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Sexual Division of Labor in Old World Agriculture

by

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Abstract

In this paper we formulate and test a cultural ecological model to explain cross-societal variations in female contributions to agricultural subsistence. The model includes tow kinds of variables—labor allocation constraints and technological factors. We assume that the male contribution to agriculture increases with societal complexity primarily because (a) women's labor gets redirected to other tasks such as the care of domesticated animals, and (b) men's labor is pulled into agriculture by the increase in the total daily agricultural workload.

The importance of domesticated animals to subsistence emerges as the single most powerful predictor of male participation in agriculture. Population pressure and a long dry season also act to increase the relative contribution of men to agricultural subsistence. Both increase the amount of work to be done per unit of land and time, and hence increase the amount of agricultural work that men must do. The plow also acts to decrease female participation in agricultural subsistence, presumably through its effect on land ownership and the form of marriage, but it does not have the strength of relationship to female subsistence participation that often has been claimed for it.

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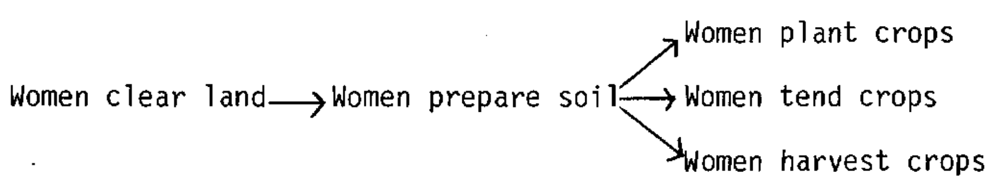
Sexual division of labor in agriculture is important to anthropological theories of social structure. It has been shown that the female contribution to agricultural subsistence is a major determinant of polygyny (Heath 1958; Burton and Reitz 1981; White, Burton and Dow 1981), and the sexual division of labor in agriculture has been hypothesized to affect such important variables as residence. Because most human subsistence is from agriculture, and because agricultural labor is a large portion of agrarian peoples' time expenditures, agricultural labor comprises in many ways the most important set of tasks to study in research on the sexual division of labor. A number of hypotheses have been put forward to explain variability in the agricultural division of labor. The present paper will focus specifically on cultural ecological explanations for variability in the agricultural division of labor.

Previous work has established the existence of entailment relationships with respect to the sexual division of labor in production sequences (Burton, Brudner and White 1977; White, Burton and Brudner 1977). These take the form of partial orderings, similar in form to the orderings of color terms found by Berlin and Kay (1969). The entailment structure for five agricultural tasks appears in Figure 1. This structure, with very few exceptions, is valid across all agricultural societies in the Standard Cross-Cultural Sample (Murdock and White 1969).

Figure 1. Entailment Sequence for Agricultural Tasks



Here we see that in societies where women clear the land (an infrequent event) they also prepare the soil. In societies where women prepare the soil (about 25% of the cases) they also do planting, tending, and harvesting. This structure establishes limits upon variation in the sexual division of labor, but there still remains a considerable degree of variability to account for. For example, the entailment structure allows for societies in which women do all five of the tasks as well as societies in which men do all five of the tasks.

It has often been noted that female contribution to agricultural production declines with agricultural intensification (Boserup 1970, Martin and Voorhies 1975, Ember 1981, Sanday 1973, Goody 1976). This decline is statistically associated with a shift from the strongly polygynous marriage systems that are common in patrilocal horticultural societies to a predominantly monogamous form of marriage, as well as with decreases in female participation in a number of other tasks, such as potterymaking, housebuilding, and weaving. In Boserup's formulation, population pressure causes agricultural intensification, and agricultural intensification leads to decreased female participation in agriculture, as well as to monogamy. Boserup does not, however, specify a causal mechanism that would help us to understand why agricultural intensification would lead to decreased female participation in agriculture.

Goody (1976), Heath (1958), and Burton and Reitz (1981) all discuss the relationships among female participation in agriculture, polygyny and the presence of the plow. In Goody's formulation, the intensification of agriculture, as measured by the presence of the plow, leads to private property in land and to diverging devolution. This inheritance strategy is not compatible with polygyny and hence is the cause of monogamy. Heath hypothesized a direct relationship between polygyny and female participation in agriculture, based on the value of female labor. In Heath's formulation, polygyny and bride price are both consequences of high female participation in subsistence, being adaptations to the high value of female labor.

