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TITANIUM HOES? FARMERS, WEALTH AND HIGHER YIELDS IN WESTERN SUDAN[1]

By
Michael Kevane

Abstract:

Village-level data from western Sudan cast doubt on the universal applicability of an inverse relationship between farm wealth and production per hectare, and the attendant explanation of imperfect labor markets. Wealthy farmers have higher levels of output per hectare; they use more labor per hectare. Insecurity in renting land, financing constraints and the absence of insurance are the vital elements in explanations of the observed pattern of variation in yields. Examination of the performance of land rental, credit and insurance markets in western Sudan suggest that insurance and financing constraints are the crucial market failures.

> "The natives are not acquainted with the plough, the harrow, or, in fact, with any other civilized engine of husbandry; a single piece of iron, pointed at either extremity, and furnished in the centre with a staff, answers the purpose of all necessary implements. This instrument is called a *hashash* [sic], and is to be found in every hut; thus all the agricultural utensils of a Kordofanese peasant cost... little more than three half-pence."
>
> Ignatius Pallme [1844]

1. Introduction:

Wealthy farmers in the Sheikan district of Kordofan province in western Sudan produce more per hectare than do poorer farmers. Explaining this fact is not easy. Since basically the only tool used in smallholder rainfed agriculture remains the *hashasha*, why should wealthy farmers have higher yields per hectare? Their hoes are not made of titanium.

Of course, farmers who know how to hoe, as it were, will be wealthier than other farmers. So no one should be surprised that they obtain higher yields. Unless there were more to the story than this. For example, if the actions of wealthy farmers were easily replicated and observed by other, less skilled

farmers, then we could hardly attribute wealth to the way a hoe is handled. In addition, if wealthy farmers relied on hired labor to perform much of the work on their farms, then we could not argue that the skills of the poor laborers enriched the employer but were wasted on the fields of the laborers themselves. So some mysterious talent or crop management skill- an X-factor- would have to explain the production differential.

How important is such an X-factor in Sheikan? The nature of agriculture makes it unlikely that wealthy farmers have higher yields mostly because they are 'better' farmers. Rainfed agriculture in Sheikan has not changed greatly since Ignatius Pallme travelled through the area one hundred and fifty years ago. The *hashasha* remains to this day the predominant agricultural tool, and is representative of a broader stasis in local agriculture.[2] Agriculture is still mostly extensive. There is no ridging, no application of fertilizer or manure, no hybrid seed.[3] The use of tractors is limited and animal traction is non-existent. The influence of formal institutions such as extension services and agricultural research programs is limited because of extreme variation in rainfall, poor soils and pests, and budget constraints and priorities. Very few adult farmers have any formal schooling.

Farmers do disagree over what constitutes 'best practice', and acknowledge that 'best practice' varies depending on differing interpretations and reactions to seasonal conditions. Hill, one of the foremost students of savanna agriculture, observed some time ago that [1972:173]:

> In a hostile natural environment like northern Hausaland, the soil does not complacently yield its fruit to those who meekly follow traditional techniques, but poses an ever-changing series of challenging problems, which it is the business of the efficient man to solve by innovation, foresight, experimentation and so forth. Systems of permanent cultivation of manured farmland may be old, but they are not 'traditional agriculture'... Virtually every farmer has his own opinion on the merits of different crop mixtures... Many men obtain low yields because they are poor, others because they are bad farmers.

This paper accepts that men and women differ in their abilities and motivations, and in the extent of their farming knowledge. It maintains, however, that systematic variation in practices is probably not due to variation in this unobserved heterogeneity, because ability, knowledge and motivation

are probably not correlated with wealth, gender, ethnicity, or other socio-economic variables. Because agriculture is stagnant, and since skills and abilities have more room to manifest themselves in changing and dynamic agricultural systems, then skills and abilities probably do not play a large role in explaining variation in farming practice in Sheikan. The syllogism is imperfect, but reasonable. There is no intrinsic obstacle preventing a 'bad' farmer from simply replicating the practices of a 'good' farmer. Indeed the sizable differences in yields would be a tremendous incentive to do just that.

Since farmers use the same technology, and since unobservable heterogeneity is most likely randomly distributed across economic classes, we can only conclude that systematic differences in yields are due to different choices regarding input ratios. Such choices are influenced by differences in the implicit cost of inputs like land, labor, and credit. These differences in the costs of inputs arise because of market imperfections. Poorer farmers confront different implicit prices for labor and land than do wealthier farmers.

Here lies the central problem of this paper. Models of market imperfections that explain variation in yields all explain *inverse* relationships between wealth or land and yields per hectare [Carter and Wiebe, 1990; Eswaran and Kotwal, 1986; Feder, 1985; Moene, 1992; Sen, 1966; Srinivasan, 1972; Swamy, 1991]. We have a *positive* relationship.

This paper develops two persuasive models that explain a positive relation between yields and assets. First, if there were insecurity in renting land, in the sense of a renter being likely to claim the land he or she is renting, and some form of financial market imperfection, either a credit constraint or imperfect insurance, then poor farmers would farm with lower labor-land ratios. The credit constraint or their risk aversion would make them want to rent out extra land, but they would worry that renters might claim the land for themselves. Second, more serious breakdown in financial markets, with the absence of *both* finance and insurance, would, under certain conditions, induce wealthier farmers to use more labor on their farms. The reasoning is subtle. Poor farmers are worried about income risk, not just crop risk, and so tend to prefer to work for others for a secure wage, and to rent out their land for a secure rental income. Many poor farmers, in fact, have to spend too much time working for others because they cannot obtain credit. As one of these farmers becomes slightly better off, he does not have to work as much for

others, and can devote more labor to his farm. He does not devote more land, however, to his farm because doing so increases risk by more than the benefit of more production. To put it another way, as a farmer becomes poorer he becomes more concerned about risk. But since he has to work a lot for others, earning wages, he is not as concerned about reducing risk by renting his land. So he cultivates relatively a lot of land, and has lower yields.

