DISCUSSION PAPER SERIES

No. 3032

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PUBLIC POLICY

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ISSN 0265-8003

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Discussion Paper No. 3032
October 2001

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CEPR Discussion Paper No. 3032

October 2001

ABSTRACT

On the Structure of Tenancy Contracts: Theory and Evidence from 19th Century Rural Sicily*

In a world with asymmetric information, contractual terms are an important incentive device. This Paper studies the effect of crop characteristics on the choice between short-term and long-term tenancy contracts and on the choice between sharecropping and fixed-rent contracts when the production process depends on two non-contractibles: effort devoted to current production and effort devoted to plant and soil maintenance. Long-term contracts are effective in providing incentives for non-contractible maintenance investment. Since, however, incentive provision is costly, long-term contracts will be employed only when, due to the characteristics of the crop, maintenance benefits are high, or when, due to the characteristics of the tenant, the cost of providing incentives is low. The predictions of the theory are tested on a unique data set containing 705 tenancy contracts signed between 1870 and 1880 in the province of Syracuse (Sicily). The empirical evidence shows that, indeed, long-term contracts were used if the crops grown had higher maintenance needs. Other comparative static results are derived and tested empirically.

JEL Classification: D82, O12, O17 and Q15
Keywords: contract duration, rural contracts and tenancy

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*I would like to thank Alexis Arias-Vargas, Tim Besley, Maristella Botticini, Peter Gottschalk, Timothy Guinnane, Fabio Schiantarelli, participants at seminars at Boston College and Yale University, participants at the 1998 NEUDC conference and especially James Anderson and Richard Arnott for useful comments and suggestions; Antonio Bandiera and Nunzia Guzzardi for help with data collection; the Directors and the staff at the State and Notary archives in Syracuse for their kind cooperation. All errors are mine.

Submitted 05 October 2001

1 Introduction

In a world with asymmetric information contracts matter: when the principal cannot observe the level of inputs chosen by the agent, contractual structure determines input choices and ultimately productivity.

The purpose of this paper is to identify and test the determinants of the structure of tenancy contracts in a rural economy with asymmetric information. The paper focuses on crop characteristics, whose role as a determinant of contractual structure has been somewhat neglected by the existing literature. In addition to the classical choice between sharecropping and fixed rent, the paper addresses another dimension of contractual structure, that is contract length. The theory is motivated and illustrated in the context of Sicilian agriculture in the late 19th century. Its predictions are tested using a unique data set, compiled by the author, which contains information on 705 tenancy contracts signed between 1870 and 1880 in the province of Syracuse, Sicily. Compared to existing data sets, the one used in this paper contains detailed information on crops and contract length which allows a more comprehensive test of the theory.

The structure of the contract is analyzed using a two period principal-agent model with limited liability in which output depends on the level of unobservable effort devoted to two tasks: current production and maintenance. Since production effort affects current output while maintenance effort affects output in the future, production effort and maintenance effort require different incentive mechanisms. To provide incentives for current effort the landlord has to condition current pay on current output. To provide incentives for maintenance the landlord has to offer a long term contract so that the tenant's pay can be conditioned on future output, which is the only signal for maintenance effort. The limited liability constraint makes incentive provision costly because it

imposes an upper bound on the punishment that can be inflicted on the tenant. Since the limited liability constraint is more likely to bind for poor tenants, incentive provision is costlier for poor tenants. In this setting long term contracts are preferred to short term contracts when, due to the characteristics of the crop, the benefit of maintenance is high or when, due to the personal characteristics of the tenant, the cost of providing incentives for maintenance is low. The landlord will use long term contracts only when the crop is very sensitive to maintenance and/or when the tenant is rich and/or when his outside opportunity is high. A similar argument shows that fixed rent contracts are preferred to sharecropping when the marginal product of effort is low, when the tenant is rich, and when his outside opportunity is high.

The empirical results are consistent with the predictions of the theory: the probability of observing a long term contract is higher if the tenant is wealthy and/or his outside opportunity is high, and if crops with high maintenance needs like vines are grown in the rented plot. The probability of observing a fixed rent contract is higher if the tenant is wealthy and/or his outside opportunity is high, and if crops that are not very sensitive to effort like wheat are grown in the rented plot.

This paper offers a novel contribution to both the theoretical and the empirical literature on the structure of tenancy contracts. In the theoretical literature, both contract length and crop characteristics have received some attention individually, whereas their relationship has been completely neglected.[1] Most theoretical papers examine principal-agent models with only one non contractible input- current production effort. Some of these papers employ one-period models to explain the existence of sharecropping and

[1]Bloch (1970) and Hoffman (1984) analyse sharecropping and other tenurial forms in early modern France. Botticini (1998), Epstein (1994) and Galassi, Meally and Pudney (1998) research similar issues in 15th century Tuscany. Alston and Higgs (1982) and Higgs (1974) analyse contractual choice in the Southern United States at the end of the 19th century. Bliss and Stern (1982) Bardhan (1984) and Shaban (1987) among others study tenancy agreements in contemporary India.

its consequences on agricultural productivity. Others analyse similar issues using multi-period models and focus on the use of efficiency wages an eviction threats as incentive mechanisms. In this setting, the results depend only on the relationship between the tenant and the landlord being repeated over time: long-term agreements are feasible but unnecessary. In contrast, this paper analyses a situation in which a sequence of short-term contracts cannot replicate the outcome of a long-term contract: long-term contracts are necessary because they provide incentives for maintenance.[2]

The effect of crop characteristics on the choice between sharecropping and fixed rent contract has been analyzed by Botticini(1997) and by Allen and Lueck(1996) in the context of one-period models. In Botticini(1997)'s model the tenant allocates effort across different tasks which include current production and maintenance. By assumption the value added of maintenance cannot be measured, hence the landlord cannot provide maintenance incentives directly. Sharecropping contracts, which entail low incentives for current production, can then be used to provide indirect maintenance incentives.[3] Similarly Allen and Lueck(1996) show that a sharecropping contract can be used to indirectly reduce the incentive to exploit the soil because it reduces the incentives to maximize current output. Analyzing these issues in the context of a two-period model, as the one in this paper, yields sharply different results about the rationale for sharecropping. In a two-period model the long term contracts can be used to elicit maintenance effort directly while sharecropping contracts actually *reduce* maintenance incentives because the tenant receives only a share of future output.

Bardhan (1984) analyzes contract length in a two-period model with non-contractible investment. Long term contracts are useful because, as in this paper, they provide in-

[2]See Singh(1989); Dutta, Ray and Sengupta (1989); Otsuka, Chuma, and Hayami (1992) for excellent surveys.

[3]This argument rests on the assumption that the tenant exerts a positive amount of effort across tasks in the absence of incentive pay. Then reducing effort incentives for one task increases incentives for the other tasks. See Holmstrom and Milgrom(1991) for a discussion.

centives for investment. They are costly because by committing to a long term contract the landlord forgoes the opportunity to use eviction threats that elicit effort for current production. If Bardhan's horizon were extended, however, the trade-off between investment incentives and eviction threats would lose relevance. Intuitively, if there were more than two periods, eviction threats would actually provide investment incentives because, by increasing output in the second period, investment increases the probability that the tenant will keep the job in the third period and so on. The results of this paper, in contrast, do not depend on the length of the horizon since the cost of providing investment incentives derives from the limited liability constraint.

Due to the lack of adequate data, the existing empirical literature is quite slim and, given that existing data sets do not contain information on contract length, focuses mostly on the choice between fixed rent and sharecropping contracts. Allen and Lueck (1996) examine U.S. survey data, Laffont and Matoussi(1995) use a unique data set from El-Ouja, Tunisia. Botticini (1997) tests alternative models of sharecropping using 15th century data from three Tuscanian towns and Hoffman (1984) analyzes a small sample of contracts from 16th century France. The last two papers present evidence in favour of a relationship between crop characteristics and contractual structure which is consistent with my findings: the probability of observing a sharecropping contract is higher if vines are grown.

2 The Context: Facts About Sicilian Agriculture

In 1881 and 1911 the Italian Parliament published two extensive surveys that analyzed the economic and social structure of the agricultural sector in different regions of the country.[4] The surveys describe Sicilian agriculture in great detail and contain informa-

[4]The first is the "Inchiesta Jacini:Atti della Giunta per l'inchiesta agraria e sulle condizioni della classe agricola 1881" vol XII, parte I e II, tomo 1-5-rapporto di Abele Damiani per la Sicilia (Jacini

tion on the cultivation methods of the main crops that is particularly relevant for the present work. The surveys also contain information on tenancy contracts and provide some preliminary evidence in favour of a relationship between crop characteristics and contractual structure.

Until the beginning of this century Sicily was essentially a rural economy; agriculture employed more than 50% of the population and was the basis for industry and commerce. Land was the most important factor of production and was unevenly distributed.[5]

Formal credit markets were underdeveloped and accessible only to wealthy landowners since lenders required strong guarantees. Poorer farmers relied on informal lenders and on their landlords for working capital loans.

Wheat was the most widespread crop, followed by vines, olive, and citrus trees.[6] Wheat was generally cultivated in the *latifondi,* using primitive techniques. Three year rotation was the most common system: the field produced wheat the first year, was left to pasture the second year and to fallow the third year (sometimes broad beans or barley were grown during the third year). In September the land was tilled. The seeds were then planted and the soil was tilled again. In July the plants were harvested. There were no agricultural machines, no irrigation and no land manuring. Damiani (1881) reports that this method of cultivation exploited the soil and reduced its productivity. Modern

Inquiry: report by the committee for the study of rural practices and the conditions of the rural classes). The second is Inchiesta Parlamentare sulle Condizioni dei Contadini nelle Provincie Meridionali e della Sicilia"- vol IV tomo I e II- relazione del delegato tecnico per la Sicilia Prof. Lorenzoni- 1909-1911("Parliamentary Inquiry on the Conditions of Farmers in the Southern Provinces and in Sicily"-vol. VI books I and II-report of the agent for Sicily-Prof. Lorenzoni).

[5]Land in the inner part of the island was concentrated in large properties -latifondi- whose typical extension ranged between 200 and 1000 hectares. Latifondi occupied about 30% of the arable land but accounted for only 16% of total agricultural income. Land along the coast and around the villages in the interior was fragmented in properties as small as 1ha.The pattern of land distribution derived from the feudal system, which was abolished in 1812. Land reforms did not succeeded in dividing the fiefs evenly. As described above, land was either too concentrated or too fragmented.

