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The Plow, Female Contribution to Agricultural Subsistence and Polygyny: A Log Linear Analysis

Michael L. Burton and Karl Reitz[*]

Relationships among plow agriculture, female contributions to crop tending, and polygyny in the Standard Cross-Cultural Sample are examined here. Without controlling for world regions, a log-linear analysis would suggest that each of these variables is related to the other two. Introducing a control for region with a four-way contingency table, we find significant relationships between region and each of the three variables. Furthermore, the control for region eliminates the relationship between plow agriculture and the female contribution to crop tending. Theorists such as Boserup have claimed that women do less agricultural labor with intensive agriculture. This relationship is apparently not a valid one, but simply a consequence of the joint diffusion of the three variables throughout the Old World.
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Introduction

Ethnologists have long been interested in the relation-
ships between food production systems and different kinds of
marriage, descent, and social stratification.   Morgan's
(1877) classification of societies was related to stages of
domestication of animals and of agricultural intensifi-
cation.   Baumann (1928) discussed the relationships between
types of food production and types of marriage in African
horticultural societies.   Geertz (1963) and other cultural
ecologists have emphasized the differing consequences of
swidden agriculture and the more intensive forms of agri-
culture.   Boserup's discussion (1965, 1970) revolved around
the length of the fallow period.   She postulated population
pressure as the cause of change from long fallow agriculture
to short fallow agriculture.   Boserup said that women make a
greater contribution to long fallow agriculture than to
short fallow agriculture, and she also observed that
polygyny is more frequent in societies with long fallow
agriculture.   She noted the rise of social classes in short
fallow systems and the replacement of women agricultural
workers with male laborers from lower classes or castes.
Boserup's work coincided with an increased anthropological
interest in studies of sexual division of labor and of
women's status (Brown 1970a, 1970b; Burton, Brudner and
White 1977; Friedl 1975; Martin and Voorhies 1975; Murdock
and Provost 1973; Quinn 1977; Rosaldo and Lamphere 1974;
Sanday 1973; Schlegel 1977; White, Burton and Brudner 1977;
Whyte 1978).   Boserup's claim that population pressure
causes agricultural intensification has been controversial
(Bronson 1972; Barlett 1976; Cowgill 1975) but her
description of the social concomitants of extensive and
intensive agriculture has been generally accepted.

Agricultural intensification pertains to the process by
which increased yields are obtained per unit of land.   This
process can result from technological change, from increased
capital investment per unit of land, from increased labor
input per unit of land, or from any combination of the
three.   Many of the technical changes involve better ways
to water the land (terracing, irrigation) or to maintain

soil fertility (crop rotation, fertilization, pollarding). Capital investment includes permanently clearing the land, building fences, using draught animals or tractors, and constructing irrigation systems.   Geertz (1963) vividly described some of the ways in which labor intensification can increase rice yields.   These include transplanting and more careful harvesting.

It should be clear from this discussion that agricultural intensification is not a single process; that it is simply a convenient label for a variety of different processes that occur in different ecological circumstances.   In the literature, however, agricultural intensification has often been described in terms of two major types: plow agriculture and wet rice agriculture. For example, Barlett (1976: 124) says, "Theorists of agricultural change have come to recognize a general sequence from swidden horticultural methods to more intensive plow agriculture, and finally to labor intensive wet rice or capital intensive mechanized agriculture."   Netting (1977), by contrast describes a sequence of intensification among the Kofyar that does not involve the plow, wet rice, or mechanization; rather, intensification consists of increased manuring and terracing.   There are many systems of intensification that involve some set of conditions other than plow agriculture. Barlett herself describes one such system in Costa Rica.

Given the diversity of systems of intensive agriculture, one must ask whether there are any general consequences of agricultural intensification, or whether the outcomes that have been attributed to agricultural intensification are simply the specific consequences of one or more of such major types as plow agriculture.

Plow agriculture has been important to the historical civilizations of the Old World.   It is highly correlated with monogamous marriage systems, and payment of dowry rather than bride price (Goody 1976).   Furthermore, women rarely do plowing, a fact which may be attributed to a universal male monopoly over the care of large domesticated animals, both in agricultural and in pastoral societies. The male monopoly over plowing may have been generalized to other agricultural tasks, leading to depressed levels of

female participation in all agricultural activities. The
complex of traits that Boserup attributes to short fallow
agriculture--low female participation in agriculture
combined with monogamy--may be a specific consequence of
plow agriculture rather than of short fallow systems in
general. To date there has not been an empirical test of
the differences between plow agriculture and other forms of
agricultural intensification. We study here relationships
among plow agriculture, female contribution to agriculture,
and polygyny, as part of such a test. The sample consists
of 128 societies from the Standard Cross-Cultural Sample
(Murdock and White 1969) for which there is coded infor-
mation about polygyny, the presence of the plow, and the
female contribution to agriculture. Our goal is to dis-
tinguish between two competing theories of the cause of
monogamy propounded by Heath (1958) and Goody (1976).