Distinguishing among these two potential explanations requires an examination of the actual performance of markets. A growing literature on rural factor market performance has developed new methods appropriate to this task, and new conventional wisdom. While we do not have the data to fully implement these methods, the available evidence suggests favoring the second explanation of the positive relationship. Land rental markets function well, and so it would not be reasonable to assume that rental insecurity is necessarily responsible for the positive relationship. On the other hand, financial markets perform poorly. Insurance against most risk is basically absent, and production credit is virtually non-existent.

The outline of the paper is as follows. The next section reviews the basis for asserting that there are differences in the practices and output per hectare of different economic groups. Section Three develops the relevant explanations of variation in agricultural yields. Section Four then examines evidence on the performance of factor markets with a view to distinguishing which of the models is more relevant in understanding agricultural practice in Sheikan. Section Five concludes with some of the implications of the data and arguments.

2. Agricultural technology and variation in practices and yields:

The data presented here come from two samples of farmers in the Sheikan Council area of Kordofan: (1) a sample of 116 household heads in six villages in the area around the market center of Jaibat; and (2) fieldwork observations on 58 household heads from the village of Bireka. The data was collected in fall of 1990. The unit of analysis corresponds to nuclear families. In this part of western Sudan there are no lineage groups that carry out joint cultivation, or corporately undertake any other significant economic or social activities.

The household heads are stratified into three categories- poor, middle and wealthy- using the criteria proposed by Hill [1982:68]. Poor household heads are often laborers unable to withstand a bad harvest without destitution, migration and hunger. Middle farmers are those who would be affected by drought, but would be able to recover their losses. Wealthy farmers are able to withstand drought with minimal loss and suffering.

There are other dimensions along which households could be stratified, most notably on gender and ethnic lines. This paper will concentrate on differences in economic status, since poverty and wealth are common to both male and female headed households, and among Bederiya, Hausa, Burgo, Tomam, and Borno households, to name a few of the more prominent ethnic groups in the study villages. The basis of wealth is ownership of assets such as livestock, trading capital, and lorries, and wealth is reflected in occupational categories such as participation in the agricultural labor market. As discussed below, most land cannot be sold, and therefore does not directly constitute wealth. Nevertheless, there is a strong correlation between non-land assets and land ownership. Table 1 shows the distribution of assets, summary family demographics, and labor market participation for the Jaibat and Bireka samples.[4] .Poor households typically have no assets and have small debts from consumption loans and emergency borrowing from neighbors and kin. They own less land and they work as laborers for other farmers.

Table 1: Assets, Demographics, Land Holdings & Labor Market Participation by Economic Groups (Household only)

Household Type	Young Children Assets[a]	Old Children (Age <15)	Land (Age > 15)	Area Using Owned[b]	Hired labor[c]
JAIBAT					
Wealthy (n=31)	15.060	4.13	.81	10.35	8.37
Middle (n=28)	1,872	3.18	.93	8.00	4.08
Poor (n=57)	-194	3.18	.53	5.42	-2.11
BIREKA					
Wealthy (n=10)	na	3.30	2.40	12.08	7.05
Middle (n=19)	na	1.47	.63	5.97	.88
Poor (n=25)	na	2.16	.68	4.40	.12

[a] Mean of sum of value of livestock holdings using typical prices prevailing at the beginning of the rainy season for 'standard' animals, and value of trading capital, and value of net cash and kind borrowing during the rainy season, all measured in Sudanese pounds (official rate in 1990 was LS 12 = $1).
[b] Mean area in *mukhammas* owned.
[c] For Jaibat, area weeded in *mukhammas* during the period of first weeding by hired labor minus area weeded by household head for others (i.e. net area weeded by hired labor). For Bireka, only the area hired in is reported, not the area hired out.

2.1 Variation in Yields:

Table 2 shows the average value of production per *mukhammas* (about one hectare). The values are calculated at the post-harvest prices. The value of production per *mukhammas* on the fields of wealthy households is almost twice as high as that on the fields of poorer households. There were no significant differences in the percentage of each farmer's land allocated to different crops (about sixty percent was devoted to grain, ten percent to groundnuts, and twenty percent to sesame).

Table 2: Average Value Produced Per Hectare (in LS) by Economic Group (for Household Heads Only)

Household Type	Value in LS	Standard Deviation
BIREKA[a]		
Wealthy (n=9)	589	(230)
Middle (n=19)	517	(320)
Poor (n=21)	321	(240)
JAIBAT[b]		
Wealthy (n=28)	543	(320)
Middle (n=25)	438	(231)
Poor (n=48)	307	(161)

[a] F-ratio= 4.1, Sig.= .023, for difference in means.
[b] F-ratio= 9.5, Sig.= .000, for difference in means.