Burton and Reitz analyze data from the standard cross-cultural sample and find evidence to support both Goody and Heath. The plow acts to inhibit the practice of polygyny, and a high female participation in crop tending acts to encourage polygyny. Although there is a strong negative correlation between presence of the plow and female participation in crop tending, a control for regional effects and the presence of polygyny suggests that this correlation is spurious. It is a good example of the phenomena that have been called Galton's problem. The plow, monogamy, and the sexual division of labor in agriculture are all strongly regionally clustered, with low female participation in agriculture, monogamy, and the plow all being highly prevalent in Europe and Asia, while polygyny, high female participation in agriculture and the absence of the plow are prevalent in Africa, Oceania, and the Americas. Although the studies by Goody and by Burton and Reitz help us to understand the complex relationships among technology, agricultural intensification, and the division of labor, they still do not provide an adequate causal account of the observed decline in female participation in intensive agriculture.

Ember (1981) discusses possible causes of the change in the sexual division of labor with agricultural intensification. She hypothesizes that this change is due to the change in the nature of women's domestic work, and that women are "'pulled into' additional domestic work with the intensification of agriculture..." (Ember 1981:3). The increase in female domestic workload prevents them from increasing the number of hours per week that they spend on agriculture, while the total agricultural workload is increasing, since intensive agriculture requires a higher total labor input. At the same time, men have fewer competing activities to agriculture, since they do not have the hunting, warfare, and trading activities that are common in horticultural economics.

Ember hypothesizes that the female domestic workload increases because of increased time spent on child care, food preparation, and other household chores. The increased time in child care would be due to the higher birth rates that are characteristic of intensive agriculturists. In Ember's view (also see Martin and Voorhies 1975 and White, Burton and Dow 1981), increased food preparation time is a direct consequence of specialization in cereal crops, which apparently require more labor to prepare than do root or tree crops. Cereal crops are strongly associated with intensive agriculture.

Ember discusses data from an article by Minge-Klevana (1980) which support her argument. These data show (a) that women work more hours per day than men in both simple and intensive agricultural societies, (b) that men and women do about the same amount of agricultural work in simple agricultural societies (about 5 hours per day), (c) that women do a similar amount of agricultural work in intensive agricultural societies (about 4.5 hours per day), (d) that men's agricultural workload is much higher in intensive agricultural societies (about 7.3 hours per day), (e) that women's domestic workload increases from simple to intensive agriculture (2.9 hours per day vs. 9 hours per day), and (f) that men's domestic workload is low in both cases (about 1 hour per day).

The Network Autocorrelation Model

For the past two years we have been working on a model for statistical estimation where the societies in a sample are historically connected. This model, which we call network autocorrelation analysis, is a reformulation of the spatial autocorrelation model developed by geographers and sociologists (Doreian 1980, 1981; Hibbs 1979; Ord 1975). Spatial autocorrelation analysis measures the connections between societies in terms of spatial distances, especially indices of adjacency. In our formulation, other kinds of indices are allowed. We are particularly interested in measures of historical relationships between languages, as we feel that these provide especially good measures of the actual historical relationships between societies. New Zealand and England are on opposite sides of the earth; ordinary spatial autocorrelation analysis would not be able to deal with the obvious historical relationship between the two, whereas a measure based on language history would be quite accurate. We feel that network autocorrelation analysis is particularly useful for studying the kinds of regional systems of adaptation that are of interest in cultural ecology.

Network autocorrelation analysis uses a multiple regression framework. In the ordinary least squares model, a dependent variable Y is predicted as a linear combination of several dependent variables X_i:

$$Y = A + B_1X_1 + B_2X_2 \ldots\ldots + B_nX_n + \Sigma$$

We use a disturbances model autocorrelation model expressed as the following (Doreian 1980, 1981).[1]

$$(Y - pWY = A + B_1(X_1 - pWX_1) \ldots + B_n(X_n - pWX_n).$$

or

$$Y^* = A + B_1X_1^* = B_2X_2^* \ldots + B_nX_n^*$$

where

$$Y^* = Y - pWY$$

$$X_1^* = X_1 - pWX_1$$

.

.

.

$$X_n^* = Xn - pWXn$$

The autocorrelation coefficient p must fall between -1 and +1, and will usually be non-negative. If it is significantly greater than zero, then there is significant positive autocorrelation. In that case, ordinary least squares will not provide efficient or consistent estimators, and it is necessary to use the network autocorrelation model.