[6]In the province of Syracuse, wheat occupied 73% of the arable land, vines 14%, olive trees 5%, and citrus trees 1.6%.

ploughs [7] and, above all, fertilizers were needed to restore the productivity of the soil and increase wheat yields. Depending on fertility, one hectare planted with wheat yielded L.50 to L.150 in net revenue.[8]

Olive trees were usually grown in wheat fields, sometimes in olive yards. To give good yields, olive trees needed regular pruning, careful harvesting, tilling and fertilising. In general olive trees were not well tended: the soil was not fertilised, maintenance was unsatisfactory, pruning was careless and irregular. Nevertheless, because of favorable soil and climate conditions and because of their resistance, olive trees survived and produced high yields. Owner-cultivators, as opposed to tenants, tended their trees better and consequently obtained higher yields and higher quality olives.[9]

Vines were grown in the coastal areas and around villages in the interior. The characteristics of the soil and the temperate weather were ideal for vineyards, which could even be planted on hills up to an altitude of 1200 meters. Vineyards required considerable care. The soil around the plants had to be hoed four times a year and fertilized. The plants had to be pruned every year and they needed regular and precise application of pesticides to prevent pest attacks which could be devastating. Net revenues could be as high as L.800 per hectare and were rarely lower than L.300.

Citrus trees were grown in the coastal regions. The trees were quite delicate and required more working capital than vines. The soil in citrus groves had to be irrigated, fertilized and hoed 4 or 5 times per year. The trees needed pesticides and daily inspec-

[7] Damiani reports that farmers still used the plough first employed by the Romans two thousand years earlier, which was inadequate because it did not dig deeply and did not allow the soil to "breathe" properly.

[8] Italian Liras in 1881. Data are for the province of Syracuse. The average annual wage for permanent workers was about L.400. The average daily wage for casual labourers was about L.1.35; that is L270 per year, assuming 200 working days.

[9] For instance, owner-cultivators used a harvesting system called "a pettine" which entailed reaping the fruits from the tree with a instrument shaped like a comb. Tenants generally adopted a system called "abbacchiatura" which consisted in shaking the trees until all the olives fell. Beside damaging part of the harvest, this system had the serious drawback of destroying many of the buds, thereby reducing the following year's production.

tions. Citrus trees were especially sensitive to irrigation procedures and pesticide usage. Excessive irrigation and/or bad irrigation timing were known to cause the "mal della gomma", a contagious illness which would make the trees rotten. Citrus groves were very remunerative, yielding between L. 500 and L.1300 per hectare.

In general, tree crops were tended by the owner while wheat fields were contracted out. If the field contained olive, almond or fruit trees, these were often excluded from the contract. The landlord would either cultivate the trees directly or rent them to a different farmer under a different contract. Landlords were reluctant to rent out vineyards and citrus groves because "the tenant would not take proper care of the plants since they are not his own." (Lorenzoni 1911)

Fixed rent and sharecropping[10] were the most common forms of tenancy contracts. Wage contracts were used only for specific tasks: permanent laborers were often hired to guard vineyards and citrus groves and casual laborers to help during the harvest season.

Contract length varied across crops. Contracts for wheat and olives could last up to six years but were generally one to two years long. Contracts for vines and citrus were normally four to six years long but lasted up to twentynine years if the vineyard had to be created.[11] Contract length appeared to be related to the form of the agreement as sharecropping contracts were generally shorter than fixed rent contracts.

The description of cultivation methods shows that the crops had different characteristics in terms of sensitivity to both production and maintenance effort. Wheat and to a lesser extent olive trees were less responsive and resisted well to mistreatment. Vines and citrus trees were more responsive and could not be profitably grown without

[10] The usual share for the tenant was one half. The existing law ruled that output had to be divided 50-50 unless estabilished local customs prescribed a different split. See Codice Civile per il Regno d'Italia (1865) art.1654&1661.

[11] These were called "contratti di miglioria" (translates as "improvement contracts"). The tenant had to prepare the soil and plant the vines. No rent was due until the productive life of the plants had started and after that the entire product went to the farmer for at least the first three years. At the end of the arrangement the vineyard belonged to the landlord.

considerable care.

The description of tenancy contracts, meanwhile, suggests that crop characteristics were an important determinant of the structure of tenancy contracts. That the cultivation of different crops planted in the same field was often regulated by separate contracts supports this view. In particular, there seems to have been a positive relationship between the length of the contract and the maintenance needs of the crop.

Finally, the discussion suggests that providing incentives for maintenance had to be costly. For instance, if more maintenance were devoted to the soil and the trees the yields of both wheat and olive trees would have been higher, yet the cultivation method was sub-optimal especially when the crops were farmed by a tenant.

3 A model of contract choice.

This section analyzes the structure of optimal tenancy contracts in the presence of asymmetric information and capital market imperfections. The model yields testable predictions regarding the length of the optimal contract and the crop share received by the tenant as a function of crop characteristics and of the personal characteristics of the tenant.

3.1 Set up: Production

Production takes place in two periods and is subject to uncertainty. In each period the state of the world can be good or bad; output, net of material inputs cost, is equal to 1 and 0 in the good and in the bad state, respectively.

The tenant's job consists of different tasks which can be grouped into two categories: tasks related to current production and tasks related to soil and plant maintenance. The tenant chooses the level of "production effort" and the level of "maintenance ef-

fort". Effort choices are unobservable and, due to the nature of the tasks, cannot be monitored.[12]

Production effort in each period increases the probability of the good state in that period. Maintenance effort operates with a lag: it increases the probability of the good state next period. In what follows I will focus on maintenance tasks, such as the usage of pesticides and fertilizers, whose effect on second period output cannot be distinguished from the effect of second period production effort. The reason is that tasks whose outcome is clearly identifiable by a third part, like pruning and weeding, can, if necessary, be contracted upon separately and therefore do not affect the structure of the contract.[13] Unlike pruning and weeding, tasks such as the usage of pesticides and fertilisers must be performed continuously through time, which makes them integral part of the daily cultivation practice and impossible, or extremely costly, to be contracted out separately.

The probability functions are linear in effort. Output in the two periods is therefore:

$$Y_1 = \begin{cases} 1 & \text{with probability} \quad he_1 \\ 0 & \text{with probability} \quad 1 - he_1 \end{cases}$$
$$Y_2 = \begin{cases} 1 & \text{with probability} \quad he_2 + \theta hm \\ 0 & \text{with probability} \quad 1 - he_2 - \theta hm \end{cases}$$

where

e_i = production effort in period i, $e_i \in (0, 1)$

m = maintenance effort, $m \in (0, 1)$

[12] I assume for covenience that there is no monitoring technology. In reality, monitoring is likely to exist but to be unprofitable. Indeed, if the landowner hires another agent to monitor the farmer the two can collude against the landowner. The relevant issue is whether it is convenient for the landowner to supervise labor himself thus becoming actively engaged in the production process. The decision between self-cultivation and delegation is taken at an earlier stage and its analysis goes beyond the scope of this model.

[13] Contracts for tree crops often contained special clauses to regulate pruning. "Pruning experts" were hired either to do the job themselves or to supervise the tenant. Since the tenant would have had the incentive to over-prune in order to get fuel for the winter, in general the landlord would keep the pruned wood.

h = marginal productivity of production effort, $h \in \left(0, \overline{h}\right)$and $\overline{h} < 1$

θ = marginal productivity of maintenance effort, relative to production effort, $\theta \in \left(\underline{\theta}, \widetilde{\theta}\right)$ with $\underline{\theta} = \sqrt{\frac{2c}{h^2}}$ and $\widetilde{\theta} < \min\left\{1, \frac{1}{h} - 1\right\}$.

Maintenance effort entails a fixed cost c which represents the cost of material inputs like fertilizers and pesticides that are necessary for maintenance[14]. The cost of material inputs does not depend on the level of maintenance effort; for instance, the cost of pesticides is unrelated to how carefully these are employed. The fixed cost also reflects the fact that by choosing $m > 0$ the tenant forgoes the opportunity of increasing output in the first period by overexploiting the soil and the plants. The lower bound on θ implies that maintenance is always profitable in a first best sense.

Note that in this set-up the marginal productivity of production effort (h) relates to both the profitability and the riskiness of production. The higher is h, the higher is expected revenue but also the larger is the spread between the good and the bad state.

3.2 Set up: Payoffs and Constraints

The landlord offers the tenant a contract (s_i, r_i, l) where $l = 1, 2$ is the duration of the agreement, $s_i \in [0, 1]$ is the share of output received by the tenant and r_i is the rent the tenant pays to the landlord[15] in period i. If $l = 1$ the relationship between the landlord and the tenant terminates after one period. If $l = 2$ their agreement lasts 2 periods and the landlord can commit to the terms of the contract at the beginning of the first period.[16]

[14] In 19th century rural Sicily, pesticides and fertilisers accounted for a substantial share of total costs. Damiani(1881) reports that in the province of Syracuse production costs for wheat, excluding fertilisers, ranged between L50 and L.150 per hectare while fertilisers cost between L. 30 and L.60 per hectare.

[15] The restriction to linear contracts is without loss of generality because with two states of the world all contracts can be rewritten as linear contracts.

[16] This assumption receives mixed support in the existing literature. On one hand, it can be argued that there is a problem of dynamic inconsistency since once the tenant has invested in maintenance, the landlord is better off by evicting him and retaining the benefit of his investment. On the other, reputation effects can help the landlord "tie his hands" thus making his commitment credible. Moreover,

Assuming risk neutrality the utility of the landlord is

$U_L = \{(1 - s_1)e_1 h + (1 - s_2)(e_2 + \theta m)h + r_1 + r_2\}$

Assuming risk neutrality[17] and quadratic disutility of effort, the utility of the tenant is

$U_T = \left\{s_1 e_1 h - \frac{1}{2}e_1^2 - \frac{1}{2}m^2 - \delta(m)c + s_2(e_2 + \theta m)h - \frac{1}{2}e_2^2 - r_1 - r_2\right\}$

where $\delta(m) = \begin{cases} 1 & if \quad m > 0 \\ 0 & if \quad m = 0 \end{cases}$

Maximizing U_T with respect to (e_1, e_2, m) yields the incentive compatibility constraints (IC):

$$\begin{cases} e_1 = s_1 h \\ m = s_2 \theta h & if \quad s_2^2 \frac{h^2\theta^2}{2} \geq c \\ m = 0 & if \quad s_2^2 \frac{h^2\theta^2}{2} < c \\ e_2 = s_2 h \end{cases} \tag{1}$$

Note that if the tenant is offered a short term contract he will choose $m = 0$, since he would incur the costs but not reap the benefits of maintenance. In this framework, long term contracts are strictly necessary to provide incentives for maintenance effort, but for some parameters values they are not sufficient. Indeed if s_2 is small the tenant will choose $m = 0$ even with a long term contract. Note also that because the effect of maintenance effort on second period output cannot be differentiated from the effect of production effort, the choice of both m and of e_2 is driven by the same instrument - the output share in period 2.

the existence of courts within a well-established legal framework obviously enhances the credibility of the commitment, especially if the contracts are written. The assumption is a sensible one in the case of rural Sicily, both because the reputation effects were likely to be strong (close-knit villages) and because of the existing law enforcement system.