Just to make sure that the difference is not the result of a crop composition effect, however, with poorer farmers cultivating different, lower-value (but perhaps safer) crops, Table 3 (next page) shows the average values for the main five crops, for households in different economic groups.[5] Except for *najjad*, a sorghum variety, wealthier farmers had higher yields in each crop.

2.2 Variation in Land to Labor Ratios:

All else being equal, if different economic groups have different yields, it must be because their agricultural practices differ. The ratio of land to labor is a common statistic summarizing often complex differences in agricultural practice. A rough measure of the ratio may be constructed using the data from Sheikan. Household labor endowment (OWNLAB) is measured as the number of adults and children, where older children (ages 10-15) are counted as one-third of an adult. The household land endowment (OWNLAN) is the number of *mukhammas* of land owned. The actual area cultivated is measured by (TOTAREA), which adds land rented in and subtracts land rented out from the (OWNLAN) variable. Labor used in the household's own fields is measured as (TOTLAB). This measure subtracts and adds transactions in the labor market from the family labor endowment.[6] Labor market transactions were measured in the survey questions in terms of area weeded for the employer or by the laborer. To transform these areas into a measure consistent with the person-based measure (OWNLAB), the number of *mukhammas* of hired labor is divided by five, which is the average number of *mukhammas* weeded by laborers.[7]

Table 3: Average Value Produced Per Hectare (in LS) by Economic Group (for Household Heads Only), According to Crop

Value in LS

Household Type	Millet	Sorghum		Groundnuts	Sesame
		Zunaari	*Najjad*		
JAIBAT					
Wealthy	598	823	546	831	315
Middle	422	421	653	764	275
Poor	332	351	488	493	225
BIREKA					
Wealthy	567		647	902	193
Middle	551		521	1117	136
Poor	161		380	1006	151

The data from 1989 production in Bireka was not broken down by plot; rather the area of each field- which is typically divided into smaller plots- was collected, along with the total yields from the various crops. Thus only cases where an entire field was devoted to a single crop are used in this calculation; this may bias the result. Only about 20 cases for each crop are used, and so the differences are not statistically significant.

Two measures of the land to labor ratio are constructed. First is the ratio of endowments of land and labor, that is (OWNLAN/OWNLAB). Second is the ratio of cultivated area and labor used, or (TOTAREA/TOTLAB). The measures are rough, but nevertheless suggestive. Even though not all of the between-group differences are significant because of the large variation, it is clear from Table 4 that the average ratio of land and labor endowments varied with household type.

Table 4: Ratios of Land to Labor Before and After Factor Market Transactions

BIREKA Household Type		OwnLand/ OwnLabor[a]	(StD)	Total Aear/ Total Labor[b]	(StD)
All	(n=55)	2.89	(3.22)	4.88	(6.31)
Wealthy	(n=10)	4.75	(4.44)	3.12	(1.55)
Middle	(n=19)	2.95	(3.24)	4.25	(3.36)
Poor	(n=25)	2.14	(2.40)	6.07	(8.69)

[a]F-ratio= 2.51, Sig.= .091, for difference in means.
[b]F-ratio= 0.92, Sig.= .403, for difference in means.

JAIBAT					
All	(n=115)	2.88	(2.39)	4.28	(4.77)
Wealthy	(n=31)	3.47	(2.54)	3.24	(1.59)
Middle	(n=28)	2.81	(2.15)	2.88	(1.54)
Poor	(n=56)	2.59	(2.40)	5.56	(6.43)

[c]F-ratio= 1.4, Sig.= .256, for difference in means.
[d]F-ratio= 4.2, Sig.= .018, for difference in means.

Wealthier households had more land relative to labor (despite having larger numbers of children of working age). After transactions in land and labor markets, however, poor households were cultivating large areas relative to the labor left over after working on other people's farms.[8]

In the Jaibat sample, twelve of the eighteen households with land-labor ratios greater than six were laborer households. The average age (37 years) of these household heads was also lower than those household heads with lower land-labor ratios (44 years), and this explains in part their high ratios; none of these households had grown children to work in agriculture.

The relation between the land to labor ratio and value per *mukhammas* is not as strong as we would like. The correlation coefficient is only -.20. While the top fifteen households, in terms of value per hectare, all had ratios of land to labor below the mean, the bottom fifteen were evenly divided between households above and below the mean. This discrepancy may be attributed to the very rough measurements being used.

2.3 Multivariate Analysis:

The 'inverse relationship' that is discussed in the literature is usually expressed as a relation between land owned and output. We have shown above that there is in Sheikan a positive relationship between assets and output. But perhaps we get significant results because assets are correlated with land owned. A multivariate analysis will enable us to see whether land, labor and wealth endowments have independent effects on output. These independent effects might be precisely what is needed to distinguish between different models that have the same predictions about the relation between output and assets, but different predictions about the relation between yields and land, or between yields and labor endowments.

In the literature, multivariate regressions are justified as attempts to test specific hypotheses about market imperfections. If markets were perfect then endowments of land, labor or wealth should not explain variation in yields or practices.[9] (Consider the large mechanized farms of Gedaref or Habila; if the lease-holder has a few more children, this does not mean he will apply more labor to his 1000 hectares.) Thus Carter and Wiebe [1990] use farm size as the independent variable (proxying for farm wealth) in a regression explaining variation in the marginal product of labor. The coefficient was significantly

different from zero, and they interpret this as evidence of labor market imperfections. Swamy [1991] uses the ratio of land to other inputs as the dependent variable (under constant returns to scale the ratio varies directly with the marginal products of the inputs) and variables measuring endowments of land, labor and assets as explanatory variables. He finds that the endowment variables are significant in simple OLS equations, but when he uses panel data to control for omitted variables he is unable to reject the perfect markets hypothesis.