We can see that the disturbances model involves transforming the variables from Y to Y*, from X_1 to X_1* and so forth. The interpretation of these transformations is that we subtract from each variable the portion that is due to diffusion or other historical connections with other societies. The matrix W measures the relationships of each society to each other society. Details can be found in Dow, White and Burton (1981). Having substracted the portion of the variance in each variable that is due to autocorrelation, we then explain the remainder in a causal model using regression.

The first application of the network autocorrelation model was with data on the sexual division of labor in African agriculture (White, Burton and Dow 1981). There we found that crop type and slavery had strong effects on sexual division of labor in agriculture. Cereal crops and slavery both acted to reduce female participation in agriculture, while neither population density or agricultural intensity had any relationship to female participation in agriculture. The network autocorrelation procedure found significant autocorrelation, using a measure of historical relationships among languages. We were able to pinpoint the autocorrelation as being due to a higher female participation in agriculture in Bantu speaking societies than would be expected from other variables. Although there was significant autocorrelation, regression results in the autocorrelation analysis were not markedly different from the results with ordinary least squares regression.

In our discussion of the results, we mentioned two other factors which we thought accounted for the relationship of crop type to the sexual division of labor. These were the importance of domesticated animals and the length of the dry season. In doing so, we took a limited cultural materialistic position, arguing that much of the variation in the agrarian division of labor could be accounted for by material constraints upon production. By so doing, we do not claim that idealist constructs, such as ideology, have no effect on the division of labor, but only that those effects will be less important, cross-culturally, than material constraints. In fact, we did find some evidence for the effect of ideology in the African society. Monotheistic societies in the sample appear to have somewhat less female participation in agriculture than would be expected, all other things being equal. This, of course, is primarily an effect of Islamic customs, such as female seclusion, since 10 out of 11 monotheistic societies in the sample practice Islam. However, monotheism has a much weaker effect than crop type and slavery, and we favor a research strategy where the effects of ideology are considered only after an adequate model of material constraints has been constructed. We claim that ideological variables will account for much less than half of the variance in the sexual division of labor once this has been done.

Sexual Division of Labor in Old World Agriculture

The present paper expands the sample of societies used in our paper on African agriculture (White, Burton and Dow 1981) to include the entire Old World, with the exception of the Insular Pacific. Our sample includes Africa, Europe, and Asia. In this sample there are 77 agricultural societies for which we have information on all of the variables to be included in our model. The sample extends in the Pacific fringe roughly to the furthest limits of the classical old world agrarian civilizations, so that the Ifugao, Ainu, Iban, and Atayal are included in the sample, but Micronesia, Polynesia, and Melanesia proper are not included.

We have reformulated the model that we presented earlier to deal explicitly with variables pertaining to domesticated animals and the length of the dry season, variables which we hypothesized to account for the different divisions of labor in root crop and cereal crop agriculture. We assume that these variables provide constraints which act to increase male participation in agriculture.

In our model we assume that agriculture tends to be a female task in the absence of forces that lead to increased male participation. The main forces causing increased male participation are those that increase the total amount of agrarian work to be done, with the consequence that the female agriculture workload remains constant, but the male workload increases. Hence the proportion of agriculture done by men will increase, even though the amount done by women has not changed.

Length of the dry season is a good example of a variable that affects the total labor input per day. With a short growing season, the same amount of work has to be done in less time, increasing the daily work load. Men will have to increase their participation in agriculture to allow the work to be completed. People of Northern European ancestry are most aware of the effects of a long winter upon the growing season, but on a worldwide scale drought is a more serious constraint upon agriculture than frost, since most of the world's societies are located in areas that rarely experience serious cold.

We hypothesize that the presence of domesticated animals will also increase the subsistence workload. Animals have to be cared for, and women will do certain tasks, such as milking and feeding young animals, as well as related tasks such as tanning hides and leatherworking. This increase in female subsistence workload must come at the expense of female involvement in agriculture. Since the total subsistence workload has increased, men must increase their involvement in agriculture to take up the slack.

Population pressure also increases the amount of agrarian work to be done. Its effect is to cause agricultural intensification. Intensification has mainly been discussed in terms of the short fallow and the plow, although there are ways to intensify production other than to shorten the fallow or introduce the plow (Netting 1977). One can, for example, resort to such simple expedients as green manuring, pollarding, or terracing. They all require more work, and hence will require male participation in agriculture to increase.