[17] Many explanations of sharecropping rely on the fact that, being poorer, the tenant is more risk averse than the landlord. It follows that ultimately what matters for the results is the wealth difference between the two parties. This paper assumes that both agents are risk neutral and accounts for difference in wealth by introducing a limited liability constraint (see below). The results would be similar if risk aversion were assumed instead of limited liability, since both are related to wealth in similar ways.

Due to capital market imperfections, the tenant is subject to a limited liability constraint[18] which ensures that in any period and in any state he is left with enough resources to survive. To satisfy the limited liability constraint, the equilibrium rent must be smaller than the tenant's residual wealth- the amount of liquid assets he owns after paying for input costs and subsistence consumption. The limited liability constraint imposes an upper bound to the penalty the landowner can inflict on the tenant. Furthermore, the limited liability constraint guarantees that the contract is renegotiation-proof.[19] If it were not met the parties would have to renegotiate in the bad state because the tenant could not afford to pay the rent. It is implicitly assumed that, in case of renegotiation, the landlord can correctly measure and expropriate the tenant's wealth, which is realistic in the institutional setting under consideration.

Finally, the optimal long term contract must satisfy a "no take the money and run"(MR) constraint which guarantees that the contract is subgame perfect for the tenant. Since maintenance benefits accrue in the second period whereas the costs are incurred in the first, the landlord might want to give a loan to poor tenants who could not otherwise afford to pay the cost. A loan is equivalent to charging a low rent in the first period and a high rent in the second. This, however, could give the tenant the

[18]Banerjee and Ghatak (1996), Mookherjee (1997) and Shetty (1988) present models in which the tenant is subject to a limited liability constraint. It is important to note that the assumption of limited liability is consistent with observed facts, hence appropriate for the institutional context under study. Damiani(1881)'s analysis of farmers'saving behaviour suggests that in general whealty farmers could and did save, whereas poor farmers could save only in good years and had "just enough to survive" in bad years, which, as shown below, is consistent with the equilibrium outcome under limited liability. Also, Damiani's analysis of social relationships between farmers and landowners shows that incentive mechanisms such as threats of physical punishment, which would make the limited liability constraint irrelevant, were not used in practice. In the province of Syracuse the relationship was characterised by "friendship", "reciprocity" and "respect" in the best cases; by "exploitation" and "unfairness" in the worst. Physical mistreatments or threaths thereof were not observed in any village.The information on social relationships is extracted from interviews with the Chief Prosecutor in each village and the answer of the Prosecutors did not show any favouritism towards landowners, as one might fear. Indeed, most Prosecutors openly accused the landowners of exploiting the peasants, of charging high interest rates on loans, of paying low wages, and of charging rents that were too high.

[19]This is without loss of generality. See discussion below.

incentive to stay for the first period, pay the low rent and leave in the second period without supplying maintenance effort. The "no take the money and run" constraint rules out this possibility.[20] Sicilian landlords realised that loans could push the tenant to "take the money and run"; indeed "the owner carefully limits the size of the loans because there is the danger that the tenant leave the field(..) the owner has to make sure that the tenant prefers to stay and get his share of output" (quoted from Lorenzoni (1911)).

3.3 Optimal short term and long term contracts.

It is convenient to solve for the optimal short term and long term contract separately. The comparison of the landlord's payoffs in the two cases will determine the optimal length.[21]

The optimal short term contract (s, r) solves

$$\max_{s,r} \left\{ sh^2 (1 - s) + r_1 \right\}$$

s.t.

$$\frac{1}{2} s^2 h^2 - r - \overline{u} \geq 0 \tag{PC}$$

$$w - r \geq S \tag{LL}$$

[20] (MR) reflects the fact that the contract is effectively binding only for the landlord, mostly because the tenant can leave the relationship without being punished. It could be argued that the landlord can sue the tenant for breach of contract and recover the money he lost plus a fine. Because of limited liability, however, it would not be worthwile for a landlord to take a poor tenant to court. And the MR constraint is not binding for wealthy tenants.

[21] This model analyses contract length only as a device to give incentives for maintenance effort. It does not deal with other issues related to the duration of the relationship between the landlord and the tenant. Landlord's strategies that involve conditioning the terms of the current contract on past performance and those that involve eviction threats are ruled out. The first were not used in practice. The second should be analysed in an infinite horizon context.

where $\overline{u}$ is the tenant's reservation utility, w is the tenant's initial wealth in both periods and S is his subsistence level of consumption, which is assumed equal to zero.

The objective function is obtained by plugging the incentive compatibility constraint into the landlord's payoff function.(PC) is a standard participation constraint. It requires that the contract provides the tenant with utility level at least as high as his reservation utility.(LL) is the limited liability constraint.

The solution to the maximization problem is algebraically cumbersome and it is reported in the appendix. Lemmas 1 and 2 state the properties of the optimal short term contract with respect to the technological characteristics of the crop h and θ and to the personal characteristics of the tenant, summarized by the variable $W = w + \overline{u}$.

Lemma 1. *There exist $\overline{W}$ and $\underline{W}$ such that:*

(i) for $W \geq \overline{W}$ the tenant's share is equal to one, i.e. fixed rent contracts are chosen (only PC binds);

(ii) for $\overline{W} > W > \underline{W}$ the tenant receives a share of the output that is increasing in wealth and earns no information rent (PC and LL bind);

(iii)for $W \leq \underline{W}$, the tenant receives a constant share of the output and earns more than his reservation utility (PC does not bind).

Lemma 2. *$\overline{W}$ is increasing in h; that is, the higher the marginal product of effort the more likely the limited liability is to bind. $\underline{W}$ too is increasing in h, that is, if the crop exhibits high marginal product of effort the tenant is more likely to earn information rents.*

The intuition for Lemma 1 is as follows: if the tenant is "rich" or his outside opportunity is very high, the landlord can offer him a fixed rent contract that induces the maximum level of effort and therefore maximizes the rent that satisfies the participation constraint. But if the tenant's wealth is lower than the rent defined above, the contract is not feasible because it does not satisfy the limited liability constraint. In

the constrained optimum consistent with the limited liability constraint, the landlord charges the highest possible rent (i.e. w) and lowers the share so that the participation constraint binds. Finally, if the tenant is extremely poor the landlord will prefer to pay some information rents (PC does not bind) in order to induce effort. Intuitively, it is not optimal to push the tenant down to his reservation level because doing so would result in a very low level of effort, lower for poorer tenants: the landlord is better off by giving the tenant a little extra in terms of utility in order to get a higher level of effort.[22]

Lemma 2 follows from the fact that an increase in h increases the first best level of rent, implying that the limited liability constraint is more likely to bind and that fixed rent contracts can be offered only to very wealthy tenants. In practice this implies that sharecropping contracts are more likely to be used for crops that are both very profitable and very risky.[23]

The optimal long term contract that provides incentives for maintenance is the quadruplet (s_1, s_2, r_1, r_2) that solves

$$\max_{s_1,s_2,r_1,r_2} \left\{ s_1 h^2 (1 - s_1) + s_2 (1 - s_2) h^2 (1 + \theta^2) + r_1 + r_2 \right\}$$

s.t.

$$\frac{1}{2} s_1^2 h^2 + \frac{1}{2} s_2^2 h^2 (1 + \theta^2) - (r_1 + r_2) - c - 2\overline{u} \geq 0 \tag{PC}$$

$$\frac{1}{2} s_2^2 h^2 (1 + \theta^2) - r_2 - c - \overline{u} \geq 0 \tag{MR}$$

$$s_2^2 \frac{h^2 \theta^2}{2} \geq c \tag{IC}$$

[22]Note that if the tenant were risk averse the link between wealth and contract form would be similar as poorer tenants, who are more risk averse, would get sharecropping contacts.

[23]Also in this case the prediction would be similar if the tenant were risk averse, as he would get more insurance (i.e. sharecropping) for riskier crops.

$$w - r_1 - c \geq S \tag{LL$_1$}$$

$$w - r_2 \geq S \tag{LL$_2$}$$

(PC) is the participation constraint; (MR) is the "no take the money and run" constraint. (IC) is the incentive compatibility constraint; it guarantees that the second period share is sufficiently high so that the tenant will choose $m > 0$. Note that (IC) is more likely to bind when θ is low relative to c, i.e. when maintenance is not very profitable. (LL_1) and (LL_2) are the limited liability constraints.

The solution for the optimal long term contract has the same structure with respect to W an h, but is complicated by the presence of the (MR) and the (IC) constraints, and depends on the magnitude of θ. Figure 1 illustrates the regions of parameter space over which different sets of constraints bind; the parameters of the optimal contract are reported in the appendix.

INSERT FIGURE 1

3.4 Results

Figure 1 shows that Lemmas 1 and 2 hold for every θ, and that fixed rent contracts are more likely the lower is the crop sensitivity to maintenance effort (the range of W over which the limited liability binds increases with θ). This leads to:

Proposition 1 *About the Output Share:*

The share of output received by the tenant is non-decreasing in W and non-increasing in θ and h. Moreover, $\overline{W}$ is non decreasing in θ and h. That is, share contracts are more likely to be observed when the tenant is poor and/or his outside opportunity is low and/or the marginal productivity of production effort is high and/or the crop has high maintenance needs.

Proof: see Appendix

Direct comparison of the landlord's payoffs under short and a long term contracts yields:

Proposition 2 *About Contract Length:*

There exists a $\widehat{\theta} \in \left(\underline{\theta}, \overline{\theta}\right)$ *such that for* $\theta < \widehat{\theta}$ *there exists a* $\widehat{W}$ *such that short term contracts are preferred to long term contracts for all* $W < \widehat{W}$ *and long term contracts are preferred to short term contracts for all* $W > \widehat{W}$*. Moreover* $\frac{\partial \widehat{W}}{\partial \theta} < 0$*. For* $\theta > \widehat{\theta}$ *long term contracts are preferred to short term contracts for all* W*.*

Proof: see Appendix.

Intuitively, when capital markets are imperfect providing incentives for maintenance effort is costly for two reasons. First, it raises the information rents that the landlord has to pay to poor tenants. This happens because the tenant chooses a positive level of maintenance effort (i.e. IC is met) only if the share in the second period is high enough. Note that since the share that satisfies IC is decreasing in θ, the extra information rent is higher for low θs. On the other hand, if θ is high enough the IC does not bind (see Figure 1), implying that the landlord does not need to pay any additional rent to elicit maintenance effort.

