Competition and Custom in Economic Contracts: A Case Study of Illinois Agriculture

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ABSTRACT

A customary contract is a set of terms that is standard in a given locale for a given economic purpose. Once established, such a standard tends to perpetuate itself because it creates expectations about what is fair and appropriate in a given type of economic bargain. We propose a dynamic model of how contractual customs form endogenously. Agents are situated in a geographical or social space, and they recontract periodically based on expected returns, focal properties of the contract, and its conformity with local practice. The model predicts that the most likely geographic pattern consists of "patches" where contractual terms are nearly uniform, separated by boundaries where contractual norms jump from one set of terms to another. Differences in regional customs are roughly related to *average* differences in economic fundamentals, but they mask the considerable amount of heterogeneity that exists within regions. We compare these predictions with contractual practice in contemporary Illinois agriculture, and find considerable support for the model's predictions.

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> [T]he constraining force of custom and public opinion . . . resembled the force which holds rain-drops on the lower edges of a window frame: the repose is complete till the window is violently shaken, and then they fall together."
>
> *Alfred Marshall*

1. The role of custom in agricultural contracts

Economists have long been puzzled by the extent to which local custom, rather than competition, shapes the terms of certain kinds of contracts. A well-known example is cropsharing contracts, whereby a landlord leases his farm to a tenant laborer in return for a fixed share of the crops. The high degree of uniformity in the terms of such contracts has attracted the attention (though by no means the approval) of almost all writers on the subject, both ancient and modern. In speaking of the system then prevalent in Italy and France, for example, John Stuart Mill remarks: "This proportion . . . is usually (as is implied by the words *metayer, mezzaiuolo,* and *medietarius*) one-half. There are places, however, such as the rich volcanic soil of the province of Naples, where the landlord takes two-thirds. . . Whether the proportion is two-thirds or one-half, it is a fixed proportion, not variable from farm to farm, or from tenant to tenant." (Mill, 1848, p.303). Similarly, in a more recent study of contract forms in West Bengal, Ashok Rudra writes: "the proportion 50:50 for paddy shows a great resilience in that it is known to have existed for a long time in this state . . . irrespective of soil conditions, improved or backward methods of cultivation, and other factors which could be expected to affect the profitability of farm business." (Rudra, 1975, p. A58).

For those who find these observations disturbing or implausible, there are two comforting explanations. One is that cropsharing is largely a feature of pre-economic, custom-bound cultures; in modern societies, contracts are surely structured more rationally and are governed by competitive forces. Marshall seems to have been of this view, asserting that the sway of custom is a feature of "primitive times and backward countries," and that the "English" system of straight land rent contributed to its superior position in agriculture (Marshall, 1920, Chapter X). Other commentators went even further, claiming that "wherever this system [of cropsharing] prevails, it may be taken for granted that a useless and miserable population is found." (Arthur Young, 1792).

A second possibility is that people pay their respects to custom without really following it. In other words, while the nominal terms of contracts may appear to be uniform, this is largely an illusion: the side terms of the contract and the actual performance of the parties yield factor returns that are in line with competitive forces (Cheung, 1969). This argument is not supported by the evidence either, as we show in a companion paper (Burke and Young, 2000). Moreover, even if the data did support it, one would still have to explain why people bother to maintain the illusion of "fairness" unless they actually do care about it, a point that seems to have been overlooked by exponents of this view.

In this paper we shall argue that custom is a real force in setting contract terms, even in modern economies (see Akerlof, 1980, 1997). The evidence that we marshal in support of this claim is based on a statewide survey of contract terms that prevailed on nearly one thousand farms in the state of Illinois in 1995. These data provide information on the contractual division of both outputs and inputs by each party as a function of the size of the farm and the quality of its soil. Conventional theories fail to explain certain key features of these data, particularly the observed spatial pattern of contract forms. There are regional "patches" where contractual terms are nearly uniform, separated by boundaries where contractual norms jump substantially from one set of terms to another. These regional customs are roughly related to average differences in economic fundamentals, but they mask the considerable amount of heterogeneity that exists within each region. We introduce a dynamic model of contract formation that explicitly takes the role of custom into account, and show how it resolves these and other apparent puzzles in the data.

2. Focal shares

The data come from a sample survey conducted by the Illinois Cooperative Agricultural Extension Service in 1995. Tenants were asked to report in detail the terms of the contract they operated under, including the shares of each output and each input, cash payments (if any), and responsibilities for providing farm machinery. The stated purpose of the survey was to provide information that would enable the agency to give better advice to local farmers; individual respondents could not be identified from the data and there is no reason to think they were motivated to misreport.

Almost all of the reported contracts fall into one of two categories. *Cropsharing contracts* specify fixed shares of outputs and inputs for each party, and generally involve no cash payments. *Land rent contracts* specify a fixed rental rate per acre; the other inputs are usually provided by the tenant. Many other contracts exist in theory, including pure wage contracts and hybrid forms of rent, wage, and share contracts (Stiglitz, 1974, 1979), but it appears that they are seldom used in practice. Of the 1704 responses in the 1995 survey, cropsharing contracts were the most frequent (55%), land rent contracts the next most frequent (41%), and all other contract forms (mostly livestock and pasture leases) constituted less than 4%. Here we shall restrict ourselves to an analysis of the 935 cropsharing contracts, though we conjecture that the force of custom may operate on land rent contracts as well.

In principle, the terms of cropsharing contracts can be extremely varied and flexible. For example, one could specify different shares for each of the major outputs (corn, soybeans, and wheat), as well as for each of the major inputs (seed, fertilizer, and machinery). But in practice very few of the possible contracts are used. Indeed, almost all of the Illinois contracts apply the same share to all of the outputs, and these shares are almost invariably expressed in denominators of two, three, or five. Figure 1 shows the frequency distribution of shares of corn output, which is virtually the same as the frequency distribution of shares for soybeans and wheat. Fifty-fifty division is by far and away the most common contract, just as Mill, Marshall, and others noted for the European agriculture of their day.

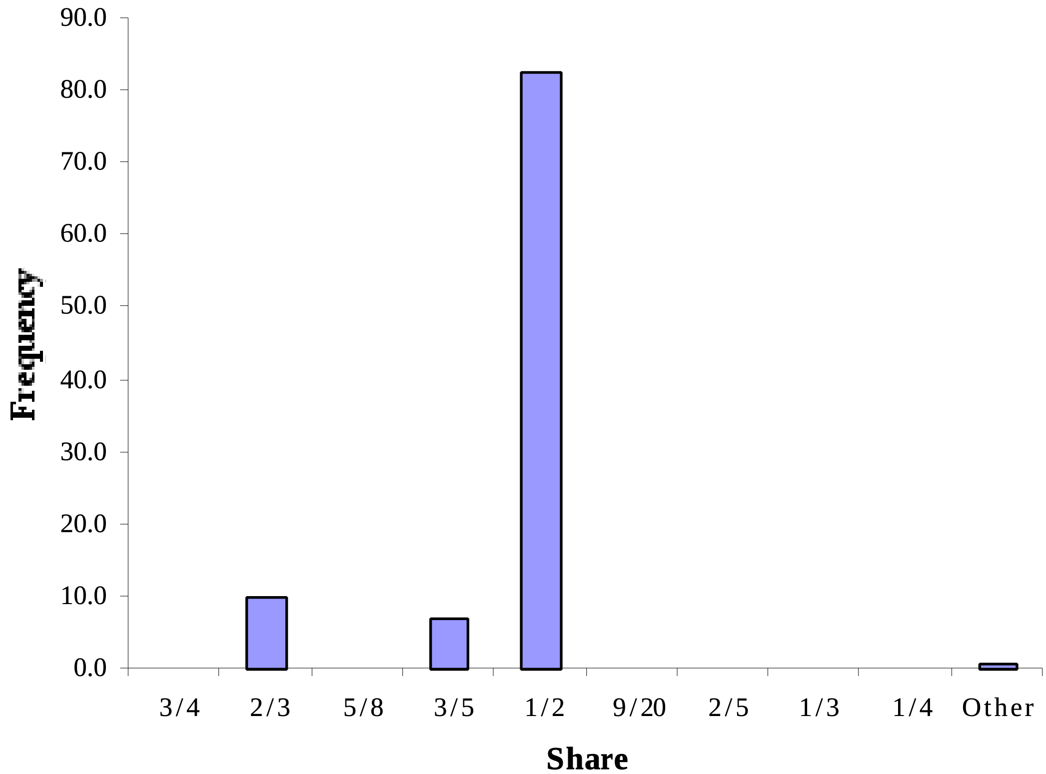

Figure 1. Crop share frequencies in Illinois: tenant's share of the corn crop. Illinois Cooperative Agricultural Extension Service Farm Leasing Survey, 1995. 935 data points.