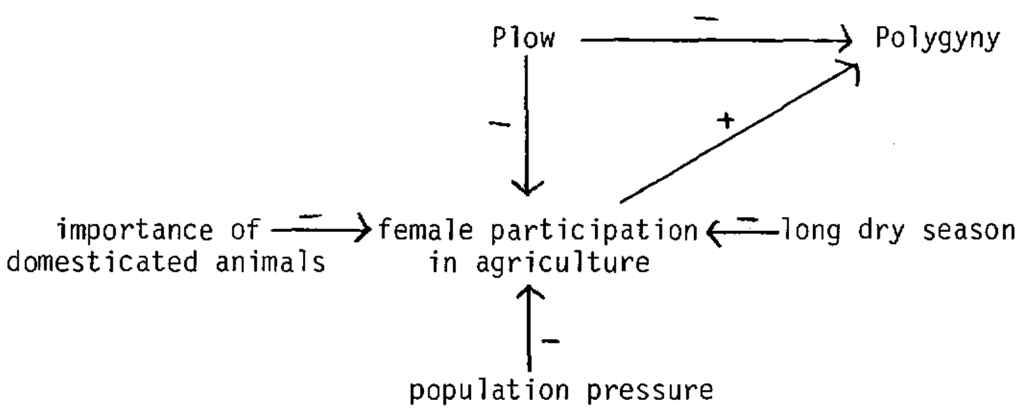
Finally, we should mention the plow. Once we have taken these other constraints into consideration, the plow no longer appears to be the overarching determinant of the sexual division of labor that it once was. But it does affect at least one of the agrarian tasks--soil preparation--the main task for which the plow is used. Plowing is always done by men, so soil preparation in plow societies will be done by men. The plow is also used for weed control, so it may affect the nature of crop tending. Plowing also is one of a complex of activities, including irrigation, that leads to private property in land, and to the degree that this property is controlled by men, there will be increased rewards to men to engage in agricultural labor on their own land.

We do not include measures of social stratification, such as caste, slavery, or political centralization in our model. We think these phenomena are consequences of the same material circumstances that affect the division of labor, and are not themselves causes of the division of labor.

We also have not included polygyny in the model, although it is well known to have strong relationships to several of the variables in the model. We take the position that polygyny is in part a consequence of high female participation in subsistence, so that it would be erroneous to include it in a model to explain the division of labor.

Our final model appears in Figure 2. The remainder of the paper is devoted to a test of the model.

Figure 2. Model of Causes of the Division of Labor in Agriculture



Data Analysis

The following are definitions of variables used in the analysis.

1. Fixity of settlement (Fixity). A 6 point scale from the codes on settlement patterns and community organization (Murdock and Wilson 1972).

    1 = migratory bands
    2 = seminomadic
    3 = rotating settlements
    4 = semisedentary
    5 = impermanent
    6 = permanent

2. Population density (Popden). A 7 point scale from the codes on settlement patterns and community organization.

    1 = less than 1/5 per square mile
    2 = 1/5 to 1 per square mile
    3 = 1 to 5 per square mile
    4 = 5 to 25 per square mile
    5 = 26-100 per square mile
    6 = 101-500 per square mile
    7 = Greater than 500 per square mile

3. Population pressure (Poppres). As defined by Dow (1980), the product of fixity and population density.

4. Polygamy (Poly). From the codes on settlement patterns and community organization.

    1 = polyandry
    2 = monogamy
    3 = polygyny less than or equal to 20% of all marriages
    4 = polygyny greater than 20% of all marriages

5. Importance of animal husbandry to subsistence (Animals). Codes from the ethnographic atlas (Murdock 1967).

   0 = 0-5%
   1 = 6-15%
   2 = 16-25%
   3 = 26-35%
   4 = 36-45%
   5 = 46-55%
   6 = 56-65%
   7 = 66-75%
   8 = 76-85%
   9 = 86-100%

6. Importance of agriculture to subsistence (Agimpt). Codes from the ethnographic atlas, same as variable 5.

7. Agricultural intensity (Agint). Codes from the ethnographic atlas.

   1 = no agriculture
   2 = casual agriculture
   3 = extensive or shifting agriculture
   4 = horticulture
   5 = intensive agriculture
   6 = intensive agriculture with irrigation