The regressions presented here are more exploratory in nature; we do not yet know which hypothesis to test, so we are simply examining the data in order to generate appropriate hypotheses. Table 5 shows the results of regressions explaining yields and input ratios for the Jaibat sample of 115 households and the smaller Bireka sample. The explanatory variables included are: household assets (ASSETS1), the endowment of land owned (OWNLAN), the endowment of labor (OWNLAB), a measure of subsistence requirements (SMCHILD) that is the number of children under ten years of age, and two dummy variables, one for whether the household head is a woman (FEMALE), the other a village dummy for the village group (HAJSALIH) that was relatively isolated, and where land was more abundant than in the other, more crowded villages (the other village dummies had insignificant coefficients and were dropped).

Table 5: Regressions Explaining Yields and Land-Labor Ratios

	JAIBAT				*BIREKA*			
	Average value per *mukhammas*		Land/Labor Ratio		Average value per *mukhammas*		Land/Labor Ratio	
Variable	ß	t-stat	ß	t-stat	ß	t-stat	ß	t-stat
(Constant)	298.9*	4.92	6.67*	6.18	271.3*	3.06	8.80*	4.92
Ownlabor	18.5	1.00	-1.17*	-3.40	-2.2	-.09	-.58	1.05
Ownland	-2.0	-0.42	.09	1.07	9.5	1.35	-.82	-0.52
Female	15.1	0.20	-3.17*	-2.57	-20.9	-.17	-3.33	-1.19
Yg child	6.7	0.65	.40*	2.15	6.1	.33	-.20	-0.51
Assets	8.9*	2.74	-.11@	-1.87	-	-	-	-
Wealth	-	-	-	-	187.6*	2.23	-1.82	-1.00

n = 100	n = 114	n = 48	n = 53
R^2 = .14	R^2 = .14	R^2 = .18	R^2 = .12
F = 3.15*	F = 3.42*	F = 1.84	F = 1.25

* = Sig. at 5% level
@ = Sig. at 10% level

There are two dependent variables. First is the measure of the average value produced per *mukhammas* Second is the constructed measure of the land to labor ratio used in cultivation. Given the significant measurement error associated with these rough measures of practices and yields, it is encouraging to find that the variable measuring assets is always significant. This result is at odds with the 'perfect markets' hypothesis that land to labor ratios should be independent of endowments. The estimates from the second regression in particular show that the wealthier the household the lower the land-labor ratio (and the higher the value per hectare), the more land owned the higher the land-labor ratio, and the more labor available in the household the lower the land-labor ratio. The negative coefficient on (FEMALE) suggests that female headed households either have difficulty renting land from others, have difficulty obtaining employment, or face lower wages.

These results should be tempered by a number of considerations. The overall explanatory power of the regressions is low, and the regressions with value per *mukhammas* as the dependent variable do not yield significant coefficients for land and labor endowments. The regressions run on the Bireka data yielded coefficients with the expected signs, but only a dummy variable (WEALTH)- that subsumes the wealthy and middle categories- is significant, and only in the regression on yields.

Land quality is a potentially important source of variation in value and practices, but there were no consistent patterns of variation across groups for broad measures of land quality such as type of soil or proximity to seasonal watercourses, or even endogenous variables like fallow and rotation that partially determine fertility.[10] The relative abundance of land has muted possible associations of land quality with socio-economic categories. The correlation of land quality with other variables is usually explained as the result of a

Malthusian process whereby increases in population lead to the splitting up of land into smaller and smaller ownership units. No such process is evident in Sheikan. In any case, quality differentials (such as between clayey and sandy soils) are not always straightforward; more productive or fertile soils require more labor for weeding, and their net profitability may be lower than less productive soils.

Indexes of plot fragmentation and crop composition (the ratio of grain crops to non-grain crops like sesame and groundnuts) were also initially included, in the hopes that they might reflect how differential strategies for avoiding risk reduced average yield. These variables all turn out insignificant when included in the regressions, and were dropped.

We conclude this section by noting that more formal models that explain the pattern of variation observed in Sheikan should have the following prediction: an increased endowment of land should raise the land to labor ratio, increased labor endowment should lower the ratio, and increased wealth should lower the ratio. We will see in the next two sections whether any reasonably simple models are consistent with this pattern.

3. Market Imperfections and Variation in Yields:

Suppose farmers shared the same technology and goals. If they could transact for factors of production and insurance through perfect 'neoclassical' markets, then they would all carry out the same production plan. If they were observed to have different production plans, it must be because markets were non-competitive, segmented or rationed, or because of high transactions costs due to the imperfect enforceability of contracts. Imperfections in these markets would affect the optimal choice of a decision-maker (profit or expected-utility maximizing, as the case may be) who chooses the optimal allocation of land and labor, given endowments of land, labor and assets.

Table 6 presents the predictions of how changes in a farmer's land endowment, labor endowment and wealth endowment affect the choice of the land to labor ratio for six different scenarios of market imperfections. The models are consistent with those used in the literature; they assume constant returns to scale in production, and only two market imperfections. The results are straightforward to derive once the market imperfections are formulated mathematically: A labor-financing constraint, a labor supervision function,

a function representing the cost of rental insecurity (the possibility that renters might not return land rented to them), and the expected utility model to represent the absence of insurance. We will discuss the intuition of the results below; the formal results are available in Kevane [1996].