A similar pattern holds in developing countries, such as the village economies of India and Africa (Bardhan and Rudra, 1980, 1981, 1986a,b; Bardhan, 1976, 1984; Robertson, 1987). To illustrate, consider Figure 2, which shows the distribution of shares among paddy farmers in West Bengal.[1]

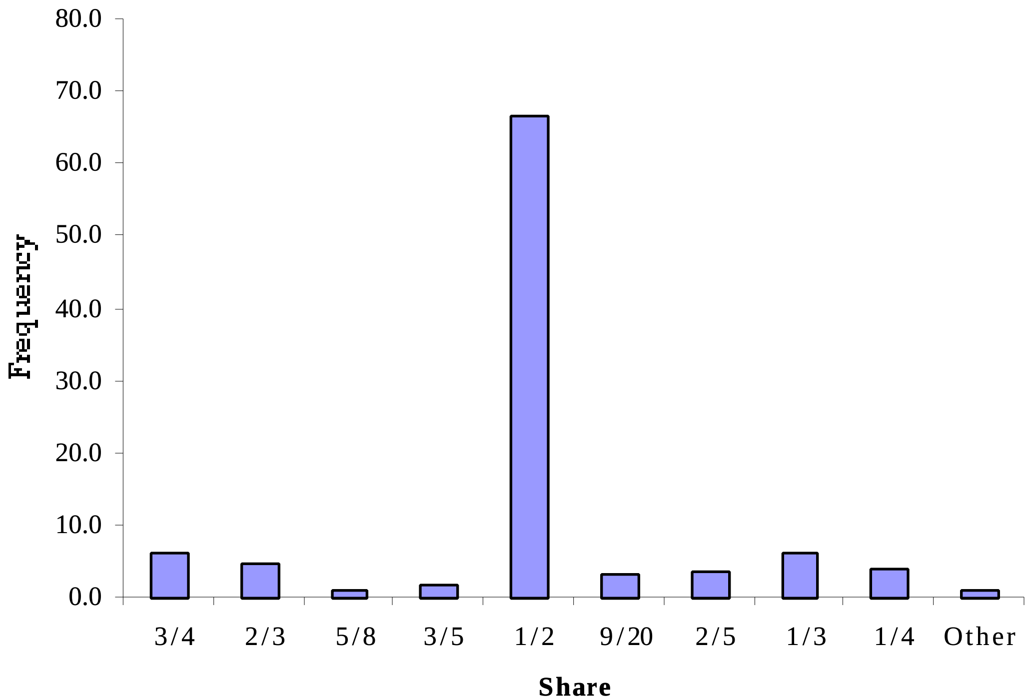

Figure 2. Crop share frequencies in West Bengal, 1975-76: tenant's share of paddy. Source: Pranab Bardhan, 1984, Table 9.2.

A common explanation of this phenomenon is that equal division expresses a relationship of *fairness* between owner and tenant, and fairness is of fundamental importance in traditional cultures where market psychology is weak. If we take this explanation at face value, however, then Illinois agriculturalists would appear to be even more traditional, and less market-oriented, than those in India. This is scarcely credible: contemporary Illinois

[1]We should say that Bardhan's remarkable study inspired us to undertake this project. For other treatments of cropsharing contracts see Johnson, 1950; Stiglitz, 1974; Reid, 1975, 1979; Bell and Zusman, 1976; Roumasset and James, 1979; Braverman and Stiglitz, 1982; Bliss and Stern, 1982; Murrell, 1983; Binswanger and Rosenzweig, 1984; Allen and Lueck, 1993; Hayami and Otsuka, 1993.

agriculture is a sophisticated, capital-intensive, and highly decentralized business. Landowners typically own plots of several hundred acres, and tenants typically farm even larger amounts (sometimes over 1000 acres) by contracting with several different owners. These tenant laborers have substantial capital investments in equipment, and they tend to be well-informed about recent developments in seeds, fertilizers, and cultivation techniques. Markets in both crops and in labor are dynamic due to low transportation costs. In short, there is every reason to think that landlords and tenants would be highly sensitive to market forces, and that tradition would play a secondary role in determining the returns to labor and land.

The data in Figures 1 and 2 suggest, however, that market forces might not be enough to overcome the focal power of particular shares. This interpretation is reinforced by observing that the frequency of contract forms is a decreasing function of the size of the denominator. In Figure 2, for example, 66.9% of the contracts have denominator 2, 11.1% have denominator 3, 10.5% have denominator 4, and 5.6% have denominator 5. (An exception is the denominator 20, which is more prevalent than the denominator 8.) A similar pattern holds for Figure 1. In West Bengal, this monotonicity produces a trimodal distribution with peaks at 1/3, 1/2 and 2/3. Similarly, Illinois has a bimodal distribution with over 90% of the mass concentrated on 2/3 and 1/2.

It might be, of course, that these "easy" fractions are just a way of rounding off the economically justifiable shares, that is, the shares that yield competitive returns to labor and land. If this were the case, however, then we would have to accept that: i) a share of about fifty-fifty represents the competitive returns to labor and land on most farms and for different crops in both Illinois and India;[2] ii) land quality is not unimodally distributed, but has peaks that fall at or near numbers that justify 2/3, 1/2, or 1/3. Both of these explanations seem rather implausible. We hypothesize that a different mechanism is at work that has to do with the psychology of bargaining. "Easy" fractions--those with small denominators--are inherently more focal than "hard" fractions. When a principal and an agent bargain over how to split a pie, they are drawn to

[2]Not to mention Africa; see Robertson (1987).

these natural focal points, thereby avoiding protracted and confrontational haggling that might damage the subsequent relationship.[3]

If we accept that focal points matter, then we are left with the question of how much they matter. An extreme position would be that cropsharing contracts are constructed around focal points that completely ignore economic fundamentals, such as the quality of the land, the quality of the labor, or the wage to labor in alternative employments. This hypothesis is not supported by the data either. To see why, let us disaggregate the Illinois contract data by region. The state consists of two parts that are noticeably different in their soil characteristics and geology. In the north, the land is flat and the soils are on average highly productive. In the south, the land is hillier, the topsoil is not as thick, and on average it is less productive. This north-south division is quite sharply defined, especially in the middle and eastern part of the state, where it corresponds to the southern boundary of the last major glaciation (Mausel, Runge, and Carmer, 1975). When we compare contract frequencies in the northern and southern parts of the state, substantial differences appear (see Figures 3 and 4).

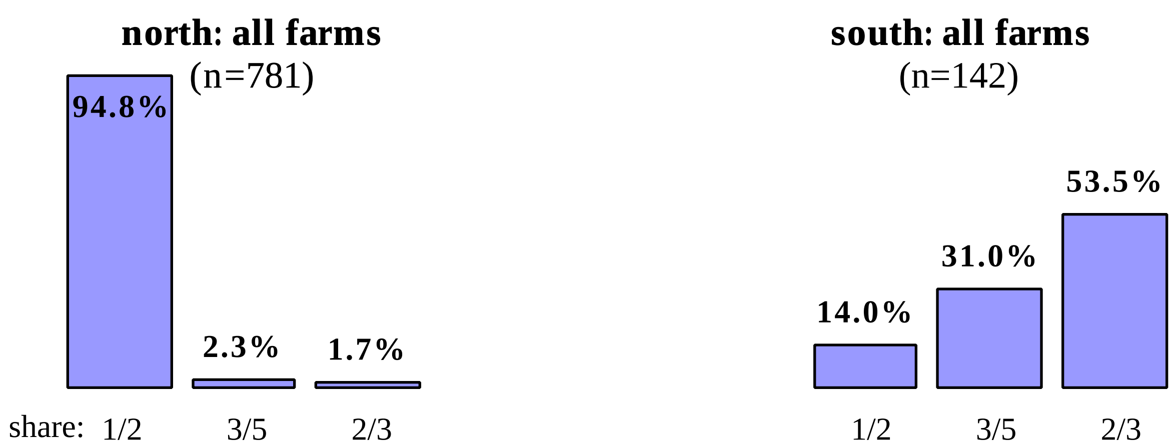

Figure 3. Distribution of share contracts by region: Illinois, 1995.

[3]The importance of focal points in bargaining was first pointed out by Schelling (1960). See Roth et al. (1985) and Binmore et al. (1993) for empirical studies of this phenomenon. To our knowledge the proposition that focalness decreases as the size of the denominator increases has not been tested in laboratory settings.