8. Presence of the plow (Plow). Codes from the ethnographic atlas.

   1 = absent
   2 = not aboriginal, but well established at period of observation
   3 = present prior to contact

9. Total female contribution to agricultural production (Log(A)). From codes pertaining to the sexual division of labor.

   A = soil preparation + planting + harvesting + crop tending

   We use the natural log of this variable in the analysis.[2]

   Each of the four variables is coded as follows:

   1 = entirely male
   2 = mainly male
   3 = divided equally
   4 = mainly female
   5 = entirely female

10. Length of dry season, in months (Dry). From Whiting's climate codes.

Correlations among the 10 variables for the entire sample are found in Table 1.

Table 1. Correlations Among Variables

	Fixity	Popden	Poppres	Poly	Animals	Agimpt	Agint	Plow	Log(A)	Dry
Fixity	1.00	.63	.78	.06	-.48	.68	.27	.25	.10	-.30
Popden	.63	1.00	.96	-.09	-.21	.62	.40	.38	-.19	-.05
Poppres	.78	.96	1.00	-.09	-.34	.69	.43	.39	-.12	-.10
Polygyny	.06	-.09	-.09	1.00	-.09	-.09	-.20	-.44	.30	.21
Animals	-.48	-.21	-.34	-.09	1.00	-.55	-.03	.23	-.58	.29
Agriculture	.68	.62	.69	-.09	-.55	1.00	.44	.20	.25	-.19
Ag Intensity	.27	.40	.43	-.20	-.03	.44	1.00	.56	-.17	.11
Plow	.25	.38	.39	-.44	.23	.20	.56	1.00	-.45	-.13
Log(A)	.10	-.19	-.12	.30	-.58	.25	-.17	-.45	1.00	-.35
Dry	-.30	-.05	-.10	.21	.29	-.19	.11	-.13	-.35	1.00

Although most of the correlations in this table are in the right direction for confirmation of the model, bivariate correlation analysis cannot tell us whether the relationships will hold when we control for the effects of the other variables. Bivariate correlational analysis also cannot tell us whether the relationships are valid causal relationship or whether they are due to the effects of diffusion or other historical processes. We will compare four kinds of analyses to test the validity of the model:

a) Ordinary least squares regression analysis for the entire sample.

b) Ordinary least squares regression analysis for two regional samples--the Eastern and Western halves of the entire sample.

c) Network autocorrelation analysis for the two regional subsamples.

d) Ordinary least squares analysis for split halves of the entire sample.

a) <u>OLS analysis for the entire sample</u>

In the first equation we see the OLS regression for the entire sample of 77 societies for predicting the division of labor in agriculture:

$$\underset{}{Ln(A)} = \underset{(.32)}{3.20} - \underset{\substack{(.012)\\ p<.005}}{.035(DRY)} - \underset{\substack{(.025)\\ p<.001}}{.132(ANIMALS)} - \underset{\substack{(.047)\\ p<.005}}{.137(PLOW)} - \underset{\substack{(.004)\\ p<.05}}{.008(POPPRS)} \quad R^2 = .517$$

The equation lends support to our model. All coefficients are significant and in the predicted direction.[3]

Interestingly, a partial correlation analysis shows that the equations can be improved by the addition of another variable, the importance of agriculture. When the preceding four variables are controlled, the importance of agriculture has a positive relationship to the degree of female participation in agriculture:

$$\underset{(.31)}{Ln(A)=2.90}-\underset{\substack{(.011)\\ p<.005}}{.034(DRY)}-\underset{\substack{(.027)\\ p<.001}}{.104(ANIM)}-\underset{\substack{(.046)\\ p<.005}}{.147(PLOW)}-\underset{\substack{(.005)\\ p<.005}}{.014(POPPRS)}+\underset{\substack{(.031)\\ p<.025}}{.072(AGIMP)} \quad R^2=.546$$

Although the relationship is not as strong, substitution of agricultural intensity for the importance of agriculture in the above equation would also show a significant positive relationship. Thus, when we control for specific factors, such as the plow, increasing dependence upon agriculture or increasing intensity of agriculture are both associated with increases in the female participation in agriculture. This is opposite to the direction of relationship that was claimed by Boserup.