Second, providing maintenance incentives distorts the choice of production effort both for poor and for middle-income tenants. For poor tenants -those for whom the PC does not bind- the second period share is distorted because it must satisfy IC as explained above. For middle income tenants- those for whom both PC and LL bind- the second period share must be high enough to satisfy the MR constraint, otherwise the tenant would run away after the first period. To bring the tenant down to his reservation utility the landlord will reduce the first period share. Thus, when the MR constraint binds the choice of both first and second period production effort is distorted. Note that

MR is more likely to bind for low θs (see Figure 1), which implies that also the cost in terms of production distortion are decreasing in θ.

Overall, since the costs of providing maintenance incentives are decreasing in θ while the benefit is increasing in θ, for low levels of θ the costs outweigh the benefits and short term contracts are preferred to long term contracts that give incentive for maintenance.[24]

Note that when capital market imperfections are not relevant, that is when the limited liability constraint does not bind ($W \geq \overline{W}$), the optimal level of maintenance effort is always positive, and long term contract are preferred to short term contracts for every value of θ.(see Figure 2)

INSERT FIGURE 2

3.5 Related Issues

It is important to note that financing of material inputs by the landlord and/or lending are implicitly considered here. Neither lending nor provision of material inputs can improve matters. The size of the feasible loan the tenant can receive is limited by the (MR) constraint, indeed a loan is equivalent to a reduction in $r_1$combined with an increase in r_2. If the landlord pays for material inputs, the first order conditions of the problem are the same, since he will give the tenant the incentive to literally "take the money and run". If the landlord provides the optimal quantity of material inputs the choice of m will be efficient (if the tenant does not breach the contract) but the tenant

[24]The relevant issue is whether maintenance incentives are provided in equilibrium, rather than the duration of the contract per se. The model shows that in some cases providing maintenance incentives is not profitable, which justifies the use of short term contracts that were observed in reality. The model explains the choice between short-term contracts and long-term contracts that provide maintenance incentives, rather than the more general choice between short and long-term contracts. In some instances, a long term contract that does not provide maintenance incentives can do better than a long-term contract that does provide maintenance incentives because the former replicates the outcome of a short-term contract. Still, there are cases in which a long-term contract is always worse than a short-term contract because the former inevitably provides incentives for maintenance (when IC does not bind) hence it cannot replicate the outcome of the latter.

can still sell the inputs on the market and keep the money[25], thus in this case too the first order conditions are unchanged.

It is often argued that land sales are Pareto improving because the tenant would have better incentives to invest in the land if he owned it. In this model a long term contract is equivalent to a land sale since the landlord can commit to the terms of the contract and ownership does not carry any additional benefits. It follows that whenever long term contracts are not profitable, land sales are not either. The intuition is that poor tenants would have to borrow to purchase the land and this would reduce incentives for investment. Indeed, because of limited liability, the tenant knows that he will default on the loan in the bad state and will therefore want to increase the probability of the bad state by reducing investment.

In this model the same results can be obtained by offering contracts that are not renegotiation-proof. A fixed rent contact that does not satisfy the limited liability constraint has the same effect on incentives as the optimal sharecropping contract. Indeed, if the bad state happens, the parties will have to negotiate a different payment. The equilibrium payment will then equal the tenant's wealth since this is the most he can pay. When the tenant chooses effort levels, he takes into account the outcome of the renegotiation and his incentives are reduced accordingly. The landlord can give the same incentives either by using a sharecropping contract, where the share is the solution of the maximization problem above, or by offering the a contract with an implied renegotiation clause. This point is particularly important to understand the empirical predictions of the theory. Indeed, both contracts- sharecropping and fixed rent with renegotiation- were used in practice. In Sicily the share was established by law and by common custom. Given this limitation, the landlord would then offer sharecropping contracts only

[25] Although the last assumption may sound extreme, the data I collected seem to support it. Indeed, in the few cases material inputs were provided by the landlord, the contract contained a clause forbidding the tenant to sell them on the market or employ them outside the plot.

when the optimal share was close to a feasible one and use contracts with renegotiation in the other cases.

It has often been argued that if the relationship between the landlord and the tenant is repeated the landlord can elicit effort by keeping the tenant above his reservation utility and threatening eviction in case of default. For eviction threats to be effective, however, all that matters is that the relationship, as opposed to the contract itself, between the two parties is long term. This argument cannot therefore be put forward as a convincing explanation for the existence of long term agreements.

Finally, it is important to note that, due to limited liability, long term agreements are effectively binding only for the landlord[26], which implies that they must be employed to commit the landlord, rather than the tenant, to a long term agreement. That the tenant is not bound to stay for the entire duration of the agreement suggests that the existence of long term contracts cannot be explained by the fact that the landlord wants to reduce turn-over to exploit the tenant farm's specific knowledge.

4 Empirical Evidence.

4.1 Data Description

The theoretical model presented above shows that the structure of the optimal contract depends on the wealth and outside option of the tenant and on the technical characteristics of the crop, namely its sensitivity to production and maintenance effort.

In order to test the predictions of the theory I have compiled a data set which contains information on 705 contracts written in a region of Sicily, Syracuse and thirteen

[26] As argued above, the tenant can be punished at most up to his wealth, poor tenants can therefore easily break the contract before it expires.

neighbouring villages, during the period 1870-1880. This particular period was chosen to match with the available descriptive literature and to avoid the aftermath of the pest attack that destroyed most of the existing vineyards (and most of the variation in the independent variable).[27] From each contract the following were extracted and coded: form of the contract (sharecropping or fixed rent[28]), duration of the agreement, crop cultivated on the rented plot, village in which the plot is located, village in which the landlord lives, landlord's sex and tenant's social class. Contract type and duration are the dependent variables: contract type is naturally coded as a 0-1 variable (1 for fixed rent), contract duration is also coded as a binary variable, defining as long term (1) all agreements longer than one year.[29]

In their description of Sicilian society, both Damiani (1881) and Lorenzoni (1911) report that social classes could be ranked according to wealth and that a farmer's class depended essentially on his wealth. Since social class is closely linked to wealth, it can be reasonably used as a proxy for the latter. Most of tenants in the sample belong to one of four social classes. The lowest class was made up of "villici", whom Damiani (1881) describes as poor farmers who own "only the strength in their arms"; the second lowest were "contadini or coloni", farmers who own a mule and/or a small house; third

[27] As discussed in section II, the main sources of information are the two Parliamentary Inquiries. The first one is dated 1881 (started in 1876), the second 1911 (started in 1909). The pest attack happened in between, and at the time of the second Inquiry vineyards were being restored. Since the new vines had different characteristics, it would be interesting to study whether this affected contractual structure. Unfortunately, contract data are freely available for research purposes one hundred years after the contract was signed.

[28] In sharecropping contracts the split was 50:50; in addition the tenant had to pay a rent, generally in kind. Most fixed rent contracts specified the rent to be paid in cash, other in kind and some both in cash and in kind.

[29] Since most contracts in the sample are one or four years long this seems the most natural classification. Nevertheless, the distinction between short- and long-term in the data is much less clear cut than it is in theory; in the model there are only two periods thus contract length can only take two values while in the sample it ranges from one to nine years. Classifying one and two-year contracts as short term does not affect the qualitative results, nor does so classify one, two and three-year contracts (three is the sample median).

came "massari", wealthy farmers who own draft animals, a house and some plots of land; the wealthiest class were "possidenti", that is landowners. Since only 6% of the tenants in my sample belong to the third class, in most regressions they are classified as landowners.[30]

The theory predicts that the structure of the optimal contract depends on the tenant's wealth *and* on his outside opportunity. It can be reasonably argued that the two are positively correlated, so that tenant's social class can be used as a proxy for both variables. Nevertheless tenants who belong to the same social class but live in different villages might have different outside options, depending on the characteristics of the village.[31] Two variables that capture relevant information about the labor market at the village level are used to address this issue: the daily wage for rural workers and a qualitative variable indicating whether there is excess demand for rural workers in the local labor market.[32] Since it is reasonable to assume that wealthy farmers would not take casual jobs, both proxies can be used for poor tenants only.

The crop to be cultivated was chosen by the landlord. It was either wheat or a tree

[30]This assumption does not affect the results and the coefficient on "third class" is generally not significant. Furthermore a small percentage of tenants belonged to the class of "industriosi", i.e. artisans. From Damiani's description their level wealth was similar to that of the second class, and they have been classified accordingly. Results are robust to this grouping.

[31]There might also be a tenant specific effect: two tenants with similar level of wealth who live in the same village might nonetheless face different outside options depending on their ability and on their connections among other things. See also footnote n. 36.

[32]Both variables are from Damiani (1881), who collected the information from interviews with the villages' Mayors. The latter were asked to report the typical wage for a male worker and to indicate whether the local labour market was in equilibrium or whether there was excess demand or excess supply. To the extent that farmers are unwillingly and/or unable to move between villages, which is consistent with the existence of wage differentials, these variables capture the differences in outside option among farmers residing in different villages. Unfortunately information on these variables was collected only at one point in time during the second half of the decade, which implies that they can be used as proxies for the entire period only if during the period itself there have not been major changes. Evidence from Mayors' interviews suggest that this might indeed have been the case: when asked whether the wage had changed considerably during the preceding twenty years, Mayors replied it hardly had. To control for time variation, year dummie are included in the regressions. Obviously the control is far from being perfect as other factors might be varying with time as well.

crop. The tree crops in the sample are olives, vines, citrus (lemon and oranges) and fruit (peaches, apricots, cherries and similar). Contracts for tree crops often contained a clause which forbad the tenant to plant other crops, such as garden vegetables, in the soil around the trees. Although generally only one crop was planted in the rented plot, in some cases there were two or even more rarely three. Often in these cases some of the crops were subject to a different agreement with the same tenant or excluded from the agreement altogether. For instance, if there were wheat and a tree crop and both were included in the agreement, the contract for wheat was often fixed rent while that for the tree crop was sharecropping. Since the contracts for different crops grown in the same plot were often different, I coded them as separate observations.[33]

The description of agricultural practices presented in Section II illustrates that crops had different characteristics in terms of sensitivity to both production and maintenance effort. Wheat and to a lesser extent olive trees were less responsive and resisted well to mistreatment. Vines and citrus trees were more responsive and could not be profitably grown without considerable care. Vines and citrus were more profitable but also riskier crops. In terms of the parameters of the model wheat would have the lowest h and θ, followed by olive trees and then vines and citrus trees. The Parliamentary surveys did not contain detailed information on the characteristics of fruit trees.