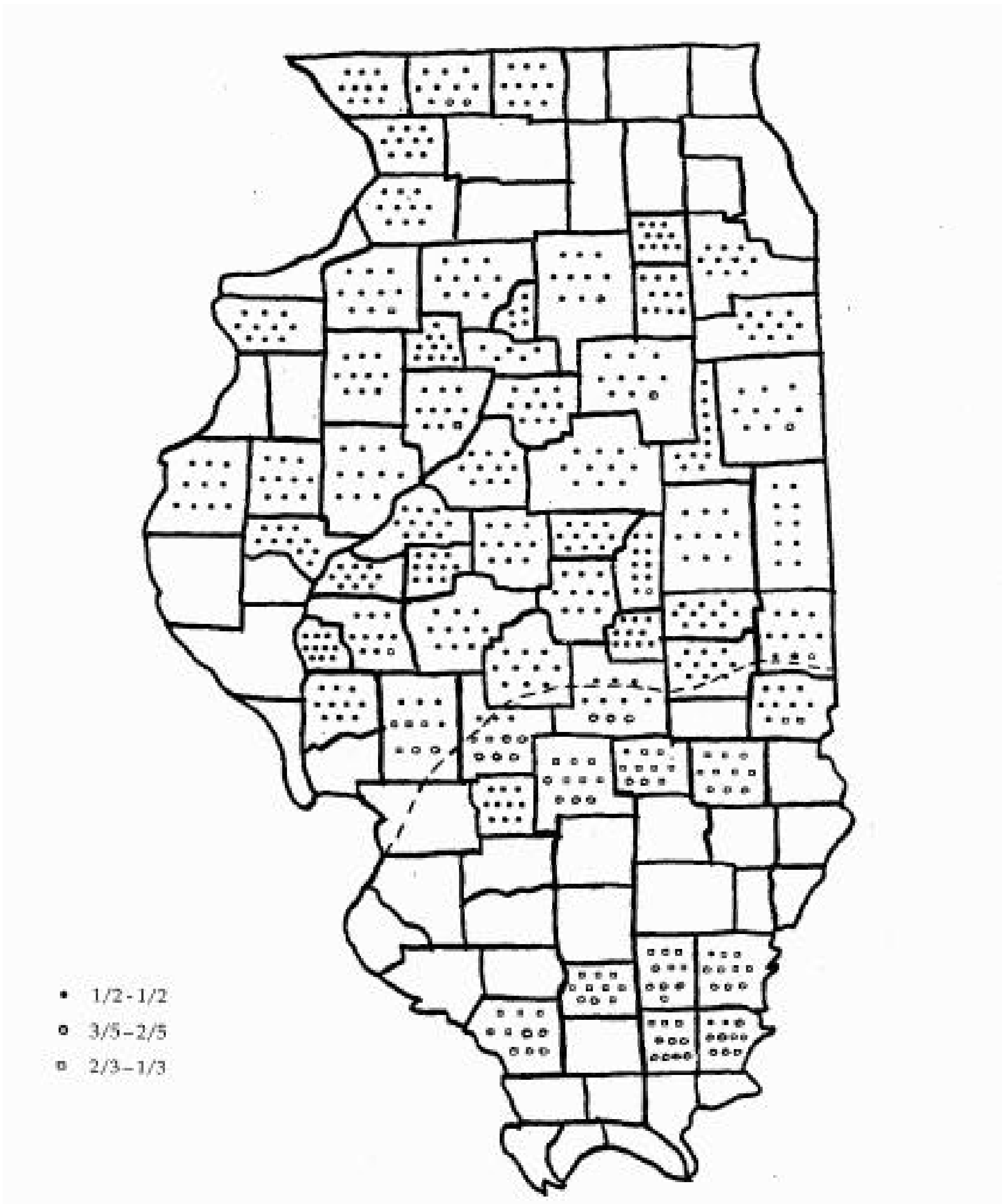

Figure 4. Distribution of share contracts by county: Illinois, 1995. (Blank counties had too few data to be statistically meaningful.)

In the north, contract terms are concentrated on 1/2 - 1/2, whereas in the south the predominant contracts are 2/3 - 1/3 and 3/5 - 2/5. (Here as elsewhere we write the tenant's share first, and the landlord's second.) Moreover there is a simple explanation for this shift: the land in the south is, on average, inherently less productive than the land in the north. Hence the share for the tenant must be higher in the south if net returns to the tenants in the two regions are to be comparable.

Of course, this is very far from saying that the observed shift from 1/2-1/2 to 2/3-1/3 is exactly the right amount to compensate for the difference in average land quality. Indeed it would be quite a coincidence if 1/2 -1/3 = 1/6 represents just the right additional compensation necessary to equilibrate the tenant labor market between north and south. A more plausible explanation is that thirds and fifths have the most focal power when market forces push the parties away from equal division.[4] While the quantum jump required to move from halves to fifths or thirds may bring things closer to market equilibrium, it will at best be a rough approximation.

3. Competition vs. custom

How does one compute the shares that would, in principle, exactly equilibrate factor markets? The answer depends on such factors as variability in returns, degree of risk aversion, and monitoring costs. It also depends importantly on the quality of the inputs, and in particular on the productivity of the land. Fortunately the survey instrument includes a measure of each farm's inherent productivity, called the "soil quality index," which estimates the expected yield per acre holding labor input constant. This measure is constructed as follows. Soils are classified into some 435 distinct types based on chemical composition, texture, color, and moisture content (Fehrenbacher et al., 1978).[5] For each type of soil, average yields are computed on test plots under a standardized measure of labor input called "standard management practice" (Odell and Ochswald, 1970). Based on these test plot results, the index of a soil is calibrated so that expected yield, holding labor input

[4]Compare Mill's remark about the customary share on rich soils around Naples (see p. 1).
[5]In some areas contests are held in which people try to identify the soil type by inspecting a sample, much as one would identify the origin and vintage of a wine by tasting a glass.

constant, is a linearly increasing function of the index. The soil index, s_i, of a specific farm i, is the average of the soil indices on that farm, weighted according to the number of acres of each soil type. This index, which is reported for each farm in our data set, amounts to an exogenously estimated predictor of the average yield of basic crops grown on that farm under standard management practice.[6]

A standard model of contracting is to suppose that landlords set contract terms in order to maximize returns subject to tenants earning their reservation wage (Johnson, 1950; Cheung, 1969; Roumasset and James, 1979; Hayami and Otsuka, 1993). In this literature it is assumed that landlords can costlessly enforce the terms of the contract, including the level of labor input. When factor markets are in equilibrium, contract shares are determined by the local reservation wage and the soil quality. The specific predictions depend on the assumed form of the production function. Under most specifications the tenant's share either stays constant or decreases as soil quality increases.[7] Since the average soil quality in the northern part of Illinois is higher than the average soil quality in the south, it comes as no surprise that the shares in the north are, on average, lower.

While this confirms the predictions of theory in the broadest sense, however, a closer look at the data shows that little else about the neoclassical predictions are confirmed. The difficulty is that soil quality is highly variable within each of these two regions, and in fact even within quite localized areas. Within a given county, for example, it is not at all unusual for the highest-rated farms to be nearly twice as productive (in terms of expected yield per acre) as the lowest-rated farms. Standard theory would predict that the shares should reflect these local differences, especially since labor (and other factor inputs) can be assumed to be fully mobile locally.

[6] The following analogy may be helpful: one could rate the reliability of different makes of automobile by test driving them under "standard conditions" using subjects who follow "standard driving practice." One could then compute the frequency (or cost) of repairs needed over, say, the first twenty thousand miles driven. From this one could construct a reliability index for each type of automobile that is analogous to the productivity index of a soil.

[7] For a Cobb-Douglas production function and risk neutral agents the equilibrium share is constant. However, this specification implies that labor input per acre should increase substantially with soil quality, a prediction that is not borne out by the data (Burke and Young, 2000).

