Common Property Rights as an Endogenous Response to Risk

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In recent years, considerable progress has been made in improving our understanding of rural institutions, including property rights (e.g., Binswanger and Rosenzweig). On close inspection property rights often turn out to be multidimensional and complex (Bailey, Migot-Adholla et al.). Despite the widely acknowledged advantages of private property rights regimes, numerous authors have demonstrated the resiliency and surprising pervasiveness of common property rights (Bromley and Chavas, Ciracy-Wantrup and Bishop, Ostrom).

Although variations in weather in general, and rainfall in particular, have often been recognized as important sources of production risk and thereby as important determinants of property rights, almost all the attention has been directed to intertemporal variability. Virtually neglected have been the local (spatial) variability of rainfall and hence such important issues as (*a*) the extent to which the production risks of rural production covary from one local community to another, (*b*) the behavioral and institutional adaptations to such environmental conditions, and (*c*) implications for public policy.

Several factors would seem to have contributed to the neglect of such issues: (*a*) In the more heavily studied temperate and relatively humid zones of the world, the local variability of rainfall is relatively small (Huff and Shipp; Hutchison; Jackson; Johnson and Dart; McConkey, Nicholaichuk, and Cutforth); (*b*) there is a dearth of data from a multiplicity of weather stations in arid regions; (*c*) intertemporal variations of rainfall have been of greater interest than interregional ones; and (*d*) because drought-induced agricultural production shortfalls are generally associated with price increases, price risk tends to offset production risk, thereby lowering the overall importance of weather-related risk for farm incomes.

However, there is strong evidence from various arid and semiarid regions (ASARs) of the world that the local variability of rainfall is considerably greater than in the more temperate and humid areas (Thompson and Wilson; Sharon, 1972, 1974, 1979, 1981; Giovinetto, 1972, 1974; Jackson). Such studies also show (*a*) that studies based on annual rainfall greatly understate the magnitude and impact of such variability over the relevant productive season of the year, (*b*) that intertemporal and local variability tend to be rather highly correlated, and (*c*) that in the more arid of ASARs rainfall may be insufficient for agriculture, implying that only animal husbandry might be viable. In such situations, price changes are unlikely to offset production changes. Indeed, in drought conditions, animal herders are often forced to sell off their animals at low and falling prices (distress sales), implying that production and price risk are likely to compound (rather than offset) each other. Therefore, income risk is bound to be considerably more important in the drier ASARs. Moreover, with neither insurance nor credit markets accessible to ASAR residents (for reasons identified by Binswanger and Rosenzweig), the sharp terms of trade deterioration associated with drought often give rise to severe exchange entitlement failure and famine, explaining why herders are especially prominent among those suffering from famine (Sen).

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The aforementioned greater relative importance of local variability of rainfall in ASARs than in non-ASARs can be attributed to their following natural characteristics: (*a*) the more unstable, less predictable, and shorter duration of their rainstorms; (*b*) the smaller diameter of their rain-producing clouds; (*c*) the more rapid evaporation of the pools formed after such rains; and (*d*) the stronger convection in both air currents and rainstorms formed by any interspersed mountains.

The focus of this paper is on the implications for property rights and other institutions of local variability in rainfall to the exclusion of other sources of environmental variability. This is dictated by two considerations: (*a*) that rural incomes in ASARs are far more dependent on rainfall than on other sources of environmental variability and (*b*) that rainfall statistics are far more available than those on insect, plant, and animal disease infestations and flooding.

Theory and Behavioral Hypotheses

The economic theory of property rights has evolved only slowly from its original emphasis on the rising value of assets as the primary reason for the emergence of property rights. The rising asset values can be brought about by higher population density, increased productivity, or an increase in the price of the good produced with the asset (Demsetz). The more valuable the property, the greater the threat of rent dissipation and hence the greater the benefits relative to costs of establishing property rights, be they private or common.

There have been at least three extensions of this theory over the last two decades (Eggertsson): (*a*) recognition of the role of monitoring and exclusion costs in determining the particular form (private or common) that such property rights would assume, (*b*) recognition of the multidimensionality and incompleteness of property rights (Bailey, Migot-Adholla et al.), and (*c*) empirical examination of the effects of variations in the structure of property rights. In the absence of either transaction costs or externalities, the creation of private property rights necessarily implies the creation of net benefits over costs. Yet, empirical assessments have not always confirmed the alleged advantages (rent maximization, credit-inducing collateral, and greater investment) of well-defined private property rights over less completely defined rights held in common (Migot-Adholla et al.).