In an earlier paper (Burton and Reitz 1981) it was shown that the plow has a spurious relationship to the division of labor in crop tending when we control for region and the presence of polygyny. We have not included polygyny in the present model. The previous result suggests that doing so would decrease or perhaps eliminate the relationship of the plow to the division of labor in agriculture. To test this, we have added polygyny as a last variable in the regression equation. This is an ordinal variable with four values: polyandry, monogamy, limited polygyny, and intensive polygyny. The resulting equation does indeed show a weaker effect for the plow, but it is still statistically significant ($p < .05$):

$$Ln(A) = 2.46 - \underset{(.011)}{.039(DRY)} - \underset{(.027)}{.105(ANIM)} - \underset{(.049)}{.098(PLOW)} - \underset{(.004)}{.015(POPPRS)}$$

$$+ \underset{(.030)}{.072(AGIMP)} + \underset{(.051)}{.132(POLY)} \qquad R^2 = .580$$

It should be noted that we are using a different measure of division of labor in agriculture than in Burton and Reitz, and that one of the components of our index, soil preparation, is strongly affected by the presence of the plow, since soil preparation with the plow is always done by men.

b) and c) Division of old world into eastern and western regional samples

We divided the sample so as to have nearly equal numbers of societies in each half. The boundary coincides closely with the boundary between Europe and Asia. The Hebrews, Babylonians, Armenians, and Turks are included in the Eastern half; the Russians and the Tanala are included in the Western half. The societies in each half of the sample are listed in Table 2.

For each region we first compute OLS regression equations and then do network autocorrelation analysis on the same data. For the network autocorrelation analysis we use two different measures of connection between

Table 2. Societies in Eastern and Western samples, with Standard Cross-Cultural Sample ID numbers.

EAST (N = 38)		WEST (N = 39)	
44	Hebrews	3	Thonga
45	Babylonians	4	Lozi
47	Turks	5	Mbundu
56	Armenians	7	Bemba
57	Kurd	8	Nyakyusa
58	Basserri	10	Luguru
59	West Punjabi	11	Kikuyu
60	Gond	12	Ganda
62	Santal	14	Nkundo
63	Uttar Pradesh	15	Banen
64	Burusho	16	Tiv
65	Kazak	17	Ibo
66	Khalka Mongols	18	Fon
67	Lolo	19	Ashanti
68	Lepcha	20	Mende
69	Garo	21	Wolof
70	Lakher	22	Bambara
71	Burmese	24	Songhai
72	Lamet	26	Hausa
73	Vietnamese	27	Massa
74	Rhade	28	Azande
76	Siamese	29	Fur
78	Nicobarese	30	Otoro Nuba
80	Vedda	31	Shilluk
82	Negri Sembilan	32	Mao
83	Javanese	33	Kaffa
84	Balinese	35	Konso
85	Iban	37	Amhara
87	Toradja	38	Bogo
88	Tobelorese	40	Teda
89	Alorese	41	Tuareg
112	Ifugao	42	Riffians
113	Atayal	43	Egyptians
114	Chinese	48	Albanians
115	Manchu	49	Romans
116	Koreans	50	Basques
117	Japanese	51	Irish
118	Ainu	54	Russians
		81	Tanala

societies. The first is based on a tree of genetic relationships among old world languages. The second is an exponentially-decreasing function of distance between the territories inhabited by the societies. These are computed according to the procedures described in White, Burton and Dow (1981). Results of the OLS and autocorrelation analyses for the first equation are found in Table 3. Here the independent variables are domesticated animals, length of the dry season, the plow, and population pressure.

Strongest replication occurs for the importance of domesticated animals, where the beta weights are almost identical between the two regions. The length of the dry season has a strong negative relationship in both regions, as predicted, but the beta weight has greater magnitude in the West than in the East. The plow shows only weak replication. The beta weight has much higher absolute value in the West than in the East, and the plow attains statistical significance in only one of the three Eastern equations. Population pressure replicates only in the West, where the relationship is in the same direction, but of higher magnitude, than in the entire sample. Population pressure appears to have no relationship to the sexual division of labor in the Eastern sample. In none of the cases is there significant autocorrelation, and the autocorrelation regressions do not change results appreciably.

A possible reason for lack of replication across regions is that there is specification error--that is, variables have been left out of the equations which should have been included. Detailed analysis shows that the equations in Table 3 are not the best equations for explaining the division of labor in each region. In particular, the two regions differ in the effects of population density and settlement fixity upon the sexual division of labor.