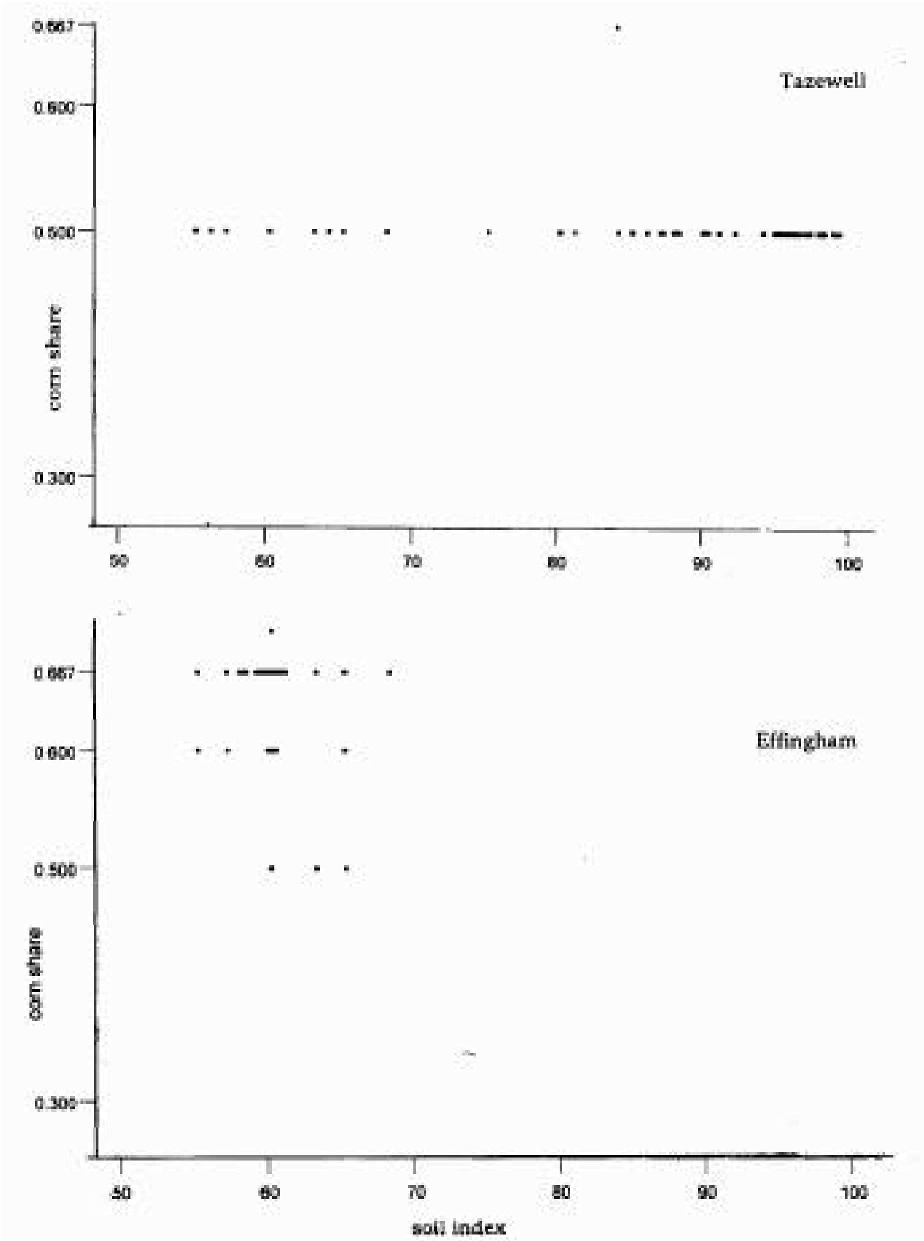

Figure 5. Distribution of shares: Tazewell Co. (north), Effingham Co. (south).

The data tell a different story however. Figure 5 shows the distribution of shares in a representative northern county (upper panel) and a representative southern county (lower panel). In the north, fifty-fifty is used on almost all farms despite the fact that there is a wide range of soil qualities on which it is used. In the south, the 2/3 - 1/3 contract is the most frequent and there is greater variation; nevertheless, only three contracts (1/2 - 1/2, 3/5 - 2/5, 2/3 - 1/3) are used with any appreciable frequency. Notice also that the same contract is used on soils of substantially different qualities, while substantially different contracts are used on soils of the same quality. Indeed most of the contracts in the south give the tenant more—in fact substantially more--than contracts in the north *holding soil quality fixed*.

How can these facts be reconciled with standard theory? One possibility is that labor is not very mobile between the regions, and reservation wages differ between the two because of alternative employment opportunities. In Burke and Young (2000) we examine this hypothesis in more detail and show that if anything it makes the puzzle greater, since the wage differential between the two regions goes in the wrong direction: average wages in the south are lower, even though laborers on southern farms generally get a larger fraction of the crop than do laborers on northern farms of similar quality.

A second possibility is that the adherence to customary shares is more apparent than real, that is, other terms of the contract vary enough to pull the outcomes back into line with neoclassical predictions. This explanation does not hold up, however, when we examine the actual variation in the other terms. We have already noted that almost all of the contracts apply the *same* share to all of the crops (e.g., corn, wheat, and soybeans), so there is little variation there. Next let us consider the division of responsibilities for providing key inputs, namely, seed, fertilizer, and machinery. In virtually all cropsharing contracts, the tenant is solely responsible for providing mobile farm equipment (tractors, ploughs, harvesters, etc.), so there is almost no variation in this dimension. Moreover, in the vast majority of contracts, fertilizer and seed are either shared fifty-fifty or are provided solely by the tenant (see Tables 1 and 2). Taken together, these constitute the bulk of the economically relevant parameters in the contract. [8]

[8] Of course, it is possible that adjustments occur in aspects of the contract that are not observable. It can be shown, however, that the observable differences in contract terms are reflected in the actual net returns to labor, that is, they flow through to the tenants' bottom line (Burke and Young, 2000).

Table 1: Tenant's corn output share (rows) vs. bulk fertilizer share (columns)

	0.25	0.34	0.4	0.5	0.53	0.587	0.6	0.666	1
0.200	0	0	0	1	0	0	0	0	0
0.250	0	0	0	1	0	0	0	0	0
0.300	0	0	0	1	0	0	0	0	0
0.400	0	0	0	1	0	0	0	0	0
0.450	0	0	0	1	0	0	0	0	0
0.500	1	1	1	717	1	1	11	0	24
0.530	0	0	0	1	0	0	0	0	0
0.587	0	0	0	1	0	0	0	0	0
0.600	0	0	0	16	0	0	19	9	18
0.666	0	0	0	11	0	0	23	25	29
0.667	0	0	0	1	0	0	0	0	0
0.700	0	0	0	0	0	0	1	0	0
0.750	0	0	0	0	0	0	1	0	0
1.00	0	0	0	2	0	0	0	0	0

Table 2: Tenant's corn output share (rows) vs. corn seed share (columns)

	0.25	0.4	0.5	0.53	0.587	0.6	0.666	1
0.200	0	0	0	0	0	0	0	1
0.250	1	0	0	0	0	0	0	0
0.300	0	0	0	0	0	0	0	0
0.400	0	1	0	0	0	0	0	0
0.450	0	0	1	0	0	0	0	0
0.500	0	0	748	0	0	0	0	7
0.530	0	0	0	1	0	0	0	0
0.587	0	0	0	0	1	0	0	0
0.600	0	0	1	0	0	2	0	59
0.666	0	0	0	0	0	0	4	85
0.700	0	0	0	0	0	0	0	1
0.750	0	0	0	0	0	0	0	1
1.00	0	0	0	0	0	0	0	2

A third possibility is that high-quality tenants migrate to farms of high productivity, that is, the market equilibrates through assortative matching rather than through variation in contract terms. We point out that this would still pose a challenge to conventional theory, since it is not clear why the contract terms should fail to adjust unless some notion of custom is at work. Leaving this issue aside, one can test the assortative matching hypothesis by examining the rate at which total output per acre rises as soil quality increases. The hypothesis is supported if the rate of increase is higher than it would be using the benchmark inputs under which the soil index was originally calibrated. The data do not support this hypothesis either: tenants on high quality land succeed in capturing a substantial portion of the land rent without increasing labor productivity, and this is directly attributable to the failure of the shares to adjust to local differences in soil quality (Burke and Young, 2000).

4. A dynamic model of contractual custom

Let us recapitulate the empirical facts that need to be explained. First, standard theory predicts that contract terms should vary continuously as a function of economic fundamentals. The most important of these are: the reservation wage for labor, the quality of the land, the quality of the labor, and the degree of risk aversion of the contracting parties. While the reservation wage may be uniform in a given locality, the other three parameters are almost certainly not uniform. Thus we would expect that contracts are locally heterogeneous. As we have seen, however, the data are not consistent with this view. Rather, the terms are concentrated on a very small number of combinations that have *a priori* focal significance.