Our aim is to further develop a newly emerging extension of property rights theory, namely, one that takes into account the relevance of income risk derived from (exogenous) variations in environmental circumstances, especially rainfall (Behnke; Bromley and Chavas; McCloskey 1976, 1989; Nugent and Sanchez 1989, 1993; Sanchez and Nugent; Townsend; Wilson and Thompson). This approach starts from the proposition that the optimal property rights regime should depend not only on transaction costs and the expected value productivity of land but also on the variance in such productivity over space and time.

Assume that each risk-averse household in a given region (R_i) attempts to achieve a utility-maximizing trade-off between expected income and the risk associated with the variance in that income. A parameter, A, characterizes the degree of risk aversion of the household. Assume also that R_i consists of different fields, each owned by a different household with hereditary rights to an amount of land measured in hectares, H. Initially, everyone is satisfied with his particular field because, under normal weather conditions, each such field is sufficient to raise a crop large enough to keep the entire family well nourished. On the rare occasions when the rainfall is insufficient, households in region R_i can borrow from relatives in other regions (e.g., in R_j) whose fields are not adversely affected by the weather. Such borrowing is feasible because of the infrequent need to do so and the trust and mutual responsibility relations that exist among relatives and friends living in close proximity.

Assume now that a long-term climatic change begins to affect regions R_i, R_j, and others in the area, bringing about both a decrease in rainfall (hence also in the expected, or mean, productivity of each individual's owned field, μ) and an increase in the variance of rainfall (σ^2). These two changes render both the mean yield and the traditional insurance mechanism insufficient for providing each household with an adequate income. Three behavioral adaptations are likely: (*a*) The owners of plots would switch their economic activity from agriculture to animal husbandry, forcing some families to migrate to other regions but allowing the remaining families to find enough grass suitable for animal fodder even in years of relatively poor weather. (*b*) Because of emigration and greater distances between households, households are less likely to give credit to one another, quite conceivably raising the value of A. (c) The remaining households would subdivide their fields into subplots and exchange them for plots in other parts of R_i. This occurs because, with several fields, each having the same variance (σ^2), the average variance per unit of land owned by each household can be expressed as

$$(1) \quad \sigma_R^2 = [\sigma^2/m][1 + (m - 1)r],$$

where r is the mean of all pairs of correlation in the variations in rainfall (and hence productivity) in the m different fields owned by the household. Hence, whereas the remaining households are able to acquire some additional land from emigrating households, the total land available to each household is split among different plots. Note that when $r = 1$, $\sigma_R^2 = \sigma^2$, indicating there would be no risk reduction advantage in land pooling. Yet, when $r < 1$, σ_R^2 declines as the land is broken up into a larger number of plots (m), thereby explaining this form of adaptive behavior.

This argument is similar to that used by McCloskey (1976, 1989) to explain the scattering of fields of medieval English families, except that we allow for more extreme changes in weather and hence more significant adaptations, including emigration and substantial changes in the nature of productive activities. An agent's desire for risk reduction is indicated by both the size of his risk-aversion parameter (A) and the risk he faces. However, the risk-reducing advantage of plot scattering comes at a cost in terms of expected productivity, for example, as a result of the time and animal weight loss required to move the animals from one scattered plot to another (η). Hence, there is necessarily a transformation function between expected productivity (μ) and its variance (σ^2).

In the absence of productivity losses associated with plot scattering, every household would hold very small plots scattered throughout region R_i to take advantage of the risk-reduction effects of plot scattering by choosing an extremely large value of m. The gains from diversification would rise as r falls. The greater the subdivision and scattering of plots, however, the more animals owned by a particular owner would trespass on the plots owned by others. In the absence of low-cost means of preventing and adjudicating such trespassing problems, once some limiting value is reached, the property rights regime would necessarily change to one of common property, wherein any animal owner with land ownership rights in the region would have the right to have his animals feed anywhere in the region. This result follows from the mathematical theory of complexity (Day).