In the West, fixity of settlement has a strong negative relationship to the division of labor, so that there is more female participation in agriculture with nomadism or seminomadism than there is with sedentary residence, all other things being equal. This is in tune with a common observation about African pastoralism, where it is common to find men caring for animals and women doing the agricultural labor. Fixity of settlement does better than either population density or population pressure in predicting sexual division of labor in Western agriculture: The OLS equation is:

$$\begin{array}{lllll} \text{Ln(A)} = 4.38 & -.080(\text{DRY}) & -.135(\text{ANIMALS}) & -.210(\text{PLOW}) & -.181(\text{FIXITY}) \quad R^2 = .621 \\ & (.019) & (.035) & (.062) & (.045) \\ & p < .001 & p < .001 & p < .005 & p < .001 \end{array}$$

Our earlier paper on African agriculture (White, Burton and Dow 1981) found a negative relationship between cereal crop agriculture and the division of labor in agriculture, with women doing less agricultural work in cereal crop societies. We also suggested that this relationship was due to other factors, such as the dry season and animals variables. When we control for the four variables in the above equation, we find that the partial correlation between the division of labor and crop type is close

Table 3. Beta Coefficients for OLS and Autocorrelation Equations, Eastern and Western Regions

	DRY	ANIMALS	PLOW	POPPRES	R^2
Ln(A) as dependent variable					
<u>East</u>					
OLS	-.037 (.015) $p < .01$	-.124 (.034) $p < .001$	-.087 (.062) n.s.	-.003 (.005) n.s.	.536
LANGUAGE	-.034 (.014) $p < .01$	-.126 (.031) $p < .001$	-.077 (.060) n.s.	-.004 (.005) n.s.	.575
DISTANCE	-.034 (.010) $p < .005$	-.128 (.027) $p < .001$	-.114 (.049) $p < .025$	-.002 (.004) n.s.	.642
<u>West</u>					
OLS	-.061 (.018) $p < .001$	-.123 (.037) $p < .005$	-.192 (.069) $p < .005$	-.017 (.006) $p < .005$	.560
LANGUAGE	-.078 (.014) $p < .001$	-.132 (.038) $p < .001$	-.230 (.057) $p < .001$	-.014 (.006) $p < .025$	.691
DISTANCE	-.063 (.017) $p < .001$	-.132 (.035) $p < .001$	-.197 (.059) $p < .005$	-.109 (.005) $p < .001$	.512

to zero. Hence, we can be confident that the relationship between cereal crop agriculture and low female participation in agriculture is not due to an intrinsic attribute of cereal crops, but is due rather to the ecological circumstances under which they are usually produced--in sedentary societies, with the presence of domesticated animals, and often in places where there is a long dry season. When cereal crops are produced in seminomadic societies, with no dry season, without the plow, and with no domesticated animals present, then they would require the same amount of female labor as root crops.

The earlier paper also found a significant effect for membership in the Bantu language family upon the division of labor. Although the autocorrelation program shows no significant autocorrelation, we have tested the relationship between membership in the Bantu language family and the division of labor. Here we find that there is still a residual positive relationship between Bantu language family membership and female participation in agriculture, when we control for the other four variables:

$$
\begin{array}{llllll}
Ln(A)=4.09 & -.067(DRY) & -.127(ANIM) & -.172(PLOW) & -.065(FIXITY) & +.218(BANTU) \quad R^2=.642 \\
 & (.019) & (.034) & (.064) & (.045) & (.121) \\
 & p < .001 & p < .001 & p < .01 & p < .001 & p < .05
\end{array}
$$

The implication of this finding for autocorrelation analysis is that there may be local autocorrelation that is not detected by the autocorrelation analysis, and that also does not have a serious effect on statistical estimation.