4.2 Theoretical Predictions and Empirical Results

The theory predicts that the probability of observing long term contracts is higher if the crop has strong maintenance needs, if the tenant is wealthy and/or if his outside opportunity is high. Thus, the probability of observing a long term contract should be

[33]The results of the regressions below are not sensitive to this assumption; that is they do not change if I drop the observations or if I condition on the fact that the contract is actually a part of a larger contract. The only notable exception is that the duration of the contract is significantly affected if a wheat field has trees planted in it and the trees are included in the agreement.

higher if the tenant belongs to the higher social classes; if, given his social class, he lives in a village where the wage for daily workers is higher and if the crop grown on the rented plot is vines or citrus as rather than wheat and maybe olives.[34] The first and second column of table 3 show that, as expected, the probability of observing a long term contract is higher when vines or citrus trees, the most maintenance intensive crops, are grown on the rented plot and that the probability is lower if the tenant is poor, that is if he belongs to one of the lower classes. The second column of table 3 includes estimates of the effect of the tenant's outside opportunity, proxied by the logarithm of the wage for casual workers in the local labor market. Since the wage is a good proxy for the outside opportunity of tenants belonging to lower classes only, the regression includes interaction terms between the wage and the poor and middle dummies. The results suggest that the probability of observing a long term contract is higher when the outside opportunity of tenants belonging to the lowest social class is higher.

The theory also predicts that for a given crop, the wealth and the outside opportunity of the tenant should affect contract length only if the crop has low maintenance needs while contracts for maintenance intensive crops should be long term regardless of tenants' wealth. The third through fifth columns in Table 3 show that tenant's wealth significantly affects the length of contracts that regulate the cultivation of wheat, the least maintenance intensive crop (column 3), but it does not matter for the duration of contracts that regulate the most maintenance intensive crops[35](column 5). Finally tenants' wealth matters somewhat (the coefficient of *poor* is significant at the 10% level, the coefficient of *middle* is not significant) if olives are included in the trees sub-sample

[34]Although ex-ante it is impossible to say which social class is sufficiently wealthy and which crop is sufficiently sensitive to maintenance to make the landlord prefer a long term contract, the ranking can be predicted. If for instance, the probability of observing a long term contract is higher for olives than for wheat, it should also be higher for vines and citrus, which are more maintenance intensive. Similarly if the probability of observing a long term contract is lower for middle class tenants than for rich tenants, it should also be lower for tenants belonging to the lowest class.

[35]The result is robust to the exclusion of fruit trees.

(column 4), which is consistent with olive trees requiring more maintenance than wheat but not as much as the other tree crops.

Finally, sharecropping contracts are theoretically preferred to fixed rent contracts when the tenant is poor, when his outside opportunity is low and if the crop is both very profitable and very risky (marginal product of effort is high). The results in the first two columns of Table 4 show that the probability of observing a sharecropping contract is indeed higher if the tenant is poor and if grows vines and citrus trees- the crops for which the marginal product of effort is higher.[36] Also, the probability of observing a sharecropping contract is higher the lower the outside opportunity of the tenant if he belongs to the middle class; that is, the coefficient of *middle*wage* is positive.[37] The estimates in the third and fourth column of table 4 present some additional evidence about the effect of the tenant's outside opportunity on the choice between sharecropping and fixed rent contracts. Column 3 estimates the effect of the wage, column 4 of the condition of the labor market at a village level as a proxies for the tenants' outside opportunity. Since both variables are a reasonable proxy for alternative employment for tenants belonging to the lower classes only, wealthy tenants are excluded from this regression. The coefficient of *wage* and of *lmarket* are positive and significant, suggesting that an increase in the tenants' outside opportunity, proxied by the wage and the tightness of the labor market, increases the probability of observing a fixed rent contract.[38]

[36]The surveys do not report precise information on the cultivation of fruit trees hence it is impossible to infer how sensitive to effort they were. The results are robust to the exclusion of fruit trees.

[37]The coefficients of both poor and poor*wage are insignificant, maybe because of multicollinearity– see also regressions in column 3 and 4.

[38]Note that there might be unobserved variables that affect both the length and the type of the contract. In particular, tenant's characteristics such as his actual wealth (here proxied by social class), his outside opportunity, his ability, his previous and/or other existing deals with the landlord affect the cost of providing him with incentives. Since long-term (fixed rent) differ from short-term (sharecropping) contracts because they provide stronger incentives, one would expect tenant's specific omitted variables to affect both dimensions of contractual structure. It seems natural in this context to allow the disturbances of the equations for length and for type to be correlated, that is to estimate the two

4.3 Some Econometric Concerns

The area under study can be divided into three separate regions (hills, northern plains, southern plains) which have similar climate and soil characteristics. Table 5 shows that regional location explain most but not all the variation in cropping patterns. In the sample, wheat was cultivated in 93% of the plots located in the hills while trees occupied 83% and 77.5% of the plots located in the northern and southern plains, respectively. This pattern is consistent with the descriptions in Damiani(1881) and suggests, as one would expect, that soil type and climate are important determinants of crop choice. That notwithstanding, in each region there were plots in which different crops could be profitably grown. These plots cannot be identified because the data contains no information regarding the soil quality of individual plots. That crop choice was not entirely dictated by geographical location raises some concern regarding the exogeneity of the crop dummies in the regressions above. In particular, some variable might affect both contractual structure and crop choice and, if omitted, generate a spurious relationship between the latter and the former.[39] It is important to note that in this context most crops are trees that take many years to reach the production stage and that, as a consequence, cannot be changed by the year. Nevertheless if agents are forward looking there could still be a simultaneity bias. The potentially omitted variables can be divided

equations as a system. The results of this exercise show that the estimated correlation is positive, as expected, but it is significant at the 12% level only. The coefficient estimates obtained by seemingly unrelated methods are very similar to those reported in tables 3 and 4.

[39] Ideally, one would like to find appropriate instruments and test for the endogeneity of crop choice; unfortunately, given the nature of the data there is no variable that can be convincingly put forward as a determinant of crop choice but not of contractual structure.The only potentially valid instruments are village dummies, but one can argue that these might affect contractual structure because of customs and traditions. Still one can argue that since villages within each region are very close, traditions can be proxied by region dummies. A two-stage linear probability model has been estimated using village dummies as instruments and area dummies in the second stage regressions. The results are similar to those reported in the paper, that is the crop dummies have the right sign and are still significant. While the Hausman test suggest that OLS is consistent, the test of overidentifying restrictions casts doubt on the validity of the instruments.

into three groups: plot or plot-type specific, village or area specific and landlord specific. Since they affect crop but not contract choice, unobserved plot characteristics such as soil type, access to water or irrigation facilities are not likely to be a source of simultaneity bias.[40] Village or area specific variables, such as traditions and learning externalities, are potentially more troublesome. To control for their effect area and village dummies were included in the regressions. The results indicate that while these are important[41], they do not fully account for the relationship between crop characteristics and contractual structure, that is crop dummies are significantly different from zero even after controlling for area specific effects.[42]

Finally, since the landlord chooses both the crop and the contract, landlords unobserved characteristics are the most likely source of simultaneity bias. In particular, the determinants of landlords' opportunity cost of time can be reasonably expected to affect both crop and contract choice. Indeed, if the landlords' opportunity cost of time were high he would choose carefree crops, such as wheat and maybe olives[43], and time saving contracts -long term, which saves renegotiation time, and fixed rent, which saves output measurement time.[44] Note that this argument goes *against* the predicted relationship between contract length and crop characteristics: if the landlord's opportunity cost of

[40]Note that even if they do not create a spurious relationship between the variables of interest, omitted variables are particularly worrisome in probit models since the coefficients are biased even if the omitted variable is uncorrelated with the regressors (Yatchew and Griliches (1985)). Furthermore, in case of heteroscedasticity the estimators are inconsistent. Since OLS estimators do not suffer from these problems, to address these issues the equations have been also modeled as linear probabilities, using the White robust estimator for the covariance matrix. The linear probability estimates are very similar to those reported in tables 3 and 4, suggesting that the model is not seriously mis-specified.

[41]Contracts for plots located in the southern plains and in the hills were significantly more likely to be short-term Contracts for plots located in the hills were significantly more likely to be fixed rent.

[42]As is well known, fixed effects estimation of a probit model can yield inconsistent parameter estimates. Conditional logit estimates, on the other hand, do not suffer from this problem (see e.g. Hsiao (1986) p.159). Re-estimating the equations by conditional logit yields very similar results.

[43]Vines and citrus trees were more prone to diseases and pest attacks and therefore more likely to require the landlord's active participation.

[44]If the landlord offers a sharecropping contract he must visit the farm before harvest to make sure he receives the correct share of the effective output.

time were empirically relevant it would result in long term contracts for wheat and olives. On the other hand, since busy landlords would choose wheat and fixed rent contracts, landlords' unobserved characteristics could account for the observed relationship between contract and crop type. The sex and the residency of the landlord are included in the regressions as (partial) controls for landlord's characteristics. The first is relevant because women would have faced social disapproval had they been "too involved" in business; the second matters because a landlord who lives far from the rented plot faces both a higher transportation cost and a higher opportunity cost in terms of time. The intuition finds support in the empirical evidence: when significant, both variables have the expected sign. Most importantly, the results show that the relationship between crop characteristics and contractual structure is robust to the inclusion of the landlords' type variables.[45]

A second cause for concern is that while in the model landlords and tenants are randomly matched, in reality matching could have be endogenous. In particular if tenants were risk averse, one would expect poorer tenants to have preferred less risky crops, like wheat and olives. The data (Table 6) might be supportive of this hypothesis but overall do not present a clear pattern. Even if endogenous matching happened in practice, however, the qualitative results of this paper would not be affected. Indeed because of matching one would expect little variation in tenants' wealth within each crop so that the coefficient on tenants' wealth would actually be biased *downwards.*[46]

Finally, since the moral hazard problem is more serious for vines and citrus, it could be argued that only landlords whose outside opportunity is high (or whose opportunity cost of time is high) would rent out vineyards and citrus groves instead of managing

[45]Consistent with the argument above, the coefficients on the crop dummies in the contract length regressions are larger when landlords' variables are included.

[46]Ackelberg and Botticini (1999) control for endogenous matching in a sample of tenancy contracts from 15th century Tuscany. In their sample the effect of tenant's wealth on the probability of observing a sharecropping contract is significant only if matching is controlled for.

them personally. If this were true, there would be a sample bias which could explain the positive relationship between vines, citrus and contract length if, at the same time, landlords with a higher opportunity cost of time prefer long term contracts. This alternative interpretation, however, is inconsistent with both with the fact that sharecropping was more common for vines and citrus (landlords whose time is costly would choose fixed rent contracts as argued above) and with the fact that tenants' wealth is a significant determinant of the length of wheat contracts.