More realistically, with productivity losses in moving the animals from one plot to another, the risk-reduction benefits of plot scattering have to be balanced against the productivity losses thereof (η). For this reason, for any given level of rainfall, the limiting value of plot scattering at which the property rights regime switches to one of common property would occur later than in the absence of such costs. Initially, as mean rainfall and productivity (μ) fall, and A and the variance of both rainfall and productivity all increase, the risk-reduction benefits of plot subdivision and scattering might outweigh the transport cost disadvantages (η). As this process continues, however, trespassing and the costs of resolving trespassing disputes inevitably increase, raising the prospects for a switch in the property rights regime. Hence, even in this more realistic situation, the subdivision and scattering process induced by declining rainfall and increasing local variability should trigger a regime shift from private property to common property rights to avoid these costs without sacrificing the benefits of plot diversification. Nugent and Sanchez (1996) derive these conclusions from a more formal model. Both the basic productivity benefit of individual private property rights and all the important extensions of the basic theory, such as the transport costs and the environmental risk elements, have a role in this formulation. As the optimal number of different fields owned (m^*) increases and plot size falls, trespassing and hence the costs of resolving the resulting disputes would rise sharply. Once these costs rise to some threshold level, the property rights regime shifts from private to common property rights (*CPR*).

This model may also yield implications for other types of institutions. For example, high local variability of rainfall might reduce the need for public goods and hence the degree of organizational hierarchy. Given the scarcity of the population and the high degree of mobility required for survival and success in animal husbandry and other activities in such circumstances, the higher would be the marginal costs of dispute resolution and hence the lower the degree of hierarchy (C). Yet, with less need for hierarchy, the higher would be the likelihood of a *CPR* for any given value of m^*: Hence,

$$\text{(2)} \quad \text{prob}(CPR) = B\ m^{*\epsilon}\ C^{\phi},$$

where prob(*CPR*) is the probability of a *CPR*, B is a positive constant, and $\epsilon > 1$, $\phi < 0$. Assuming that ϵ is sufficiently high but unlikely to vary because of environmental conditions, this formulation yields a number of testable hypotheses, including the following:

H1: The higher the productivity or scarcity value of the land (γ), the lower will be m^*, and the lower will be the probability that a *CPR* regime will prevail.

H2: The higher the efficiency or transportation cost loss due to diversification (η), the lower will be m^*, and for similar reasons, the lower is the likelihood that a *CPR* will prevail.

H3: The higher the value of variance in yields (σ^2) or the coefficient of risk aversion (A) and the lower the value of r, the larger will be m^*, and the more likely a *CPR* will prevail.

H4: From equation (2), the higher the degree of hierarchy (C), the lower is the likelihood of a *CPR* for any given value of m^*.

As noted above, C could be affected by some of these same environmental conditions, such as land productivity, the variance in that productivity, and population density, but also by various other external conditions, such as proximity to a powerful, competing group, which causes a society to demand more resources for defense and security (Barth, Gellner, Irons, Khazanov, Salzman, Schneider).

Empirical Applications to Sudan's Tribes and the American West

In this section we describe two applications of this theory carried out in previous studies, one on Sudan (Nugent and Sanchez 1996) and another on the American West (Sanchez and Nugent).

Among the special advantages of Sudan for such an analysis are (*a*) that most of its land is divided into a number of different tribal areas that, from the late nineteenth century until rather recently, had remained intact and largely unaffected by modernization; (*b*) that each different tribal area has its own property rights regime, other institutions, land use, rainfall, and other environmental characteristics; and (*c*) that many such areas also have both their own meteorological stations with relatively long time series of monthly rainfall data (Hulme) and ethnographic studies suitable for identifying their institutional characteristics. The relative stability of institutional conditions in Sudanese tribes is important because it allows us to make use of relevant information from existing ethnographies of 41 of the most important tribes undertaken at somewhat different points in time.

As a measure of the extent to which the property rights are characterized by common property regime (*CPR* in equation [2]), we used an indicator called openness (*OP*). A score of 100 on this measure implies that all individual households within the tribe have the right to use land virtually everywhere within the tribal area (in Sudanese terminology, the *dar*). A zero score represents pure private rights. The degree of centralization (C) is scored in a similar way (from 0 to 100); *OP* would be expected to be negatively affected by C because the greater the value of C and hence the autonomous power of a tribal leader, the more likely that openness will be restricted. Other assumed determinants of *OP* are an indicator of the relative importance of agriculture in the culture (*PAG*); population density (*DENPOP*), traditionally an important determinant of both the scarcity value of land and the emergence of private property rights; the mean monthly rainfall (in tens of millimeters) for weather stations in or near that tribal *dar* (*RM*); the coefficient of variation in annual rainfall over time (*RCV*); and, most important, a distance-standardized index (*RD*) of the average coefficient of correlation in the monthly rainfall observations between adjacent or nearby pairs of rainfall stations. The signs of the coefficients of all variables except *RCV* would be expected to be negative.