Heath called his approach "economic functionalism."
Although he denied any intention to show that forms of
marriage were determined by economic factors, he showed
clear associations between the female contribution to
subsistence and two indices of the type of marriage. The
first index was a five-point scale ranging from polyandry
and monogamy at one extreme to three forms of polygyny
(sororal, limited, and general) at the other extreme. The
second scale contrasted dowry, minor gift exchange, and
informal exchange at one extreme to bride service, sister
exchange, and bride price at the other extreme. Heath found
strong associations between female contribution to
subsistence and both polygyny and bride price. Heath
interpreted these findings in terms of the value of women's
labor. When women's labor is valuable, their natal families
have to be compensated for the loss of their potential
economic contribution by payment of bride price, or by bride
service. When women's labor is valuable, it is also
economically advantageous for households to have several
adult women, as in polygynous households. Heath did not,
however, ascribe causation to the economic variables,
reasoning instead that economy, residence, form of marriage,
and other factors are connected in a functioning system.

Goody noted the empirical association between polygyny

and a high female contribution to food production, but claimed that this association is spurious. For Goody, the main causal variable is the rise of private property in land resulting from advanced agriculture. This rise leads to inheritance strategies designed to keep property within a close kin group, strategies that Goody called "diverging devolution." Goody defined diverging devolution as either the presence of dowry or partial inheritance of a man's property by his daughter or both. Goody claimed that this inheritance strategy is accompanied by homogamy, especially by marriage within social classes or castes. These homogamous marriages require a close match of the spouses' estates, which is supposedly difficult to achieve with a polygynous marriage system. Hence, diverging devolution leads to monogamy.

Goody's argument is reminiscent of Engels's famous argument (1972) concerning the origins of monogamy. Engels thought that human societies originally had a kind of primitive communism, and he interpreted the marriage customs of Australian section systems as examples of group marriage. He said that the progression from group marriage to monogamy began with the rise of private property, which was always monopolized by men. With private property, women came to be treated as commodities. Engels considered polygyny to be a brief stage in the transition to monogamy, a form of monogamy for women but not for men, in which men monopolized women's labor. Engels differed from Goody in his lack of detailed attention to property relations, but agreed with Goody in stressing the importance of property relations.

Goody's argument about the difficulty of matching property seems to be overly oriented to the marriage decisions of the upper classes. The difficulty of making an exact match is proportional to the value of the property. Members of royal families have more difficulty matching their estates than do peasants, yet monogamous societies are often monogamous throughout all social classes. However, there seems to be a second plausible reason why diverging devolution should lead to monogamy, an explanation formulated by Whyte (1978): this is that the payment of dowry would tend to delay the age of marriage of women.

Systems of general polygyny rely upon a fairly large age difference at marriage between men and women. Hence, widespread payment of dowry could act to inhibit polygyny.

Both Goody and Heath are concerned with explaining the conditions under which societies practice monogamy rather than polygyny. They differ in the importance placed upon agricultural intensification. For Goody, monogamy is a direct result of agricultural intensification, especially of plow agriculture. For Heath, monogamy could result from a change in the sexual division of labor without any corresponding change in the degree of agricultural intensification. Although these seem to be competing theories, it is possible that both are true. That is, either plow agriculture or a change in the sexual division of labor could act to cause a shift from polygyny to monogamy--the plow through its effect on property relations, and the division of labor through its effect on the labor value of women. If so, we would have a model as diagrammed in Figure 1.

White, Burton and Dow (1981) provide an example of other causes than agricultural intensification of change in the sexual division of labor. Using a sample of African agricultural societies, they find two causes of changes in sexual division of labor in agriculture. First, women do less agricultural labor when the main crops are cereals than when they are root crops. Second, women do less agricultural labor when there is slavery. These authors also find some confirmation for Heath's theory, in that the degree of polygyny bears a strong positive relationship to the female contribution to agriculture. Their paper does not deal with the relationship between plow agriculture and polygyny, since the plow is rare in Africa.

In this paper we test the model of Figure 1, using a multivariate technique, log-linear analysis, which allows for a test of all bivariate relationships among plow agriculture, polygyny, and female participation in agriculture, while controlling in each case for the third variable.