The first important thing to note is that endowments of land and labor affect the choice of land and labor to use in cultivation in the same way, regardless of the structure of market imperfections. Farmer wealth, whether measured as assets or liquidity or access to credit, is the variable to study when exploring how variation in practices might be due to market imperfections.[11] A larger endowment of land will always lead farmers to use relatively more land than labor, under any reasonable regime of market imperfections, and consequently have lower yields per hectare. When the empirical analyst only uses land and labor, the standard model of the inverse relationship as due to labor market imperfections will always be confirmed. Or, to the extent that assets and land are partially correlated, the hypothesis will be evaluated on the basis of biased coefficients (when assets are omitted). A measure of farm wealth must be included in empirical investigations of variation in yields.

Table 6: Direction of Change of Land to Labor Ratio for Changes in Exogenous Parameters, According to Model Assumptions

Model	Comparative Statics		
	Owned land	Owned labor	Owned assets
(a) Imperfect labor and no rental*	+	-	not relevant
(b) Imperfect labor and no credit§	+	-	+
(c) Imperfect labor and no insurance¶	+	-	+
(d) Imperfect rental and no credit¶	+	-	-
(e) Imperfect rental and no insurance⊕	+	-	-
(f) Absence of insurance and production credit¶.	+	-	-

[§]Eswaran and Kotwal [1986]
[Φ]Srinivasan [1972], Bliss and Stern [1982:70-75]
[¶] Available from author.

Models (a), (b) and (c), with imperfect labor markets, have the same pattern of predictions. In the case of imperfect land rental and imperfect labor markets, originally developed by Sen [1966] under the assumption of no land rental at all, labor is not hired to match a larger endowment of land. This is because labor becomes more expensive as more is hired in, while the benefits from renting out decrease as more land is rented out.[12] The more land is rented out, the more likely the landowner will lose rights over the land. Popular rhetoric in Sheikan has it that if someone farms a plot for a given number of years (the number varies from speaker to speaker, but the most common number is three years) without paying rent, then the local court in Jaibat will decide in favor of the renter when settling land ownership dispute. (Both sides may bring witnesses willing to attest to the ownership.) "If it belonged to you," the court would ask the aggrieved landowner, "why did you not collect rent?" Taking a troublemaking renter to court is costly, because the landowner must bring three witnesses to testify, and the trip to the court involves an entire day.[13] With that kind of rental insecurity, a greater endowment of family labor lowers the land to labor ratio.

In Eswaran and Kotwal's [1986] case, with imperfect labor and a financing constraint, the land-labor ratio increases for wealthier farmers. As the financing constraint is relaxed they use more of both inputs, but because the cost of labor rises (hired labor is harder to motivate than family labor, supposedly) they use relatively more land than labor. Farmers with larger land endowments will have higher land to labor ratios, because they will not hire labor to match the increased land. Increases in the endowment of family labor, however, mean the household can rent in extra land and hire even more labor, decreasing the land to labor ratio.

In the case of imperfect labor and uninsured risk, a wealthy farmer is less averse to risk, and so wants to increase the scale of cultivation. Hiring more labor, though, is costly because of the supervision problem. So the wealthier farmer uses relatively more land. In sum, if labor markets did not function

well, we would expect to see the land to labor ratio vary positively with assets; we would expect to see the inverse relationship.

The three remaining models explain negative relationships between assets and the land to labor ratio. Models (d) and (e) combine financing constraints or insurance constraints with rental insecurity. In model (d), increased land endowment leads to an increase in the land to labor ratio, while increased labor endowment or assets decrease the land to labor ratio. A wealthier household wants to and can use relatively more labor on its own fields. It rents in more land to use with this labor. We might reasonably assume that the benefits of renting in land decrease with the amount rented, because the probability of claiming land decreases as a household finds itself renting from closer social relations. So the household rents in relatively less land than the labor that has become available. Similarly, a poorer household has to limit its hiring of outside labor, or even have some of its own members work for wages. But it is reluctant to give up land rented in or land owned, because of the higher probabilities that this land will be claimed by others. Consequently it uses relatively too much land with the available labor.

When agriculture is risky and farmers cannot obtain insurance, and land rental transactions are insecure, then again wealthier farmers will have lower land to labor ratios.[14] Srinivasan [1972] was the first to examine how behavior toward risk might explain input ratios, and the inverse relationship. In his model, farmers were assumed to have fixed endowments of land- the land market was completely absent- and chose to allocate their labor between risky cultivation and wage laboring (which gives assured income). Srinivasan did not distinguish land endowments from assets endowments; if we do so it is possible, by making some technical but reasonable assumptions, to show that increases in land endowments lead to increases in the land to labor ratio, while increases in asset endowments decrease the ratio. Wealthier farmers have no need for 'safe' wage income; they are more willing to gamble on crop cultivation. Consequently the wealthy farmer is willing to devote more labor to cultivation. The farmer also will want to rent in more land; in the Srinivasan model there is no land rental, more plausibly we might assume that the net benefits of land rental decrease as more is rented. In either case the wealthier farmer ends up with a lower land-labor ratio.