5 Conclusions.

In a world with asymmetric information contractual structure determines incentives and hence productivity. This paper has developed a theoretical framework to identify the determinants of the structure of tenancy contracts and has tested the predictions of the theory using historical data on tenancy contracts from a region of Sicily. The paper makes two main contributions. First, it goes beyond existing theories by analysing crop characteristics as a determinant of contractual structure and by studying the choice between short and long term contracts. Second, it provides both a new data set and new empirical evidence on the structure of tenancy contracts.

The empirical evidence is consistent with a model of asymmetric information and capital market imperfections. In particular, as predicted by the theory, the results suggest that long term contracts are more likely when the crop is very sensitive to maintenance and when the tenant is wealthy and that sharecropping contracts are more likely when the crop is both more profitable and riskier and when the tenant is poor.

The analysis of crop characteristics provides new insights into understanding tenancy contracts and suggests new questions for future research. A closely related issue is crop choice: Do the crops chosen by an owner-cultivator differ from those chosen by a

landowner who delegates the cultivation of his plots? and if so, how and why? Intuitively, maintenance needs and other crops characteristics might create a wedge between the profits received by the two parties so that the owner cultivator and the landowner would optimally choose to grow different crops. In 19th century rural Sicily land ownership mattered for crop choice. Owner-cultivators preferred vines and citrus trees over wheat, while the opposite was true for landowners. Since owner-cultivators often replaced wheat with vines when they bought the land, the difference in preferences cannot be entirely ascribed to differences in land characteristics .

Understanding crop choice might provide an additional explanation for the widely observed inverse relationship between farm size and productivity; family farms could be more productive because families choose more profitable crops. Some favourable empirical evidence in this regard is found in Bharadwaj (1974) who analyzes Indian survey data and shows that after controlling for crop choice the inverse relationship disappears.

Above all, a thorough understanding of these issues is crucial in order to identify the effects of land distribution on agricultural productivity and hence to assess the benefits of land reforms and other policy measures.

TABLE 1 List of Variables

poor: dummy variable, equals 1 when the tenant belongs to the lowest class
middle: dummy variable, equals 1 when the tenant belongs to the middle class
crop_i : dummy variable, equals 1 when the crop is i = olives, vines, citrus or fruit
wage: ln of daily wage for male workers in the local labor market
vines&citrus:dummy variable, equals 1 when vines or citrus are grown in the plot
LL away:dummy variable, equals 1 when the landlord lives in a different town
LL female:dummy variable, equals 1 when the landlord is female
lmkt:dummy variable, equals 1 when there is excess demand for rural workers

Area 1 includes the northeastern plains, area 2 the southeastern plains, area 3 the western hills.

TABLE 2 - Descriptive Statistics

Crop	%	Contract Type	%	Contract Length	%
grains	36.7	rent	85.2	1 yr	26.2
olives	15.6	share	14.8	2 yrs	6.9
vines	18.5			3 yrs	10.9
citrus	17			4 yrs	35
fruit	12.2			5 +	21
labor Market		**Wage**		**Social Class**	
excess supply	14.8	L.1-1.25	29.4	low	33.7
equilibrium	52.2	L.1.3-1.6	37.6	middle	40.5
excess demand	33	>L.1.6	33	upper-middle	6.2
				high	19.6

TABLE 3- Probit Estimates of Contract length.
(Long (1) vs. Short(0))

	all crops (1)	all crops (2)	wheat (3)	trees (4)	trees- no olives (5)
poor	-.89	-7.28	-1.37	-.52	.54
	(-3.82)	(-3.31)	(-3.30)	(-1.87)	(1.27)
	[-.16]	[-.68]	[-.33]	[-.06]	[.02]
middle	-.59	-3.36	-.95	-.39	.08
	(-2.39)	(-1.51)	(-2.26)	(-1.41)	(.23)
	[-.10]	[-.48]	[-.22]	[-.04]	[.004]
Crop_{olives}	.15	.17			
	(.70)	(.76)			
	[.03]	[.03]			
Crop_{vines}	1.43	1.46		1.09	
	(4.91)	(5.03)		(4.16)	
	[.23]	[.23]		[.11]	
Crop_{citrus}	1.83	1.90		1.71	.64
	(3.92)	(3.87)		(4.17)	(1.50)
	[.25]	[.25]		[.13]	[.03]
Crop_{fruit}	1.84	1.83		1.43	.21
	(4.89)	(4.85)		(4.35)	(.64)
	[.26]	[.25]		[.11]	[.01]
poor*wage		2.36			
		(2.91)			
		[.39]			
middle*wage		1.01			
		(1.18)			
		[.17]			
LL far away	-.16	-.03	-.19	.04	-.34
	(-1.06)	(-.19)	(-1.01)	(.12)	(-.92)
	[-.03]	[-.005]	[-.05]	[.004]	[-.02]
LL is female	.78	.82	.71	.79	.39
	(3.30)	(3.54)	(2.03)	(2.19)	(.87)
	[.13]	[.13]	[.19]	[.07]	[.02]
nobs	705	705	259	446	326
log lik.	-210.23	-206.58	-109.49	-.92.27	-34.66
p-value*	.00	.00	.00	.00	.00

(*) p-value of the model's chi-square. T-statistics (based on robust standard errors) in parenthesis. Marginal effects in brackets. Marginal effects are computed as the sample average of the individual effects. All regressions include area and time dummies.

TABLE 4- Probit estimates of contract type
(Rent (1) vs Share(0))

	all tenants(1)	all tenants(2)		low class(3)	low class(4)
poor	-.74	2.05	poor	-.33	-.13
	(-4.00)	(0.63)		(-2.10)	(-.952)
	[-.16]	[.24]		[-.07]	[-.02]
middle	-.62	-7.51			
	(-3.76)	(-3.17)			
	[-.12]	[-.57]			
vines&citrus	-.34	-.41	vines&cit.	-.42	-.28
	(-2.38)	(-2.78)		(-2.60)	(-1.07)
	[-.07]	[-.08]		[-.09]	[-.04]
poor*wage		-1.01	wage	1.53	
		(-.94)		(2.07)	
		[-.19]		[.31]	
middle*wage		2.55	lmkt		.99
		(2.92)			(3.63)
		[.48]			[.15]
LL away	.26	.25	LL away	.52	1.07
	(1.45)	(1.36)		(2.47)	(2.69)
	[.05]	[.04]		[.09]	[.12]
LL female	.69	.69	LL female	.52	.30
	(3.54)	(3.49)		(2.43)	(1.08)
	[.10]	[.10]		[.09]	[.07]
nobs	705	705		524	356
log lik.	-242.9	-237.6		-193.81	-95.21
p-value	.00	.00	.00	.00	.00

(*) p-value of the model's chi-square. T-statistics (based on robust standard errors) in parenthesis. Marginal effects in brackets. Marginal effects are computed as the sample average of the individual effects. All regressions include area and time dummies. Sample in column (4) is smaller than column (3)'s beacuse there is no information regarding the labor market for two towns.

TABLE 5 CROPPING PATTERNS BY REGION

	hills	northern plains	southern plains
wheat	152 (93%)	48 (17%)	59 (22%)
tree crops	12 (7%)	231 (83%)	203 (78%)
total	164	279	262

TABLE 6 TENANTS AND CROPS

	wheat	tree crops
lower class	119 (46%)	119 (27%)
middle class	106 (40%)	180 (40%)
upper class	34 (14%)	147 (33%)
total	259	446