Because many of the same environmental considerations could be presumed to determine both C and *OP*, which in turn might be interdependent, a two-stage least squares procedure was used in estimating the equations for both. Confining our attention to the *OP* equation, the results can be summarized as follows:

$$\text{(3)} \quad \begin{aligned} OP = {} & \underset{(6.65)}{119.59} - \underset{(1.44)}{0.429C} - \underset{(4.70)}{0.656PAG} \\ & - \underset{(2.27)}{0.034RM} - \underset{(1.07)}{0.207RCV} \\ & - \underset{(2.15)}{40.202RD} - \underset{(1.39)}{0.281DENPOP} \end{aligned}$$

where the numbers in parentheses represent values of t for the coefficients immediately above them. In general, the results given in equation (3) are rather supportive of the hypotheses developed above. In particular, the effects of *PAG, RM,* and *RD* are all negative and significant at the 5% level, and the others negative but not significant. The fact that *DENPOP* and *RCV* are not significant but that *RD* is negative and significant shows that the local variability of rainfall explanation might be relatively more important than these more traditional determinants of property rights.

Next, we turn even more briefly to the case of the drier parts of the American West, a region characterized by very considerable local variability of rainfall. During the nineteenth century, especially between 1860 and about 1890, despite the absence of formal property rights, cattle were raised by groups of de facto owners operating in common. This was due in large measure to low population density, the prohibitive cost of fencing, the absence of law and order, and the Texas longhorn (a breed of cattle with low meat yield but a remarkable ability to survive under harsh environmental conditions even with only minimal supervision). The pooling system was also fostered by important economies of scale in animal supervision, marketing (driving the animals on the hoof), and security (against intrusion of the range by outsiders, cattle theft, animal predators, disease, and so on). Like the tribes of the low rainfall, high local variability of rainfall portions of Sudan, each member of these cattle pools of the American West shared access to the land with other members but excluded nonmembers and, through collective institutions, kept cattle theft, disease, and other problems to tolerable limits. When private property rights were artificially imposed or subsidized, as they sometimes were, it frequently had the effect of rendering exploitation of the land uneconomic and greatly increasing animal mortality. The open range-cattle pooling system seemed to be an institutional arrangement that evolved rather naturally and allowed use of the land to be much more profitable than it otherwise would have been.

Conclusions

The purpose of this article is to suggest that like other environmental characteristics the heretofore overlooked local variability of rainfall and other environmental factors can contribute to our understanding of institutional choices, such as the degree of openness of access with respect to land within a Sudanese tribal *dar* or cattle pool of the nineteenth century American West. In the theoretical section we outlined a model where individuals trade off the risk-pooling advantages of open access against the efficiency losses of incomplete property rights and decreased investment in land. In the application section we reported the use of data on different tribal *dars* of the Sudan to demonstrate the applicability of the model. Although objective, quantitative data on the relevant features of the different tribes and their tribal *dars* do not yet exist, when crude indexes are used at least several of the relevant variables can be constructed from existing ethnographic and historical studies. The results show that, even after controlling for other factors, the local variability of rainfall contributes significantly to the explanation of observed variations in institutional characteristics across a sample of Sudanese tribes. Moreover, in most specifications, the local variability of rainfall turns out to be a more important determinant of both openness of access to the tribal *dar* and tribal hierarchy than the traditional explanations. In this regard at least, the results are rather robust to alternative specifications of the model. Similar environmental conditions seemed to have contributed to the explanation and detailed characteristics of cattle pools in the dry and locally variable climatic conditions of the American West.

Taken together, the results are supportive of the heretofore neglected advantage in animal husbandry of relatively wide access to grazing land among members of a tribe, cattle pool, or club in situations characterized by high local variability of rainfall and other environmental conditions. This new evidence seems considerably stronger in support of the local variability hypothesis than the earlier evidence from medieval England provided by McCloskey. Because such variability is relatively high for many if not most arid and semiarid regions, this may explain why attempts to break up the commons and settle the nomads in other ASARs so frequently end in tragic failure. Finally, given the evidence in support of the endogeneity (adaptability) of the strength and character of property rights to exogenous variations in environmental conditions, this research casts doubt on the validity of conclusions concerning the effects of property rights on productive efficiency derived from models in which the character of property rights is assumed to be exogenous.

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