The last model (f) dispenses with the imperfections of the land rental market and instead derives predictions of how choices vary with endowments under constraints of production credit and insurance restrictions. Again, with some technical assumptions it is possible to show that increases in land endowments lead to increases in the land-to-labor ratio, while increases in labor endowments decrease the ratio. More importantly, higher assets lower the optimal land to labor ratio. Wealthy farmers have less of a need to earn wage income, and so use more labor in cultivation. They will then want to also cultivate more land. Since the financing constraint meant that the farmer already was using relatively too little labor, relaxing it will lead to relatively more labor than land being added, and the farmer ends up with a lower land-labor ratio.

4. Market Performance in Sheikan District:

Three models are consistent with a positive relation between yields and assets. Each has different assumptions about factor markets. In this section we examine market performance in Sheikan. Over the last decade economists have improved the framework for evaluating market performance. Tests of whether supply side variables affect demand for factors have replaced the old structure, conduct, and performance approach. Bliss and Stern [1982], using their data from Palanpur, test for whether the coefficient of household land endowment, in a multivariate analysis with land used in cultivation as a dependent variable, is significantly different from zero. Alternatively, with land rented as the dependent variable, the coefficient on land owned should be equal to minus one. Benjamin [1992b], using data from Indonesia, tests for whether demographic variables are significant in a regression with labor demand as the dependant variable. Udry [1995], using data from Zaria in Nigeria, tests whether credit markets substitute for complete state-contingent claims markets.

The data from the surveys in Sheikan is too limited to conduct tests of all four markets. Fortunately we do not need to be very careful about the labor market- significant imperfections would have generated an inverse relationship. We need only confirm that the labor market indeed functions reasonably well. The crucial market is the land rental market, since two of the three models rely on rental insecurity. Sub-section 4.2 offers a preliminary analysis of the land rental market, looking at insecurity and at an econometric test. The rental market appears to function reasonably well, and so we can

reject those explanations. We are left then with a model with credit constraints and the absence of insurance; sub-section 4.3 suggests that indeed they are responsible for the positive relationship.

4.1 Labor Markets:

There is not much evidence to contradict the presumption that, because there is no inverse relationship, labor markets function reasonably well. Hired labor accounts for around one third of the labor used in the principal farm operation- weeding. Laborers are both local villagers and transient migrant labor. Laborers work in their own and neighboring villages; they also migrate seasonally for work in the irrigated schemes. Women participate according to class and ethnicity, but not in overly large numbers; thus while they typically receive lower wages than men, this discrepancy could hardly be the basis for large difference in yields. It also would imply that families with more women, or female-headed households, would farm more intensively, using their labor more on the farm than off the farm; we have seen that this is not the case for female-headed households.

The early literature on the inverse relationship held that the stigma or supervision cost of hired labor drove a wedge between the price of family and hired labor. This ignores that family labor too must be supervised and given incentives to work hard. Grown sons are often in acrimonious disputes with their fathers over the allocation of their labor time. The sons want to accumulate bridewealth by working for cash as laborers or cultivating separate small plots. Unmarried daughters may attempt to work in local markets selling tea or processed food. Married women may want to devote more time to their own fields rather than the household plots. In any case, supervision and moral hazard appear not to be too costly; usually laborers are left unsupervised.[15]

4.2 Land Rental Market Performance:

Land rental in Sheikan district is insecure, even though most usufruct rights to land are secure. As long as the owner cultivates his or her land, the chances of disputes are low. Once land is rented out, however, this basic security is rendered vulnerable. There is a widely shared opinion that renters could claim ownership of land. According to local discourse, tribal leaders and village sheikhs originally distributed land as part of the competition for followers

and support. Sheikhs gave out land in order to "settle" the country. Migrants from the west of Sudan, who make up a considerable fraction of the population, legitimize their claims to land ownership, and security of tenure, with reference to their reward (land) for settling in a particular place rather than another. Renters may use these same arguments, implicitly or explicitly, when making a claim of land ownership.[16]

The sheikh of Bireka found himself, in the 1990 rainy season, in several such disputes. He claimed that for several plots he owned the renters had not paid rent. The renters claimed that the land belonged to them- that he had given it to them. In two cases the sheikh was interested in reclaiming the land in order to sell it; the plots were along the seasonal stream and could be used for irrigated gardens. His efforts failed as other influential villagers argued that he had lost his claim to the land. A neighboring sheikh faced a similar difficulty, having rented land to several Bireka residents. These had stopped paying rent following the drought of 1984, but continued to cultivate the land. The sheikh took them to court, and the judge ordered the Bireka residents to stop farming. But the residents ignored the order, and continued to farm. After almost eight years of continuous cultivation without paying rent, they felt very secure in their ownership rights.

But this rental insecurity has not hindered extensive land rental transactions, which account for almost one third of all land cultivated.[17] Nor does the Bliss and Stern- type test of market imperfections give much support to the rental insecurity position. Elsewhere are reported the results for various regressions with either land cultivated or land rented as the dependent variable and land owned among various independent variables [Kevane, 1997]. The estimates are reasonably robust and support the hypothesis that the rental market functions well. We would not want to rely too much on imperfections in land rental markets in our explanation of variation in yields and practices.[18]

4.3 Credit, Risk and Insurance Markets in Sheikan:

The recent resurgence of farmers' interest in credit and insurance arrangements organized at the village level leaves the impression that these may, contrary to conventional wisdom, function very effectively. These assertions have sparked an interest in examining data more rigorously. For evaluating the performance of insurance markets economists test whether the

coefficient on household income is zero while the coefficient on aggregate village income is equal to one, in explaining household consumption. For evaluating the performance of credit markets one tests whether rationing models perform better than simple supply-demand models.

