Notes: Standard errors adjusted for household level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). See Appendix Table A.1 for full sample description. Sharecrop-only village sample is subset of full sample from villages in which all leased plots are sharecropped. Dependent variable is log(kg FYM per acre + *k*), where choice of *k* is discussed in section 3.2. Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. Irrigation variables are dropped for specifications based on sharecrop-only villages sample. All estimates by GMM.

Table 4: Analysis of Tenancy Duration

	Mean (Std. dev.)[a]	(1)	(2)
Landlord Characteristics			
Log(age)	49.3	0.257	---
	(17.0)	(0.219)	
Log(yrs. of farm management)	24.5	0.006	---
	(16.0)	(0.082)	
Primary schooling	0.213	0.423**	---
		(0.154)	
Secondary schooling	0.284	0.448*	---
		(0.177)	
Post-secondary schooling	0.237	0.37	---
		(0.195)	
Owns tractor	0.231	-0.075	---
		(0.169)	
Owns tubewell	0.120	-0.298	---
		(0.233)	
Log(landholdings in acres)	48.6	0.128	---
	(57.2)	(0.081)	
Tenant Characteristics			
Log(age)	42.5	0.407*	0.037
	(12.7)	(0.198)	(0.160)
Log(yrs. of farm management)	17.7	0.261***	0.317***
	(14.6)	(0.057)	(0.070)
Primary schooling	0.158	-0.014	0.102
		(0.132)	(0.102)
Secondary schooling	0.061	0.327	0.143
		(0.177)	(0.108)
Owns tractor	0.105	-0.064	0.104
		(0.18)	(0.163)
Owns tubewell	0.038	-0.523	-0.308
		(0.243)	(0.482)
Landless	0.757	0.693*	0.086
		(0.267)	(0.306)
Log(landholding in acres + 0.1)	2.64	0.200**	0.112
	(9.70)	(0.071)	(0.077)
Relative of landlord	0.234	0.426*	0.466*
		(0.180)	(0.202)
Same caste/clan as landlord	0.114	-0.133	0.205
		(0.159)	(0.203)
Log(yrs. known landlord)	15.5	0.110	0.208**
(zero if landlord is a relative)	(14.2)	(0.059)	(0.077)
R^2		0.46	0.87

Notes: Standard errors adjusted for landlord level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). Dependent variable is log(yrs. of tenancy duration). Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. Column (1) includes 21 *tehsil* dummies. Column (2) includes landlord fixed effects. Sample consists of 342 plots leased out to different tenants by the 122 landlords having more than one tenant

[a]In levels.

Table 5: Tenure Security Effect for FYM

	GMM		GMM-IV		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Average Leasing effect	-3.35***	-3.37***	-3.15***	-3.36***	-3.21***
	(0.33)	(0.33)	(0.43)	(0.41)	(0.42)
Sharecropped plot	0.66	0.78	0.23	0.20	0.35
	(0.45)	(0.45)	(0.58)	(0.52)	(0.51)
Log tenancy duration (zero for owned plots)	0.66**	0.55*	3.45**	2.94***	2.79**
	(0.24)	(0.25)	(1.15)	(0.88)	(0.94)
Log yrs of plot ownership (zero for leased plots)	---	-0.32	---	---	---
		(0.26)			
Landlord cultivates	---	---	---	---	-0.59
					(0.55)
GMM test of overidentifying restrictions (*p*-value)	---	---	0.61	0.47	0.48
Estimation Sample	2450	2444	2450	2423	2412

Notes: Standard errors adjusted for household level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). See Appendix Table A.1 for sample description. Dependent variable is log(kg FYM per acre + *k*), where choice of *k* is discussed in section 3.2. Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. GMM is a semiparametric household fixed effects estimator that accounts for censoring as described in section 3.1.3. GMM-IV also accounts for endogeneity of tenancy duration. Excluded instruments (interacted with leasing dummy) in column (3) are as follows: (i) log of the tenant's overall farming experience, (ii) dummy for whether the tenant actively searched for a tenancy before beginning the current one, (iii) village leave-out mean of log tenancy duration. Columns (4) and (5) add: (iv) log landlord age, (v) dummy for whether landlord lives outside of local area, (vi) dummy for whether landlord has post-secondary schooling.

Table 6: Leasing and Tenure Security Effects for Nitrogen Fertilizer

	(1)	(2)	(3)[a]	(4)	(5)[b]
Average Leasing effect	0.130*	0.100	0.148	0.130*	0.128
	(0.064)	(0.066)	(0.135)	(0.064)	(0.066)
Sharecropped plot	0.010	0.013	-0.010	0.007	0.031
	(0.090)	(0.092)	(0.139)	(0.092)	(0.099)
Log tenancy duration (zero for owned plots)	---	---	---	0.015	-0.067
				(0.046)	(0.174)
Landlord cultivates	---	0.104	---	---	---
		(0.104)			
GMM test of overidentifying restrictions (*p*-value)	---	---	0.22	---	0.40
Estimation Sample	2444	2409	2444	2444	2417

Notes: Standard errors adjusted for household level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). See Appendix Table A.1 for sample description (6 observations dropped due to missing data). Dependent variable is log(kg nitrogen per acre + *k*), where choice of *k* is discussed in section 3.2. Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. All regressions estimated by OLS or IV with household fixed effects.