The tendency of contract terms to cluster on a few discrete values we shall call the *quantum effect*. The lack of heterogeneity we shall call the *local conformity effect* (Young, 1998a, p. 148). Notice that these are not the same thing: even though the quantum effect limits the number of distinct contracts that might be observed, contract terms could still vary substantially from one farm to the next, resulting in a great deal of local diversity. This is not confirmed by the data even though local differences in fundamentals might call for it.

We now propose an extension of the neoclassical framework that captures these effects. As in the standard model, we maintain the assumption that landlords propose contracts, which tenants accept or reject depending on whether they exceed or fall short of the reservation wage. In the standard model, the landlord proposes a contract that maximizes his expected returns subject to being acceptable to the tenant. In our set-up, the landlord is influenced by expected returns plus two other factors: i) the *exogeneous* salience of a contract, e.g., whether it is based on easy fractions and round numbers; and ii) the *endogenous* salience of a contract, as measured by the frequency with which it is used by others.

The process of contract choice works as follows. From time to time landlords recontract with their tenants. The landlord must offer the tenant a contract whose utility is at least equal to the utility of the reservation wage. Among all such *acceptable* contracts, the landlord offers one that maximizes his expected utility with high probability. In other words, the landlord follows a stochastic choice rule rather than strictly optimizing, a point of view that seems to fit well with empirical evidence (see, for example, Suppes and Atkinson (1960), and Roth and Erev (1995).) This adjustment process yields a stochastic dynamical system in which the distribution of contract choices evolves over time. The object of the analysis is to ascertain which distributions are most likely to emerge, starting from arbitrary initial conditions.

To be more specific, assume that agents live at the vertices of a graph, which represent distinct locations in some social or geographical space. Let V denote the set of n vertices, and let $i \in V$ denote a particular vertex. If the choice of agent j has an influence on agent i, we connect i and j by a directed edge (i, j); the amount of influence is given by a weight $w_{ij} \geq 0$. If influence is determined by geographical proximity, then we would have $w_{ij} = w_{ji}$ for all i and j. This *symmetry* assumption will be maintained in what follows.

Let X denote the finite set of contracts that people are willing to consider. At each time t, the contract in force at location i is denoted by $x_i^t \in X$, and the vector $\mathbf{x}^t \in X^n$ denotes the *state* of the process. At random times governed by a Poisson random variable ω_i, the landowner and tenant at location i renegotiate their contract. Assume that the random variables ω_i are independent and identically distributed, and that time is scaled so that, on average, there is one renegotiation per time period in each location. (Allowing differences in the rate of renegotiation at different locations does not change the results in any important way.)

Suppose that the current state is **x**, and the contract at location i is about to be renegotiated. The landowner offers the tenant a contract, and the tenant accepts if and only if the contract's expected utility to the tenant is above some reservation utility level u_i^0. The value of u_i^0 may depend on the particular location i, e.g., on local wages in alternative employment. We shall assume that the subset X_i of *acceptable* contracts that meet this reservation level is nonempty for each i. The landlord is assumed to choose a contract $x_i \in X_i$ that maximizes his utility.[9]

We treat the choice of contract at a given location as a state-dependent random variable. Let $P(x_i | \mathbf{x}_{-i})$ denote the conditional probability that contract x_i is adopted at location i when $\mathbf{x}_{-i}$ is the state of the other locations. We posit that $P(x_i | \mathbf{x}_{-i})$ is monotone increasing in the three factors mentioned earlier: the expected returns from the contract, the focalness of the contract, and its frequency of use in the "neighborhood." Denote the expected monetary returns to the landlord from contract x_i by $v_i(x_i)$. The focalness of the contract will be represented by a real-valued function $f(x_i)$, whose operational meaning will become clear in a moment. The local frequency of use is given by the function $w_i(x_i, \mathbf{x}_{-i}) = \sum_{j \neq i} w_{ij}\, \delta(x_i, x_j)$, where $\delta(x_i, x_j) = 1$ if $x_i = x_j$ and $\delta(x_i, x_j) = 0$ otherwise.

A convenient functional form is to suppose that the log probability of choosing a given contract is a linear function of these three factors. In other words, for some $\beta \geq 0$, and every x_i and $y_i \in X_i$,

$$\log P(x_i | \mathbf{x}_{-i}) - \log P(y_i | \mathbf{x}_{-i}) = \beta[v_i(x_i) - v_i(y_i) + w_i(x_i, \mathbf{x}_{-i}) - w_i(y_i, \mathbf{x}_{-i}) + f(x_i) - f(y_i)]. \quad (1)$$

[9]This take-it-or-leave-it model of the bargaining process is fairly standard in the principal-agent literature. Models of custom that give a symmetric role to the contracting parties are discussed in Young (1993b, 1998a, 1998b).

Equivalently,

$$P\left(x_i \middle| \mathbf{x}_{-i}\right) = \frac{e^{\beta\left[v_i(x_i) + w_i(x_i, \mathbf{x}_{-i}) + f(x_i)\right]}}{\sum_j e^{\beta\left[v_j(x_j) + w_j(x_j, \mathbf{x}_{-j}) + f(x_j)\right]}} \tag{2}$$

This is known as a *log-linear response function*, and β is the *response parameter* (Blume, 1995; McKelvey and Palfrey, 1995; Brock and Durlauf, 1995; Durlauf, 1997).

This model can be interpreted as a perturbed optimal response process in the following sense. Suppose that we represent the utility of agent i in state **x** by

$$U_i(\mathbf{x}) = v_i(x_i) + w_i(\mathbf{x}) + f(x_i) + \varepsilon_i(\mathbf{x}), \tag{3}$$

where $\varepsilon_i(\mathbf{x})$ is an unobserved utility shock. Suppose that these utility shocks are independent and identically distributed according to the extreme value distribution $P(\varepsilon \le z) = e^{-e^{-\beta z}}$. If i always chooses a contract $x_i \quad X_i$ that maximizes $U_i()$ conditional on the others' choices being $\mathbf{x}_{-i}$, then from the observer's standpoint it appears that i is following the stochastic adoption process given by (2). Such models are standard in the discrete choice literature (McFadden, 1974). For purposes of empirical estimation, however, it is not the utility function but the choice probabilities that matter. In principle, these could be estimated from a sufficiently rich set of event histories that give the temporal sequence of contract adoptions at different locations.

The functional form (2) is a convenient way of expressing the idea that the probability of a contract at a given location is an increasing function of three factors: return to land, focalness, and local frequency of use. The formula states, for example, that if two contracts x and y provide the same expected returns at a given location, and if they are used with the same frequency, but x is more inherently focal than y (say because x uses fractions with denominator 2 while y uses fractions with denominator 119), then x is more likely to be adopted than y. Alternatively, if x and y have the same expected returns, and both are based on very easy fractions, but x is much more commonly used than y in the neighborhood, then x is more likely to be adopted than y is, and so forth.

Unfortunately, the Illinois data set does not allow us to estimate the choice probabilities directly, because the location of farms is known only down to the county level. (Furthermore, even if the precise locations were known, the sample is not large enough to include many instances of farms that are physically close to one another.) Thus we are proposing the relationship (2) as one that seems reasonable in principle, rather than one that we can directly test with our data set.

There is considerable experimental evidence, however, that round numbers and endogeneous notions of fairness matter in similar bargaining situations. An experimental set-up that is closely related to the present one is the ultimatum game. In this game, the principal offers a fraction of the pie to an agent, which the latter can accept or reject (Guth et al., 1982). A standard finding is that agents often refuse offers that are perceived to be "stingy," even though this behavior would seem to be self-defeating. However, two other features of players' behavior are noteworthy for our purposes. First, the principals very often make offers that are in round numbers. Second, they adjust their offers to the prevailing conception of what constitutes a fair or acceptable offer, and this conception varies substantially from one culture to the next.

For example, Roth et al. (1991) conducted experiments in four different countries--Japan, Israel, the United States, and Yugoslavia--using the same experimental protocols. The experimenters corrected for differences in local currency by having the subjects express their offers in tokens, each token being worth the equivalent of about one U.S. cent. In almost every case, over half of the offers were expressed in multiples of fifty tokens (Roth et al. Figures 3-4).[10] Furthermore, Roth et al. found that, while the modal offers differed among countries, the probability of an offer being accepted depended

[10] The focalness of round numbers has been documented in many other contexts; see for example Albers and Albers (1983).

not on its absolute size, but on the extent to which it deviated from the modal offer. In other words, an agent's willingness to accept an offer appears to be governed by norms and expectations that differ from one culture to another. Both of these findings lend support (albeit indirect) to the model that we have proposed above.