We do not have the data to carry out such tests, but the evidence available suggests that financial markets, to use the term loosely, perform very poorly in Sheikan. In the 1989 season in Bireka a few private traders made a handful of loans to village residents. In 1990 there were no such loans, and the villagers even refused to borrow from the Agricultural Bank of Sudan cooperative lending program. They feared that the Bank would enforce repayments harshly by confiscating assets. Government policy of enforcing Islamic prohibitions against interest and usury may have contributed to the absence of loans. There was no informal 'market' for credit, such as one might find in Asia, with well-recognized moneylenders and terms of borrowing.

During late 1990 the local economy suffered a severe crisis of entitlements caused, in part, by a drought that led to complete crop failure, sharp rises in the price of grain, and a drying up of employment opportunities. Thus a limited number of households borrowed grain and cash, or received gifts from wealthier neighbors and relatives. This borrowing was exceptional, in the eyes of most villagers, and there were no 'formal' conditions or terms for the loans; many borrowers indicated they would in all likelihood not repay. Most households reduced their consumption dramatically; children of poor households became severely malnourished. Nevertheless, some households maintained their earlier standards of living, even undertaking new productive ventures such as establishing irrigated gardens and investing in livestock.

Such disparities are not predicted by the perfect insurance model, where individual consumption should follow aggregate income. Bireka had no multilateral 'markets' or institutions for general mutual insurance and reciprocity; neither were there patrons providing insurance to submissive clients. No villager ever disagreed with, and many actively expressed, the notion that a household was cushioned against idiosyncratic shocks only by the charity of friends and relatives.

5. Conclusion:

The main objective of this paper has been to demonstrate and explain

a positive relationship between farm wealth and farm yields for a select group of villages in western Sudan. Data on yields showed that across all crops wealthier farmers obtained higher yields. Wealthier farmers used relatively more labor per hectare- the opposite of the predictions of the inverse relationship literature. That literature was developed in the context of India, and relied primarily on imperfections in land and labor markets to explain the inverse relationship. The Sudan-Sahel zone of Africa is typically described as so land abundant that only one input- labor- is scarce. and therefore there could be no inverse relationship.

There is, however, an active land market in Sheikan. Production financing and access to insurance or consumption credit are important 'inputs' into production. Imperfections in these markets for land, credit and insurance may be responsible for the positive relationship observed. We have asked in the latter section how we might choose among the three tentative candidates for explaining the observed relationships between yields, practices, and endowments of land, labor and wealth. The three have quite distinct implications for agrarian policy in terms of intervention in land tenure, insurance, or credit. The second model, of rental insecurity and no insurance, is a bit of a nonstarter, since it relies on the suspect assumption that credit markets function well but insurance markets are absent and that post-harvest consumption credit is unavailable. The review of market performance in Sheikan cast doubt on relying on rental insecurity as the central element of any explanation, and supported the emphasis of the third model on credit constraints and the absence of insurance.

This tentative finding would be unimpressive if policymakers still believed in the futility of interventions in rural factor markets. The old dinosaur credit programs, the large-scale land reforms, the sweeping legal changes in tenure relations, all clearly failed to achieve their objectives. Instead, they engendered pessimism about state and international agency involvement in markets. That prevalent pessimism has been corrected and replaced, partially, by a new hard-nosed optimism about the possibilities for successful intervention. Project workers and policymakers are enthusiastic about village insurance schemes, indigenous rotating credit and savings institutions, market-based land tenure reform, and local public employment projects.

On the academic side, that pessimism about intervention stifled

discussion of agrarian structure and the differentiation of African peasantries. On both the right and the left the concern was with national-level process of price determination. There was much talk of the 'simple reproduction squeeze', a dynamic process whereby poorer producers would be forced off the land as terms of trade turned against the agricultural sector. At the same time international institutions emphasized price reform. Both approaches neglected the institutions that regulated factor market transactions: land, labor, credit and insurance markets. This paper has tried to develop a much richer theory of how these markets influence agricultural practice. Starting from this typology that expands the range of inquiry beyond the inverse relationship, we might generate richer models of the dynamic process of differentiation and transformation.[18] A crucial element in this research agenda is a questioning of the political and economic processes that make some markets perform more effectively than other markets.

Endnotes:

1- Helpful observations were received from George Akerlof, Pranab Bardhan, Rachel Kranton, Alan Richards, Anand Swamy and Michael Watts. Leslie Gray collaborated in all of the research, and her contributions are gratefully acknowledged. Financial assistance was provided by the Fulbright Collaborative Research Program and the Joint Committee on African Studies of the Social Science Research Council and the American Council of Learned Societies with funds from the Rockefeller Foundation and the William and Flora Hewlett Foundation. Many thanks to Ibrahim Abidallah, Ahmed Musa, and al-Dau Mohamed for help in data collection, and the Western Sudan Agricultural Research Project in El Obeid for support and assistance.

2- According to the archeologist Arkell [1937], the *hashasha* technology goes back at least five centuries; he found numerous examples of ancient iron hoes in Darfur. This is not meant to imply that the agriculture of the area is 'backward' in any sense. The jury is still out on the long-term sustainability of the low-input method of production; delayed surely by the fact that 'modern' agriculture has failed to come up with any innovations to 'improve' hoe cultivation.