[a] Leasing endogenous (see notes to Table 2 for instruments).

[b] Duration endogenous (see notes to Table 5, col. (4) for instruments).

Table 7: Leasing and Tenure Security Effects for Traction

	(1)	(2)	(3)[a]	(4)	(5)[b]
Average Leasing effect	-0.060	-0.066	-0.090	-0.062	-0.066
	(0.055)	(0.060)	(0.128)	(0.055)	(0.056)
Sharecropped plot	-0.093	-0.090	-0.060	-0.082	-0.056
	(0.072)	(0.074)	(0.131)	(0.073)	(0.075)
Log tenancy duration (zero for owned plots)	---	---	---	-0.058	-0.153
				(0.043)	(0.112)
Landlord cultivates	---	0.002	---	---	---
		(0.073)			
GMM test of overidentifying restrictions (*p*-value)	---	---	0.75	---	0.09
Estimation Sample	2449	2414	2449	2449	2422

Notes: Standard errors adjusted for household level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). See Appendix Table A.1 for sample description (1 observation dropped due to missing data). Dependent variable is log(hours traction per acre + *k*), where choice of *k* is discussed in section 3.2. Plot characteristics (included in all specifications) are detailed in Appendix Table A.2. All regressions estimated by OLS or IV with household fixed effects.

[a] Leasing endogenous (see notes to Table 2 for instruments).

[b] Duration endogenous (see notes to Table 5, col. (4) for instruments).

Table A.1: Descriptive Statistics

Sample	No. of plots	FYM (ton/acre)	Nitrogen (kg/acre)	Traction (hrs/acre)
All multi-plot households	2450	2.86	75.0	7.69
(estimation sample)		(8.18)	(78.9)	(13.0)
		[0.36]	[0.90]	[0.99]
Of which:				
Owner-cum-tenant households	1237	3.60	78.4	8.40
		(8.09)	(72.1)	(10.5)
		[0.45]	[0.89]	[0.99]
Of which:				
Owned	552	5.46	83.8	9.47
		(10.2)	(80.4)	(12.5)
		[0.57]	[0.88]	[0.99]
Leased	685	2.10	74.1	7.54
		(5.44)	(64.3)	(8.42)
		[0.35]	[0.90]	[0.99]
Of which:				
Sharecropped	343	1.46	49.6	5.69
		(4.27)	(44.8)	(6.65)
		[0.34]	[0.83]	[0.98]
Fixed Rental	342	2.74	98.5	9.40
		(6.34)	(71.2)	(9.55)
		[0.36]	[0.96]	[0.99]

Notes: Means (standard deviations) [fraction nonzero observations].

Table A.2: Descriptive Statistics and Results for Plot Characteristics

	Means (Std. Dev.)		Regression Coeffs. (Std. Errors)		
	Owned Plots (N = 805)	Leased Plots (N = 1645)	FYM	Nitrogen	Traction
Log(cultivable area)	2.74	3.25	0.134	-0.134**	-0.236***
	(0.94)	(0.88)	(0.243)	(0.045)	(0.036)
Plot outside village of cultivator	0.10	0.14	-1.74*	0.172	-0.058
			(0.78)	(0.151)	(0.060)
Outside plot ≥ 5 km from cultivator's home	0.02	0.03	-1.29	-0.716*	-0.302
			(1.47)	(0.284)	(0.223)
Log(value/acre)	4.83	4.72	0.297	0.500**	0.041
	(0.85)	(0.87)	(0.720)	(0.180)	(0.076)
Canal irrigated	0.74	0.84	3.39*	2.13***	0.439**
			(1.64)	(0.49)	(0.150)
Sweet groundwater available	0.29	0.21	2.32*	1.78***	0.264*
			(1.13)	(0.30)	(0.131)
Brackish groundwater available	0.24	0.21	0.88	1.02***	0.433*
			(1.17)	(0.29)	(0.216)
Clay soil	0.22	0.23	1.27	-0.057	-0.079
			(1.06)	(0.107)	(0.090)
Sandy soil	0.20	0.20	1.62*	0.088	0.016
			(0.81)	(0.125)	(0.086)
***Chikni* soil**	0.19	0.22	0.805	0.135	0.085
			(0.759)	(0.140)	(0.081)
Significance test: $\chi^2_{(10)}$			30.5***	108***	91.2***

Notes: Regression standard errors adjusted for household level clustering in parentheses (* = p-value < 0.05; ** = p-value < 0.01; ***= p-value < 0.001). FYM coefficients associated with col. (4), Table 2; nitrogen with col. (1), Table 6; traction with col. (1), Table 7. Omitted category for soil type is clay loam (*maira/acchi*).