The probabilistic choice model (2), together with the Poisson updating processes, defines a time-homogeneous Markov process on a finite state space, namely, the set of all states **x** that specify the contract in use at each location. This process is ergodic and has a unique invariant distribution μ. For each state **x**, μ(**x**) represents the long-run relative frequency with which state **x** is visited in almost all realizations of the process.

In the present case the invariant distribution takes a particularly tractable form. Define the *potential* of state **x** to be

$$\rho(\mathbf{x}) = \sum_{i=1}^{n} v_i(x_i) + \sum_{i=1}^{n} f(x_i) + (1/2)\sum_{i=1}^{n} w_i(\mathbf{x}). \qquad (4)$$

Potential equals the total utility from those factors that involve no social interactions, plus one-half of the utility from those that do involve social interactions. It follows from standard arguments (see e.g., Liggett, 1985; Blume, 1995; Young, 1998a, Chapter 6) that the long-run distribution of the process has the following simple form, known as a Gibbs representation

$$\mu(\mathbf{x}) = e^{\beta\rho(\mathbf{x})} \Big/ \sum_{\mathbf{y}} e^{\beta\rho(\mathbf{y})} \qquad (5)$$

It follows that, when β is large, the probability is close to one that the process will be in a state that maximizes potential. We summarize this in the following result.

Theorem. Starting from an arbitrary initial state, the long-run probability of being in any given state ***x*** *is proportional to* $e^{\beta\rho(\mathbf{x})}$. *When* β *is large but finite, the probability is close to one that the process will be in a state that globally* *maximizes potential. These are known as the stochastically stable states of the process.*

While the exponential form of the long-run distribution is especially convenient to work with, and depends on the log linear representation in (2), it needs to be emphasized that the general approach can be applied without this assumption. Suppose that the renegotiation process at each location can be represented as a stochastic choice over contracts, whose distribution is perhaps state-dependent but not time-dependent. Suppose further that, at each location, every contract in the feasible set is chosen with a probability that is bounded away from zero over all possible states. Together with the Poisson updating processes, this yields an irreducible, finite Markov chain that has a unique invariant distribution. When the variance of the individual choice probabilities is sufficiently small, the process will typically occupy a few states with high probability, and these stochastically stable states can be identified with considerable precision using the method of large deviations (see Freidlin and Wentzell, 1984; Young, 1993a, 1998a; Kandori, Mailath, and Rob, 1993).

5. Application of the model to cropsharing

We now show how this approach can help to explain some of the apparently anomalous features of the Illinois data. For purposes of illustration, let us assume that the only contractual variable is the tenant's share x of total output. Let us also suppose that labor input is fully monitored, and that the contract specifies that it must correspond to standard management practice. At each farm i, we shall represent the productivity by a real number s_i, which gives the expected output per acre, measured in dollars, under standard management practice. (For example, $s_i = 80$ means that total net income on farm i is, on average, \$80 per acre.) The tenant's expected income on farm i is thus the contract share x_i times the index s_i times the size of the farm. For mathematical convenience, assume that all farms have the same size, which we may as well suppose to be unity. (This does not affect the analysis in any important way.) The tenant accepts a contract x_i if and only if his expected return $x_i s_i$ is at least w_i, where w_i is the reservation wage at location i.[11] The expected return to the landlord from such a contract is $v_i(x_i) = (1 - x_i)s_i$.

Let us assume that all contracts are equally focal from an *a priori* standpoint, say $f(x_i) = 0$ for all i and all x_i. To model the impact of custom, suppose that each of agent i's neighbors exerts the same degree of social influence. In other words, there is a number $\gamma \geq 0$ such that $w_{ij} = \gamma$ if farm i is adjacent to farm j, and $w_{ij} = 0$ otherwise. Let $n_i(\mathbf{x})$ be the number of i's neighbors using the same contract as i does in state **x**. Then the potential function takes the form

$$\rho(\mathbf{x}) = \sum_{i=1}^{n} (1 - x_i)s_i + (\gamma/2)\sum_{i=1}^{n} n_i(\mathbf{x}) \qquad (6)$$

The term $\sum(1 - x_i)s_i$ is just the total return to land, which we shall denote by $r(\mathbf{x})$. The term $(1/2)\sum n_i(\mathbf{x})$ is just the total number of edges (neighbor-pairs) that are coordinated on the same contract in state **x**, which we shall denote by $c(\mathbf{x})$. This is the *degree of local conformity* in the system, and γ is the *conformity parameter*. We thus obtain the particularly transparent formulation

$$\rho(\mathbf{x}) = r(\mathbf{x}) + \gamma c(\mathbf{x}),$$

and

$$\mu(\mathbf{x}) \propto e^{\beta[r(\mathbf{x})+\gamma c(\mathbf{x})]}. \qquad (7)$$

In other words, *the log probability of each state* **x** *is a linear function of the total rent to land plus the degree of local conformity*. Given specific values of the conformity parameter γ and the response parameter β, we can compute the relative probability of various states of the process, and from this deduce the likelihood of different geographic distributions of contracts. In fact, one can say a fair amount about the qualitative behavior of the process even when one does not know specific values of the parameters.

[11] If tenants are not risk neutral, the lower bound w_i depends on the tenant's degree of risk aversion, the variability of the returns, and the alternative wage.

6. An illustrative example

We illustrate with a concrete example that is meant to capture some of the key features of the Illinois case. Consider the hypothetical state of Torusota shown in Figure 6. In the northern part of the state--above the dashed line--soils are evenly divided between High and Medium quality soils, whereas in the southern part they are evenly divided between Medium and Low quality soils. As in Illinois the soil types are interspersed, but average soil quality is higher in the north than it is in the south.

Let n be the number of farms. Each farm has exactly eight neighbors, so there are 4n edges altogether. As in the preceding section, contracts are one-dimensional and specify the share of output for the tenant. Suppose there are nine salient contracts: x = 10%, 20%, . . ., 90%. (Contracts in which the tenant receives 0% or 100% are not considered.) For the sake of concreteness, assume that High soils have index 85, Medium soils have index 70, and Low soils have index 60. Let the reservation wage be 32.

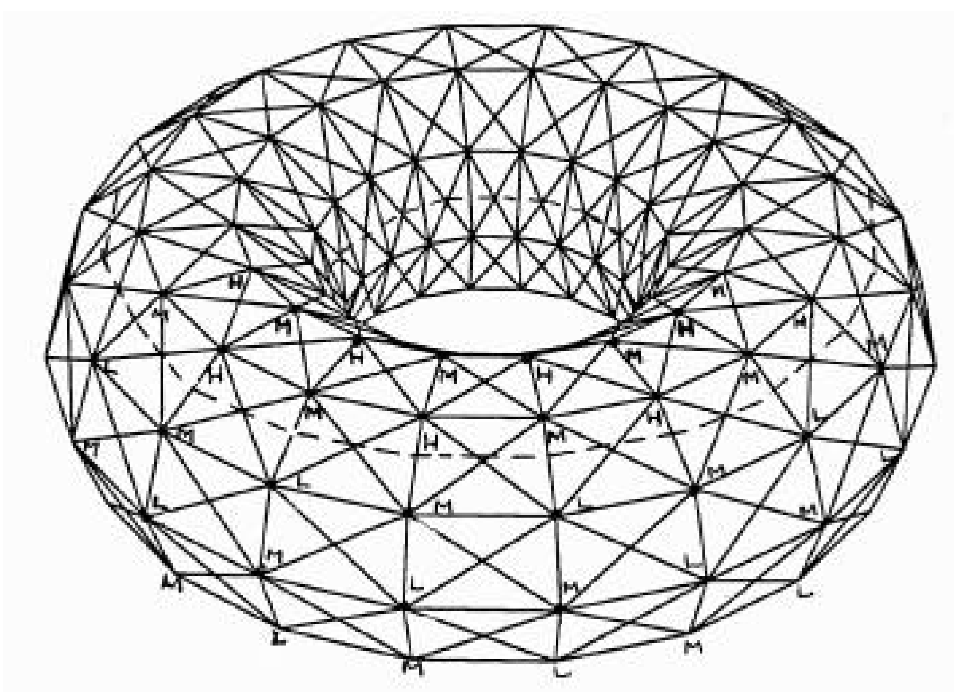

Figure 6. The hypothetical state of Torusota. Each vertex represents a farm, and soil qualities are High, Medium, or Low.