In the East both population density and fixity of residence are required in the regression equation. Fixity of residence has the opposite relationship to the division of labor to that observed in the Western sample. Eastern women do more agricultural labor in sedentary societies than in nomadic or seminomadic societies:

$$
\begin{array}{llllll}
Ln(A)=2.48 & -.031(DRY) & -.081(ANIM) & -.130(PLOW) & -.076(POPDEN) & +.125(FIXITY) \quad R^2=.587 \\
(.28) & (.014) & (.035) & (.059) & (.038) & (.060) \\
 & p < .025 & p < .025 & p < .025 & p < .025 & p < .025
\end{array}
$$

Since population density and fixity of settlement have opposite relationships in the Eastern sample, it is not surprising that their product, population pressure, has no relationship to the division of labor in the East. Given the failure of the settlement fixity variable to replicate across regions, as well as the failure of the population pressure variable to replicate, we must conclude that there are processes at work that we do not yet fully understand. One possibility is that there is a curvilinear relationship between settlement fixity and female contribution to agriculture, so that the linear regression analysis is not capturing the true process. It has often been noted that female involvement in wet rice agriculture is higher than in other advanced forms of agriculture because wet rice agriculture is so highly labor intensive. Rice agriculture is common throughout our Eastern sample, but almost totally absent from the Western sample. Hence, we hypothesized that rice could account for the observed differences between the Eastern and Western samples and we coded all of the societies in the sample for the importance of rice agriculture and the degree of intensity of its cultivation. When we entered these two variables into the equation, however, neither showed any relationship to the dependent variable.

A second possibility is that the observed difference is due to autocorrelation within each sample. We have computed network autocorrelation equations for each sample, and we find that they do not appreciably change the OLS equations reported here. In no case is there significant autocorrelation.

d) Split-halves replication

For this replication we have included a randomly selected subset of the 77 cases in the first subsample and the remainder of the cases in the second subsample. The first subsample includes 18 societies from the Eastern half of the Old World and 21 societies from the Western half. The second subsample includes 20 societies from the East and 18 from the West.

For the two subsamples we find virtually identical regression coefficients, and all coefficients are statistically significant, except for the coefficient for the importance of agriculture, which is not significant for the first subsample. Results for the split-halves replication appear in Table 4. These results provide further support for the model.

Table 4. Results for Split-halves Replication. Ln(A) as Dependent Variable

constant	DRY	ANIMALS	PLOW	POPPRESS	AGIMP	R^2	
3.02	-.035 (.016)	-.095 (.045)	-.140 (.064)	-.015 (.046) not sig	.055	.44	First sample
2.83	-.036 (.017)	-.103 (.040)	-.167 (.073)	-.014 (.007)	.084 (.047)	.57	Second sample

Conclusions

We have used different regression methods to test a model of the causes of variation in the female contribution to agricultural subsistence. Three variables--length of the dry season, the importance of domesticated animals, and the presence of the plow--replicate well across the various tests. A fourth variable--population pressure--presents some problems in that it does not replicate across regions. A fifth variable--the importance of agriculture--does not replicate within regions, and may be measuring differences between Asian and Euroafrican agricultural systems. In both cases where the model fails to replicate, a more detailed study of differences in agricultural systems may lead to an explanation for the observed regional differences.

NOTES

1. The variables in the equation are defined as follows:

   Y The dependent variable, which we are trying to explain, in this case the aggregate female contribution to agriculture.

   X_i One of the independent variables from which we predict the dependent variable.

   B_i The slope of the regression of Y on X_i. This measures the form of the relationship between Y and X_i.

   Σ An error term. Variance which cannot be explained by this model.

   p The autocorrelation coefficient. In the absence of spatial autocorrelation it will be zero and the model is identical to the ordinary regression model. A high positive autocorrelation coefficient is mathematically equivalent to the situation of positive interdependence among cases that has been referred to in anthropology under the rubric "Galton's problem."

   W A matrix that measures the historical connections among societies. W_{ij} = the relative historical importance of society j to society i.

2. By doing linear regression with the log of the dependent variable we are in effect testing a Cobb-Douglas production function of the form

$$Y = KX_1^{c_1} X_2^{c_2} \ldots X_n^{c_n}$$

   where the dependent variable Y is a multiplicative function of the independent variables raised to powers that measure their relative importance to the production process. The production process is the involvement of males in agricultural production, and the independent variables are the various factors that involve males in agricultural production. We have found that we get consistently higher R^2 values with this equation than with the usual linear formulation.

   We have interpolated some missing cases on the sexual division of labor variables using the entailment structure of Figure 1. We use a maximum likelihood procedure to estimate the most likely value on some variable, such as crop tending, for which we have no information, given observed values for the other three division of labor variables, and given the known empirical relationship among the variables. We have only done this where we had missing data for a single variable, with observations on the other three.

3. The ordinary least squares R^2 values are adjusted for degrees of freedom, a procedure that lowers them by about 5%.

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