3- Coughenour and Nazhat [1985] and Nazhat and Coughenour [1987] show that while in the past decades farmers have introduced new varieties of traditional crops, they have not changed production technology greatly. Moreover, new varieties and techniques are disseminated relatively quickly, within three or four years, so that differences in knowledge do not persist for long.

4- Data on the value of assets was not collected for Bireka, since ethnographic work was ongoing. The classification is based on an 'intimate' knowledge of each household.

5- The data on yields are for the previous season of 1989; the 1990 season turned into a complete drought three-quarters of the way through the season, during the period of second weeding, and there was a complete crop failure.

6- We assume that all household members actively work in agriculture, with the exception of married Hausa women.

7- Dividing by a larger number (the maximum area weeded during the rainy season by a laborer working for others was twelve *mukhammas* naturally reduces the land-labor ratio for laborers (who are then measured as having more labor for use on their own farm) and raises the ratio for employers. Dividing by five seems reasonable when considering that the average area cultivated per person was three for households that did not participate in labor market transactions. The directions of the changes in the ratios, given later in the text, were not sensitive to different assumptions about how to transform the hired labor variable.

8- The ratio of endowments is underestimated in the Jaibat sample, but not the Bireka sample, because data on land rented out in the Jaibat sample was not collected. This naturally biases the ratio of land-labor endowments for laborers who are renting out, and to that extent exaggerates the differences in the Jaibat before-and-after ratios.

9- A second kind of test of market imperfections begins with the *assumption* that one market is imperfect, and tests whether a second market imperfection can explain variation in yields per hectare. Many of the classic farm-size investigations (see Benjamin 1992a) assumed that land markets were absent, and tested whether the coefficient of logged farm-size, in a regression with the logged value of production as the dependent value, was equal to one. (Under constant returns to scale, a one percent increase in size should lead to a one percent increase in output, if there are no impediments to adjusting non-land inputs.) This second kind of test has no natural interpretation in Sheikan, given that there are active markets for land and labor. Furthermore, there is no natural analogue for assuming imperfections in credit or insurance markets and examining whether a second market is imperfect.

10- Bhalla [1988] and Bhalla and Roy [1988] have argued that many findings of systematic relationships between farm size and productivity are spurious results of artificially treating land as a homogenous input and ignoring variation in land quality.

11- Patnaik [1987] reviews and critiques, for precisely this reason, research conducted on the Indian farm size debates. The book's bibliography has extensive and relevant citations.

12- Note that assuming no rental market is equivalent to assuming a prohibitively high cost to renting out land; i.e. a very high probability of losing the land to the renter. Also, the predictions apply only to employer households; laboring households will all have the same land-labor ratios, since they do not face the supervision cost.

13- Witnesses are not always dependable. Occasionally witnesses, after taking the oath on the Koran, declared they had no pertinent knowledge about the case at hand.

14- By assuming non-increasing absolute risk aversion and non-decreasing relative risk aversion, Srinivasan showed that the land to labor ratio increases with the endowment of land. With more land the marginal productivity of labor in cultivation rises, but at the same time, more labor in cultivation makes income riskier. There is a disincentive to match the increase in land with an equal increase in labor. More land means lower output per hectare. The shortcoming of Srinivasan's innovative analysis was that he did not consider separately the role of farmer wealth. Bliss and Stern [1982:70-75] have made the important point that the effects of changes in assets on land to labor ratios depend on whether the assets

are viewed as separate and safe (in which case the farmer is willing to use relatively more labor) or whether farmer wealth is tied up in the risky cultivation itself (in which case the farmer is reluctant to make production even riskier by expanding the scale- the Srinivasan case).

15- Weeding with a *hashasha* leaves clearly defined rows of turned soil. Since the water deficit is critical, any interruption in weed growth effectively prevents them from competing with crops. It is enough for the blade to penetrate just under the soil surface; there is little advantage from deeper or careful weeding, and it may even increase wind erosion. Labor effort, then, is easily monitored by visual inspection of the field.

16- These considerations lend weight to Berry's [1988] contention that in many parts of Africa, "People assert claims on rural land in order to establish or reaffirm their social identity, rather than *vice versa*." Denying a renter's claim that he or she owns the rented land, then, also involves denying their membership in the community.

17- Rent was on an informal share basis, the renter paying ten percent of the crop to the landlord. In practice rental payments often deviated from a strict share; many informants indicated that rents were more 'customary' than 'economic'. There was no accounting of and little enforcement of strict shares.

18- The land sales market in western Sudan is practically non-existent for upland sandy goz soils that form the bulk of the agricultural land. Basu [1990] has a good explanation for the absence of land sales as due to thin markets, and Rosenzweig and Wolpin (1985) use an argument based on the accumulation of plot-specific experience to explain the lack of land sales. Both may be applicable to western Sudan, but in general they can be only partial explanations, because they both have difficulty explaining why different places have different frequencies of sales; e.g. why are sales so prevalent in northern Nigeria? Hill (1982:123), for instance, asserts that most writers overlook the extent of the land market in northern Nigeria, and argues that because of an "irrational" desire by the rich to cultivate large amounts of grain land prices are artificially inflated, causing dispossession and marginalization (see also Ross, 1987). Even if there were no market failure in the land sales market *per se*, the failure of credit markets would prevent efficient transfers.

19- For some initial attempts to construct dynamic models see Braverman and Stiglitz [1989] and Carter [1991].

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