We wish to determine the states with maximum potential. The answer depends on the size of γ, that is, on the tradeoff rate between economic and social payoff. Consider first the case where γ = 0, that is, there are no conformity effects. Maximizing potential is then equivalent to maximizing the total rent to land, subject always to the constraint that labor earns at least its reservation wage on each class of soil. The contracts with this property are 40% on High soil, 50% on Medium soil, and 60% on Low soil. The returns to labor under this arrangement are: 34 on H, 35 on M, and 36 on L. Notice that labor actually earns a small premium over the reservation wage (w = 32) on each class of soil. This *quantum premium* is attributable to the discrete nature of the contracts: no landlord can impose a less generous contract (rounded to the nearest 10%) without losing his tenant. Except for the quantum premium, this outcome is the same as would be predicted by a standard market-clearing model, in which labor is paid its reservation wage and all the rent goes to land. We shall call this the *competitive equilibrium* state **w**.

Notice that, in contrast to conventional equilibrium models, our framework actually gives an account of how the state **w** comes about. Suppose that the process begins in some initial state $\mathbf{x}^0$ at time zero. As landlords and tenants renegotiate their contracts, the process gravitates towards the equilibrium state **w** and eventually reaches it with probability one. Moreover, if β is not too small, the process stays close to **w** much of the time, though it will rarely be *exactly* in equilibrium.

These points may be illustrated by simulating the adjustment process. We chose n = 200, that is, 100 farms in the North and 100 in the South, and a moderate level of noise (β = 0.20). Starting from a random initial seed, we then simulated the process for three levels of conformity: γ = 0, 3, and 8. For each of these values the process settles into a characteristic pattern after the initial bias has worn off. Figure 7 shows a typical distribution of contract shares after 1000 periods have elapsed. When γ = 0 (bottom panel), the contracts are matched quite closely with land quality, and the state is close to the competitive equilibrium. When the level of conformity is somewhat higher (middle panel), the dominant contract in the North is 50%, in the

South it is 60%, and there are pockets here and there of other contracts. (This looks quite similar to the Illinois case.) Somewhat surprisingly, however, a further increase in the conformity level (top panel) does not cause the two regional customs to merge into a single global custom; it merely leads to greater uniformity in each of the two regions.

To understand why this is so, let us suppose for the moment that everyone is using the same contract x. Since everyone must be earning their reservation wage, x must be at least 60%. (Otherwise southern tenants on low quality soil would earn less than w = 32.) Moreover, among all such global customs, x = 60% maximizes the total rent to land. Hence the 60% custom, which we shall denote by **y**, maximizes potential among all global customs.

But it does not maximize potential among all states. To see this, let **z** be the state in which everyone in the North uses the 50% contract, while everyone in the South everyone uses the 60% contract. From the standpoint of potential this is almost as good as **y**, because the only negative social externalities are suffered by those who live near the north-south boundary. Let us assume that the number of such agents is on the order of $\sqrt{n}$, where n is the total number of farms. Thus the *proportion* of farms near the boundary can be made as small as we like by choosing n large enough. But **z** offers a higher land rent to all the northern farms as compared to **y**. Assume that there are n/2 farms in the north, split equally between High and Medium soils, and that there are n/2 farms in the south, split equally between Medium and Low soils. Then the total income difference between **z** and **y** is 7n/4 on the Medium soil farms in the north, and 8.5n/4 on the High soil farms in the north, for a total gain of 31n/8. It follows that, if γ is large enough, then for all sufficiently large n, the regionalized custom **z** has higher potential than the global custom **y**. [12]

[12] A more detailed calculation shows that **z** uniquely maximizes potential among *all* states whenever γ is sufficiently large and n is sufficiently large relative to γ.

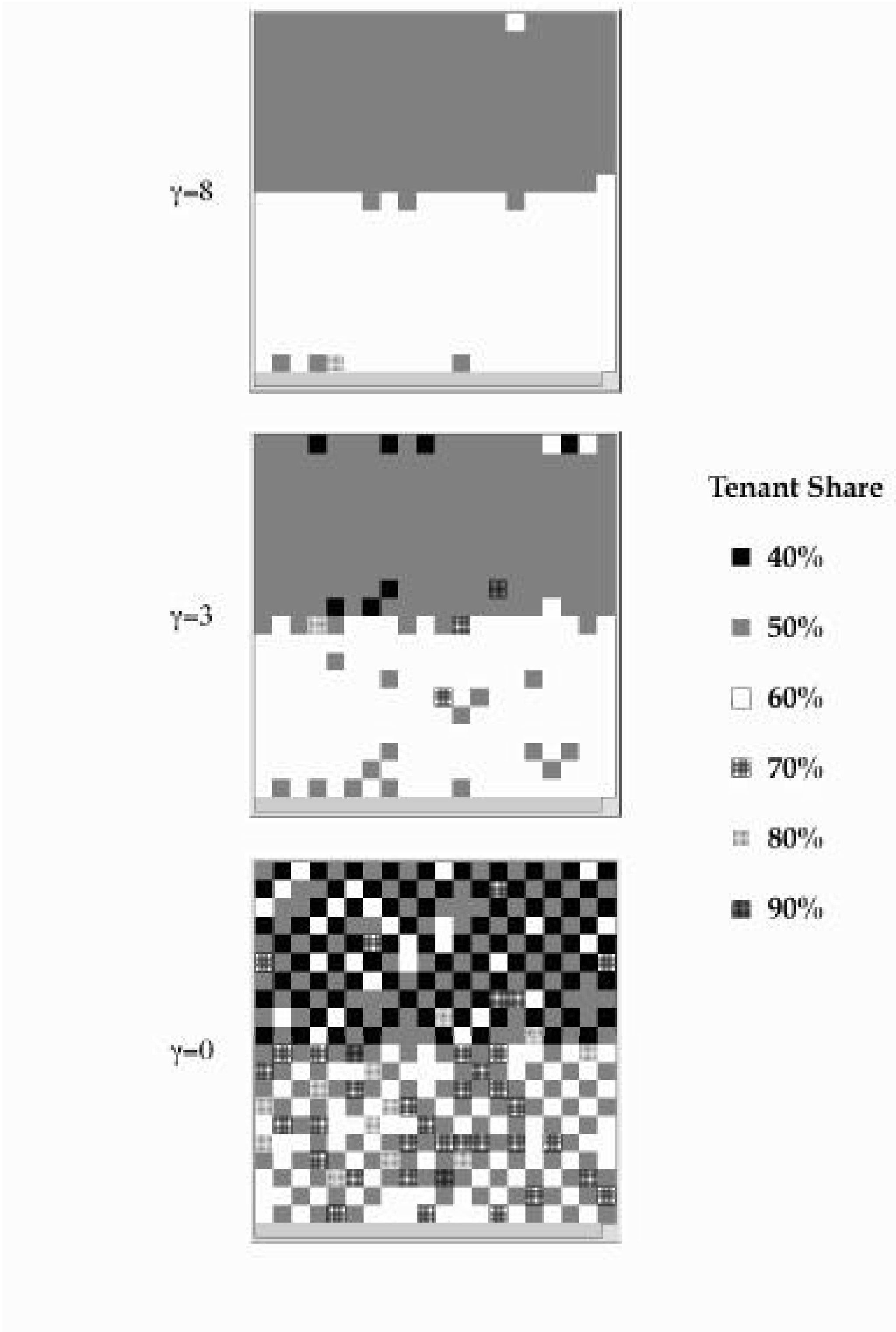

Figure 7. Simulated outcomes of the process for n = 200, β = 0.20.

While the details are particular to this example, the logic is quite general. Consider any distribution of soil qualities that is heterogeneous locally, but exhibits substantial shifts in average quality between geographic regions. For intermediate values of conformity γ, it is reasonable to expect that potential will be maximized by a distribution of contracts that is uniform locally, but diverse globally--in other words the distribution is characterized by *regional customs*. Such a state will typically have higher potential than the competitive equilibrium, because the latter involves substantial losses in social utility when land quality is heterogeneous. It will typically have higher potential than a global custom, because it allows landlords to capture more rent at relatively little loss in social utility, provided that the boundaries between the regions are not too long (i.e., there are relatively few farms near the boundaries).

In effect, these regional customs form a compromise between completely uniform contracts on the one hand, and fully differentiated contracts on the other. Given the nature of the model, we should not expect perfect uniformity within any given region, nor should we expect *sharp* changes in custom at the boundary. The model suggests instead that there will be occasional departures from custom within regions (due to idiosyncratic influences), and considerable variation near the boundaries. This seems to be a reasonably accurate characterization of the distribution of contracts in the state of Illinois.

References

Akerlof, George A. (1980): "A Theory of Social Custom, of Which Unemployment May Be One Consequence," *Quarterly Journal of Economics*, 94, 749-775.