FIGURE 1 – THE OPTIMAL LONG TERM CONTRACT

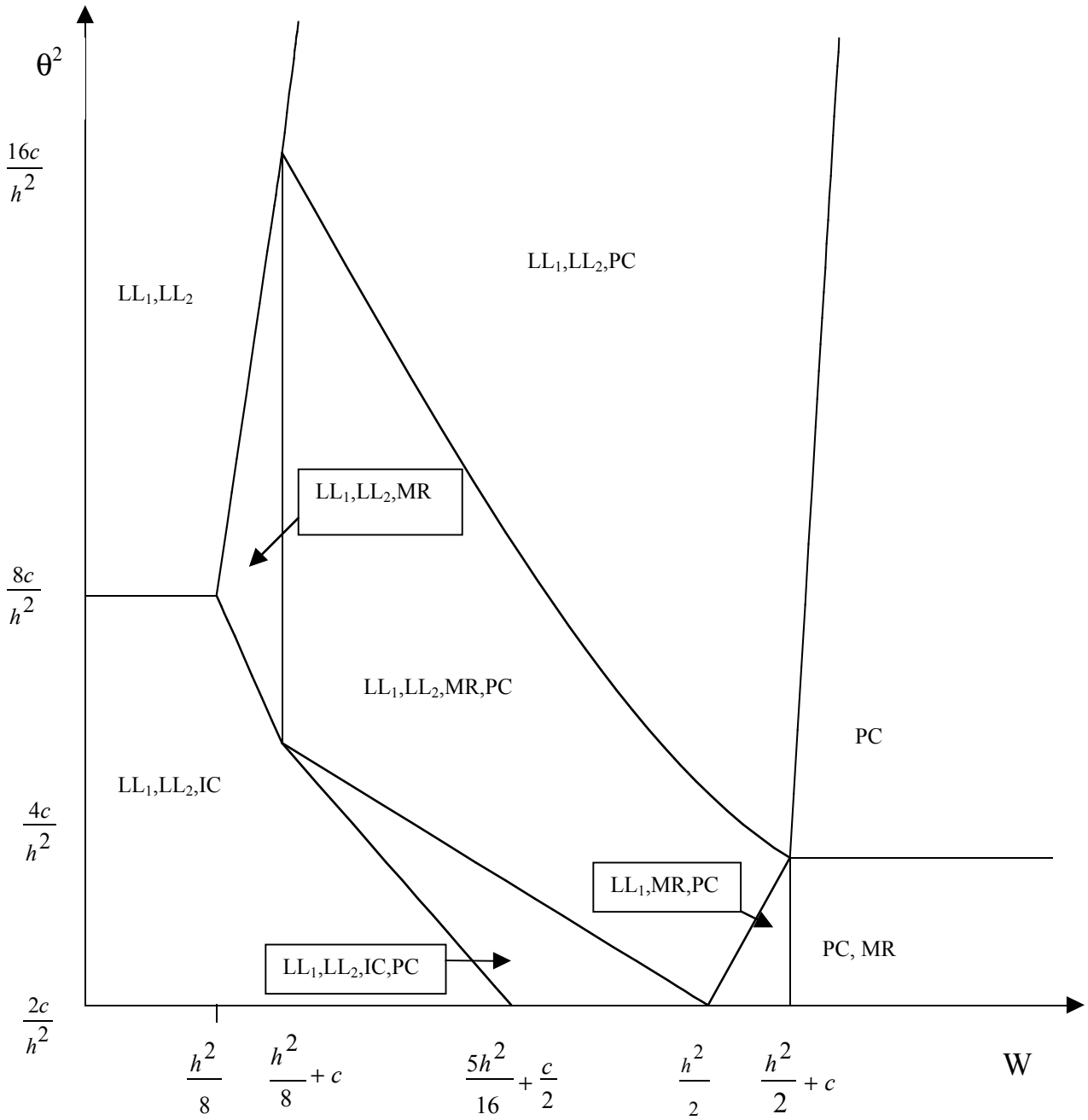
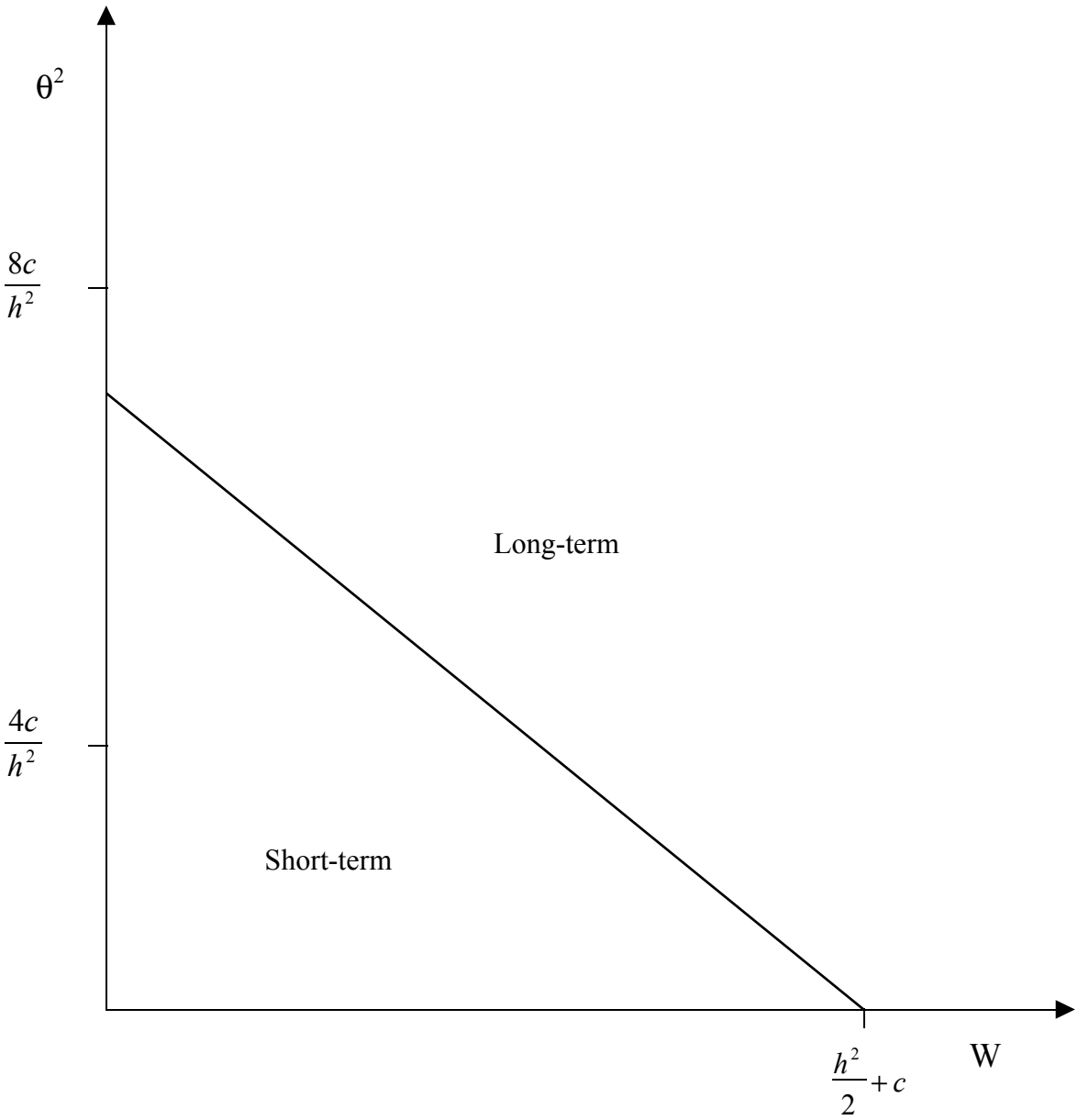


FIGURE 2 SHORT-TERM VS. LONG-TERM CONTRACTS



6 Appendix.

6.1 Data Sources.

1.Contracts.

Notary public are required by law to bind all the contracts they write during a year in a volume, which is subsequently stored at the Notary Archives. Old volumes (more than 100 years old) are then transferred to the State Archives. Following is a list of the volumes I extracted the contract in the sample from.

State Archives		Notary Archives	
Name	years	Name	Years
Baiona, Giovanni Battista	1870-74	Maxeo, Rosario	1875-80
Giarracca, Domenico	1870-77	Perricone, Alessandro	1875-77
Casaccio, Gaetano	1870-72	Tribulato, Antonino	1876
Di Giovanni, Ignazio	1870-75	Amico, Pietro	1870-79
Milito, Virgilio	1870-72	Tribulato Giuseppe	1873-75
Pancari, Vito	1870-75	Santuccio, Francesco	1873-80
Lenares, Giovanni	1872-74	Cultrera, Francesco	1873-75
Motta, Giuseppe	1872-77	Pisana, Pietro	1875-76
Pupillo, Giuseppe	1870-75	Sofia, Luigi	1876-77
Blasco, Francesco	1870-71	Sbano, Francesco	1875-80
Piccione, Rosario	1870-76	Tavana, Eustachio	1876-80
Terranova, Carmelo	1870-77	Nuzzo, Vincenzo	1878-80
Giardina, Gaetano	1870-72	Carbonaro, Raffaele	1878-80
		Scalia, Gaetano	1878-80
		Italia, Francesco	1878-79
		Leone, Gaetano	1880
		Zivillica, Alfonso	1879-80

2. Village Level Variables.

These are found in the "Inchiesta Jacini:Atti della Giunta per l'inchiesta agraria e sulle condizioni della classe agricola 1881" vol XIII, parte I e II, tomo 1-5-rapporto di Abele Damiani per la Sicilia.

Wage data: Book 2 A pages 303 and 311.

Profit Data: Book 2 A pages 298 and 307

Labor market data: Book 1 B

6.2 Algebra

Solution to the maximization problem.

The landlord solves:

$$\max_{s_1,s_2,r_1,r_2}\left\{s_1h^2\left(1-s_1\right)+s_2\left(1-s_2\right)h^2(1+\theta^2)+r_1+r_2\right\}$$

s.t.

$$\begin{aligned}\tfrac{1}{2}s_1^2h^2+\tfrac{1}{2}s_2^2h^2(1+\theta^2)-(r_1+r_2)-c-2\overline{u}\geq 0\\ \tfrac{1}{2}s_2^2h^2(1+\theta^2)-r_2-c-\overline{u}\geq 0\\ s_2^2\tfrac{h^2\theta^2}{2}\geq c\\ w-r_1-c\geq 0\\ w-r_2\geq 0\end{aligned}$$

The Lagrangian of this problem is :

$L=s_1h^2\left(1-s_1\right)+s_2\left(1-s_2\right)h^2(1+\theta^2)+r_1+r_2+$
$\lambda\left(\frac{1}{2}s_1^2h^2+\frac{1}{2}s_2^2h^2(1+\theta^2)-(r_1+r_2)-c-2\overline{u}\right)$
$+\eta\left(\frac{1}{2}s_2^2h^2(1+\theta^2)-r_2-c-\overline{u}\right)$
$+\mu\left(s_2^2\frac{H^2\theta^2}{2}-c\right)+\gamma_1\left(w-r_1-c\right)+\gamma_2\left(w-r_2\right)$

The multipliers are all non-negative. First order conditions with respect to (s_1,s_2,r_1,r_2) are:

$1-2s_1+\lambda s_1=0$
$\left(1+\theta^2\right)-2\left(1+\theta^2\right)s_2+(\lambda+\eta)\left(1+\theta^2\right)s_2+\mu\theta^2s_2=0$
$\lambda+\gamma_1=1$
$\lambda+\eta+\gamma_2=1$

Using (19) and (20) we can see there are fourteen cases depending on the values of $(\lambda,\eta,\gamma_1,\gamma_2,\mu)$. These are:

A1a) $\lambda=1,\eta=\gamma_1=\gamma_2=0,\mu=0$
A1b)$\lambda=1,\eta=\gamma_1=\gamma_2=0,\dot{\mu}>0$
B1a) $0<\lambda<1,0<\gamma_1<1,\gamma_2=\gamma_1,\eta=0,\mu=0$
B1b) $0<\lambda<1,0<\gamma_1<1,\gamma_2=\gamma_1,\eta=0,\mu>0$
B2a)$0<\lambda<1,0<\gamma_1<1,\gamma_2=0,\eta=\gamma_1,\mu=0$
B2b)$0<\lambda<1,0<\gamma_1<1,\gamma_2=0,\eta=\gamma_1,\mu>0$
B3a)$0<\lambda<1,0<\gamma_1<1,0<\eta<1,0<\gamma_2<1,\mu=0$
B3b)$0<\lambda<1,0<\gamma_1<1,0<\eta<1,0<\gamma_2<1,\mu>0$
C1a)$\lambda=0,\ \gamma_1=1,\gamma_2=1,\eta=0,\mu=0$

C1b)$\lambda = 0$, $\gamma_1 = 1, \gamma_2 = 1, \eta = 0, \mu > 0$
C2a)$\lambda = 0$, $\gamma_1 = 1, \gamma_2 = 0, \eta = 1, \mu = 0$
C2b)$\lambda = 0$, $\gamma_1 = 1, \gamma_2 = 0, \eta = 1, \mu > 0$
C3a)$\lambda = 0$, $\gamma_1 = 1, 0 < \eta < 1, 0 < \gamma_2 < 1, \mu = 0$
C3b)$\lambda = 0$, $\gamma_1 = 1, 0 < \eta < 1, 0 < \gamma_2 < 1, \mu > 0$

The participation constraint binds in cases (A_{**}) and (B_{**}) whereas the limited liability constraint binds at least in one period in cases (B_{**}) and (C_{**}). Thus the tenant earns information rents in cases (C_{**}). The "no take the money and run" constraint must bind in cases ($*_{2*}$) and ($*_{3*}$) and the incentive compatibility constraint must bind in cases ($*_{*b}$).