-------------- (1997): "Social Distance and Social Decisions, "*Econometrica* 65:1005-27.

Albers, Wulf, and Gisela Albers (1983): "On the Prominence Structure of the Decimal System," in R. W. Scholz, ed., *Decision Making under Uncertainty*. Amsterdam: Elsevier.

Allen, Douglas W., and Lueck, Dean (1993): "Transaction Costs and the Design of Cropshare Contracts,"*RAND Journal of Economics* 24(1), 78-100.

Bardhan, Pranab K. (1976). "Variations in Extent and Forms of Agricultural Tenancy—I: Analysis of Indian Data across Regions and Over Time." *Economic and Political Weekly*, September 11, 1976, 1505-1546.

------------- (1984): *Land, Labor, and Rural Poverty: Essays in Development Economics*. New York: Columbia University Press.

Bardhan, Pranab K, and Rudra, Ashok (1980): "Terms and Conditions of Sharecropping Contracts: An Analysis of Village Survey Data in India," *Journal of Development Studies*, 16(3), 287-302.

------- ------- (1981): "Terms and Conditions of Labor Contracts in Agriculture: Results of a Survey in West Bengal, 1979," *Oxford Bulletin of Economics and Statistics*, 43(1), 89-111.

----- -------- (1986a): "Labour Mobility and the Boundaries of the Village Moral Economy," *Journal of Peasant Studies*, 13, 90-115.

----- ------- (1986b): *Agrarian Relations in West Bengal: Results of Two Surveys*. Bombay: Somaiya.

Bell, Clive and Zusman, Minhas (1976): "A Bargaining Approach to Cropsharing Contracts," *American Economic Review* 66(4), 578-88.

Binmore, Ken; Swierzbinski, Joe; Hsu, Steven, and Proulx, Chris (1993): "Focal Points and Bargaining," *International Journal of Game Theory*, 22, 381-409.

Binswanger, Hans P., and Rosenzweig, Mark R. (eds.) (1984): *Contractual Arrangements, Employment, and Wages in Rural Labor Markets in Asia.* New Haven, Conn.: Yale University Press.

Bliss, Christopher J., and Stern N. H. (1982): *Palanpur: the Economy of an Indian Village*. Oxford: Clarendon Press.

Blume, Larry (1995): "The Statistical Mechanics of Best-Response Strategy Revision," *Games and Economic Behavior* 11: 111-45.

Braverman, Avishay, and Stiglitz, Joseph E. (1982): "Sharecropping and the Interlinking of Agrarian Markets," *American Economic Review*, 72(4), 695-715.

Brock, William A. and Steven N. Durlauf (1995): "Discrete Choice with Social Interactions I: Theory," NBER Working Paper 5291, Cambridge, Massachusetts.

Burke, Mary A., and H. Peyton Young (2000): "Terms of Agricultural Contracts: Theory and Evidence." Working Paper, Johns Hopkins University.

Cheung, Steven N. S. (1969): *The Theory of Share Tenancy*. Chicago: University of Chicago Press.

Durlauf, Steven N. (1997): "Statistical Mechanical Approaches to Socioeconomic Behavior." In *The Economy as a Complex Evolving System*. vol. 2, edited by W. Brian Arthur, Steven N. Durlauf, and David Lane. Redwood City, Calif.: Addison-Wesley.

Fehrenbacher, J. B., R. A. Pope, I. J. Jansen, J. D. Alexander, and B. W. Ray (1978): *Soil Productivity in Illinois*. Circular 1156, College of Agriculture, Cooperative Extension Service, University of Illinois at Urbana-Champaign.

Freidlin, Mark, and Alexander Wentzell (1984): *Random Perturbations of Dynamical Systems*. Berlin: Springer-Verlag.

Guth, Werner, R. Schmittberger, and R. Schwartz (1982): "An Experimental Analysis of Ultimatum Bargaining," *Journal of Economic Behavior and Organization*, 3, 367-388.

Hayami, Yujiro, and Otsuka, Keijiro (1993): *The Economics of Contract Choice, An Agrarian Perspective.* Oxford: Clarendon Press.

Illinois Cooperative Extension Service (1995): *1995 Cooperative Extension Service Farm Leasing Survey*. Department of Agricultural and Consumer Economics, Cooperative Extension Service, University of Illinois at Urbana-Champaign.

Johnson, D. Gale (1950): "Resource Allocation under Share Contracts," *Journal of Political Economy*, 58(2), 111-23.

Kandori, Michihiro, George Mailath, and Rafael Rob (1993): "Learning, Mutation, and Long-Run Equilibria in Games," *Econometrica* 61: 29-56.

Liggett, Thomas M. (1985): *Interacting Particle Systems.* New York: Springer Verlag.

Marshall, Alfred (1920): *Principles of Economics, 8th Edition*. London: Macmillan.

Mausel, P.W.; Runge, E.C.A., and Carmer, S.G. (1975): *Soil Productivity Indexes for Illinois Counties and Soil Associations.* Bulletin 752, College of Agriculture, Agricultural Experiment Station, University of Illinois at Urbana-Champaign.

McFadden, Daniel (1974): "Conditional Logit Analysis of Qualitative Choice Behavior," in *Frontiers in Econometrics*, ed. by Paul Zarembka. New York: Academic Press.

McKelvery, Richard D. and Thomas R. Palfrey (1995): "Quantal Response Equilibria for Normal Form Games," *Games and Economic Behavior* 10, 6-38.

Mill, John Stuart (1848): *Principles of Political Economy*. London: Longmans Green (1929).

Murrell, Peter (1983): "The Economics of Sharing: A Transaction Cost Analysis of Contractual Choice in Farming," *Bell Journal of Economics*, 14(1), 183-93.

Odell, R.T., and Oschwald, W. R. (1970): *Productivity of Illinois Soils*. Circular 1016, College of Agriculture, Cooperative Extension Service, University of Illinois at Urbana-Champaign.

Reid, Joseph D., Jr. (1975): "Sharecropping in History and Theory," *Agricultural History*, 49(2), 426-40.

-------------------- (1979): "Sharecropping and Agricultural Uncertainty," *Economic Development and Cultural Change*, 549-76.

Robertson, A. F., (1987): *The Dynamics of Productive Relationships: African Share Contracts in Comparative Perspective.* Cambridge: Cambridge University Press.

Roth, Alvin E. (1985): "Toward a Focal Point Theory of Bargaining," in *Game-Theoretic Models of Bargaining*, ed. by Alvin E. Roth. New York: Cambridge University Press.

Roth, Alvin E., Vesna Prasnikar, Masahiro Okuno-Fujiwara, and Shmuel Zamir (1991): "Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study," *American Economic Review*, 81, 1068-1095.

Roth, Alvin E., and Ido Erev (1995): "Learning in Extensive-Form Games: Experimental Data and Simple Dynamic Models in the Intermediate Term," *Games and Economic Behavior* 8, 164-212.

Roumasset, James, and James, W. (1979): "Explaining Variations in Share Contracts: Land Quality, Population Pressure and Technological Change," *Australian Journal of Agricultural Economics*, 23(2), 116-127.

Rudra, Ashok (1975): "Sharecropping Arrangements in West Bengal," *Economic and Political Weekly*, 10, A58-A63.

Schelling, Thomas C. (1960): *The Strategy of Conflict*. Cambridge, Mass.: Harvard University Press.

Stiglitz, Joseph E. (1974): "Incentives and Risk-sharing in Sharecropping," *Review of Economic Studies*, 41, 219-55.

------------ (1989): "Rational Peasants, Efficient Institutions, and a Theory of Rural Organization: Methodological Remarks for Development Economics," in *The Economic Theory of Agrarian Institutions*, ed. by Pranab Bardhan. Oxford: Clarendon Press.

Suppes, Patrick, and Richard Atkinson (1960): *Markov Learning Models for Multi-person Interactions*. Stanford: Stanford University Press.

Young, Arthur (1792): *Travels During the Years 1787, 1788, and 1789*. Bury St. Edmonds: J. Rackham.

Young, H. Peyton (1993a): "The Evolution of Conventions," *Econometrica*, 61(1), 57-84.

----------------- (1993b): "An Evolutionary Model of Bargaining," *Journal of Economic Theory*, 59(1), 145-168.

----------------- (1998a): *Individual Strategy and Social Structure: An Evolutionary Theory of Institutions*. Princeton: Princeton University Press.

----------------- (1998b): "Conventional Contracts," *Review of Economic Studies*, 65, 773-792.