Cases (A_{1b}) ,(B_{2b}),(B_{3b}),(C_{2*}),(C_{3b}) can be ruled out because they yield inconsistent results. This leaves us with nine possible combinations (A_{1a}, B_{1a}, B_{1b}, B_{2a}, B_{3a}, C_{1a}, C_{1b}, C_{3a}). The solution depends on the values of W and θ, in particular it is possible to identify five ranges of values for the parameter θ which yields different solutions. The optimal long term contract in each of the five cases is:

CASE 1 $\boxed{\theta^2 < \frac{4c}{h^2}}$

$$LT_1 = \begin{cases} C_{1b} & if \quad W \leq \frac{h^2}{16} + \frac{c\left(1+\theta^2\right)}{2\theta^2} \\ B_{1b} & if \quad \frac{h^2}{16} + \frac{c\left(1+\theta^2\right)}{2\theta^2} < W \leq \frac{c}{\theta^2} \\ B_{3a} & if \quad \frac{c}{\theta^2} < W \leq \frac{1}{2}h^2 + \frac{1}{2}h^2\theta^2 - c \\ B_{2a} & if \quad \frac{1}{2}h^2 + \frac{1}{2}h^2\theta^2 - c < W < \frac{1}{2}h^2 + c \\ A_{1a} & if \quad \frac{1}{2}h^2 + c \leq W \end{cases}$$

CASE 2 $\boxed{\frac{4c}{h^2} < \theta^2 \leq \frac{8c}{8c+h^2}}$

$$LT_2 = \begin{cases} C_{1b} & if \quad W \leq \frac{h^2}{16} + \frac{c\left(1+\theta^2\right)}{2\theta^2} \\ B_{1b} & if \quad \frac{h^2}{16} + \frac{c\left(1+\theta^2\right)}{2\theta^2} < W \leq \frac{c}{\theta^2} \\ B_3 & if \quad \frac{c}{\theta^2} < W \leq \frac{c\left(2+\theta^2\right)}{\theta^2} \\ B_{1a} & if \quad \frac{c\left(2+\theta^2\right)}{\theta^2} < W < \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \\ A_{1a} & if \quad \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \leq W \end{cases}$$

CASE 3 $\boxed{\frac{8c}{8c+h^2} < \theta^2 \leq \frac{8c}{h^2}}$

$$LT_3 = \begin{cases} C_{1b} & if \quad W \leq \frac{c}{\theta^2} \\ C_{3a} & if \quad \frac{c}{\theta^2} < W \leq \frac{h^2}{8} + c \\ B_3 & if \quad \frac{h^2}{8} + c < W \leq \frac{c\left(2+\theta^2\right)}{\theta^2} \\ B_{1a} & if \quad \frac{c\left(2+\theta^2\right)}{\theta^2} < W < \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \\ A_{1a} & if \quad \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \leq W \end{cases}$$

CASE 4 $\boxed{\frac{8c}{h^2} < \theta^2 \leq \frac{16c}{h^2}}$

$$LT_4 = \begin{cases} C_{1a} & if \quad W \leq \frac{1}{8}h^2 + \frac{1}{8}h^2\theta^2 - c \\ C_{3a} & if \quad \frac{1}{8}h^2 + \frac{1}{8}h^2\theta^2 - c < W \leq \frac{h^2}{8} + c \\ B_3 & if \quad \frac{h^2}{8} + c < W \leq \frac{c\left(2+\theta^2\right)}{\theta^2} \\ B_{1a} & if \quad \frac{c\left(2+\theta^2\right)}{\theta^2} < W < \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \\ A_{1a} & if \quad \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \leq W \end{cases}$$

CASE 5 $\boxed{\theta^2 > \frac{16c}{h^2}}$

$$LT_5 = \begin{cases} C_{1a} & if \quad W \leq \frac{1}{8}h^2 + \frac{1}{16}h^2\theta^2 \\ B_{1a} & if \quad \frac{1}{8}h^2 + \frac{1}{16}h^2\theta^2 < W < \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \\ A_{1a} & if \quad \frac{1}{2}h^2 + \frac{1}{4}h^2\theta^2 \leq W \end{cases}$$

Where:

$$C_{1a}: \begin{array}{l} s_1 = \frac{1}{2}, s_2 = \frac{1}{2} \\ r_1 = w - c, r_2 = w \end{array}, \quad C_{1b}: \begin{array}{l} s_1 = \frac{1}{2}, s_2 = \frac{\sqrt{2c}}{h\theta} \\ r_1 = w - c, r_2 = w \end{array}, \quad C_{3a}: \begin{array}{l} s_1 = \frac{1}{2}, s_2 = \frac{\sqrt{\frac{2(W+c)}{1+\theta^2}}}{h} \\ r_1 = w - c, r_2 = w \end{array},$$

$$B_{1a}: \begin{array}{l} s_1 = \frac{1}{h}\sqrt{\frac{2W}{1+\frac{\theta^2}{2}}}, s_2 = \frac{1}{h}\sqrt{\frac{2W}{1+\frac{\theta^2}{2}}} \\ r_1 = w - c, r_2 = w \end{array}, \quad B_{1b}: \begin{array}{l} s_1 = \frac{\sqrt{2\left(2W-c-\frac{c}{\theta^2}\right)}}{h}, s_2 = \frac{\sqrt{2c}}{h\theta} \\ r_1 = w - c, r_2 = w \end{array},$$

$$B_3: \begin{array}{l} s_1 = \frac{\sqrt{2(W-c)}}{h}, s_2 = \frac{\sqrt{\frac{2(W+c)}{1+\theta^2}}}{h}, \\ r_1 = w - c, r_2 = w \end{array}, \quad A_{1a}: \begin{array}{l} s_1 = 1, s_2 = 1, r_1 = \frac{h^2}{2} + \frac{h^2\theta^2}{4} - u - c \\ r_2 = \frac{h^2}{2} + \frac{h^2\theta^2}{4} - u \end{array}$$

If the landlord offers a long term contract, her payoff is equal to LP_1,LP_2, LP_3,LP_4,LP_5 corresponding to the five cases above. The functions can be obtained by plugging the parameters of the optimal long term contract into the expression for landlord's payoff.

The optimal short term contract is:

$$ST = \begin{cases} s = \frac{1}{2} & \\ r = w & if \quad W \leq \frac{1}{8}h^2 \\ s = \frac{1}{h}\sqrt{2W} & \\ r = w & if \quad \frac{1}{8}h^2 < W < \frac{1}{2}h^2 \\ s = 1, & \\ r = \frac{h^2}{2} - u & if \quad \frac{1}{2}h^2 \leq W \end{cases}$$

If the landlord offers a short term contract her payoff is equal to SP which can be obtained by plugging the parameters of the optimal short term contract into the expression for the landlord's payoff.

Proof of Proposition 1.

To prove the proposition it is useful to establish the following facts:

f1) The landlord payoffs functions (i.e. LP_1,LP_2, LP_3,LP_4,LP_5 and SP) are continuous in W. (proof: by direct substitution)

f2)The derivative of the landlord payoffs functions with respect to W always exists and it is non- negative. (proof:derive the functions w.r.t W and check that the derivative is defined for every W in the relevant range).

f3)The landlord payoffs functions are concave in W for every range of Ws.(proof: by direct differentiation)

f4) The landlord payoffs functions are globally concave in W (proof: it follows from f3 and f2).

f5) The derivative of SP wrt W is never larger that the derivative of LP_i (i=1,..,5) wrt W. That is SP is never steeper than LP (proof: by direct comparison)

The proposition can be split in 3 parts:

p1) For $\theta > \overline{\theta} = \frac{8c}{h^2}$ long term contracts are preferred to short term contracts for all W.

p2)There exists a $\widehat{\theta} \in \left(\underline{\theta}, \overline{\theta}\right)$ such that for $\theta < \widehat{\theta}$ there exists a $\widehat{W}$ such that short term contracts are preferred to long term contracts for all $W < \widehat{W}$ and long term contracts are preferred to short term contracts for all $W > \widehat{W}$.

p3) $\frac{\partial \widehat{W}}{\partial \theta} < 0$.

proof of p1):

Pick up a pair (W_0, W_1) such that $W_0 < \frac{h^2}{8}$ and $W_1 > \max\left\{\frac{h^2}{2} + \frac{h^2\theta^2}{4}, \frac{h^2}{2} + c\right\}$. That is, W_0 belongs to the lowest range of Ws and W_1 belongs to the highest range of Ws for any payoff function.

For $\theta > \overline{\theta} = \frac{8c}{h^2}$ we have:

- $LP_4(W_1) > SP(W_1)$ and $LP_4(W_0) > SP(W_0)$

- $LP_5(W_1) > SP(W_1)$ and $LP_5(W_0) > SP(W_0)$

Given f1)-f5) it follows that $LP_4 > SP$ and $LP_5 > SP$ for any W.

proof of p2):

note that $LP_1(W_0) = LP_2(W_0) = LP_3(W_0)$ then we can define a function $\Delta_0(\theta) = LP_1(W_0) - SP(W_0)$.

By direct substitution we can see that $\Delta_0(\theta = \frac{2c}{h^2}) < 0$ and that $\Delta_0(\theta = \frac{8c}{h^2}) > 0$.

Moreover by direct differentiation we can see that $\Delta_0(\theta)$ is monotonously increasing in θ.

It follows that there must be a $\widehat{\theta}$ such that $\Delta_0(\widehat{\theta}) = 0$. Thus $\theta > \widehat{\theta} \Rightarrow \Delta_0(\theta) > 0$ and $\theta < \widehat{\theta} \Rightarrow \Delta_0(\theta) < 0$.

Furthermore, $LP_1(W_1) = LP_2(W_1) = LP_3(W_1)$ and we can define a function $\Delta_1(\theta) = LP_1(W_1) - SP(W_1)$. $\Delta_1(\theta) > 0$ for every θ and $\frac{\partial \Delta_1(\theta)}{\partial \theta} > 0$.

Therefore for $\theta < \widehat{\theta}$ we have:

- $LP(W_1) > SP(W_1)$ and $LP(W_0) < SP(W_0)$

Given f1)-f5) it follows that there exists only one $\widehat{W}$ such that short term contracts are preferred to long term contracts for all $W < \widehat{W}$ and long term contracts are preferred to short term contracts for all $W > \widehat{W}$.

for $\theta < \widehat{\theta}$ we have:

- $LP(W_1) > SP(W_1)$ and $LP(W_0) > SP(W_0)$

Given f1)-f5) it follows that $LP > SP$ for any W.

proof of p3)

it follows from the fact that $\frac{\partial \Delta_0(\theta)}{\partial \theta} > 0$, $\frac{\partial \Delta_1(\theta)}{\partial \theta} > 0$ and f1)-f5).

proof of proposition 2

By direct differentiation.

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