The data set consists of three variables from the Standard Cross-Cultural Sample (Murdock and White 1969). Degree of polygyny is a four-category variable from the data

Figure 1. Possible Causal Model for the Shift from Polygyny to Monogamy
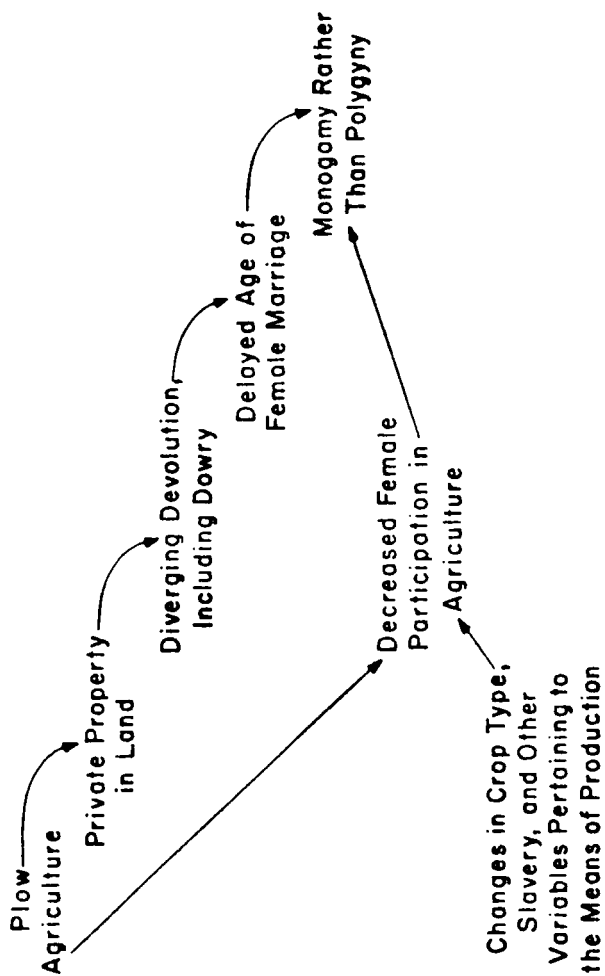
set on settlement patterns and community organization (Murdock and Wilson 1972); its four categories are polyandry, monogamy, limited polygyny, and intensive polygyny. The second variable, measuring the presence of the plow, is taken from Ethnographic Atlas (Murdock 1967) codes. As a measure of female participation in agriculture we use a variable from Murdock and Provost's (1973) study of sexual division of labor. Of the five variables in that study pertaining to agriculture, we use the crop tending variable. This choice is motivated by several considerations. First, across societies, crop tending is performed about as often by men as by women. It has the most balanced distribution of the agricultural variables. Second, crop tending is performed throughout the agricultural cycle, unlike such variables as planting and harvesting. Hence, it takes up more hours per year of labor, and can be presumed to be a more important task. Third, crop tending should be strongly affected by the presence of the plow, since the introduction of the plow decreases the need for weeding, one of the main tasks falling under the rubric of crop tending. Finally, there is some reason to think that women in polygynous societies allocate much of their agricultural labor to crop tending. The crop tending variable is highly correlated with the other four agricultural variables, and in a pretest the other variables showed similar relationships to those described in this paper.

Examining the bivariate relationships, we can see that there are strong correlations among the three variables. Gamma coefficients appear in Table 1. We see a strong negative relationship between the plow and polygyny, a negative relationship between the plow and female participation in crop tending, and a positive relationship between polygyny and female participation in crop tending. These relationships correspond to the theoretical predictions.

Given the observed pattern of bivariate relationships, one of the relationships could be spurious. For example, there could be no relationship between female participation in crop tending and polygyny once we control for the presence of the plow. The statistical relationship between these two variables could be solely a consequence of (a) the

Table 1. Gamma Coefficients for Bivariate Relationships.

	Plow	Polygyny	Female Participation in Crop Tending
Plow	1.00	-.70	-.49
Polygyny	-.70	1.00	.41
Crop Tending	-.49	.41	1.00

negative relationship between the plow and polygyny and (b) the negative relationship between the plow and female participation in crop tending. The log-linear model allows us to do a three-variable analysis to see whether all of the two-variable interactions are valid.

The Method

The Log Linear Model is based on the fact that the expected values of a contingency table are determined by a product involving the marginals of the table. If one takes the logarithm of such an equation, it can be expressed linearly. For example, in the standard test for independence of two dichotomous variables, the data are represented by a 2 X 2 contingency table, as in Table 2.

The expected values, m_{ij}, for each cell are given by the equation

$$m_{ij} = (X_{i+} * X_{+j}) / X_{++}$$

where

$$X_{i+} = X_{i1} + X_{i2}, \quad i = 1, 2,$$

$$X_{+i} = X_{1j} + X_{2j}, \quad j = 1, 2,$$

and X_{++} is the grand total. If we take the natural logarithm of this equation, we have

$$\ln (m_{ij}) = \ln (1/X_{++}) + \ln (X_{i+}) + \ln (X_{+j})$$

This equation indicates that under a model of independence

Table 2. A Two by Two Contingency Table

		Variable A Level 1	Level 2	
Variable B	*Level 1*	X_{11}	X_{12}	X_{1+}
	Level 2	X_{21}	X_{22}	X_{2+}
		X_{+1}	X_{+2}	X_{++}

of the two variables, the logarithms of the expected cell values can be expressed as the sum of a constant term (which in this case is $\ln (1/X_{++})$), a term involving a row effect $(\ln (X_{i+}))$, and a term involving a column effect $(\ln (X_{+j}))$. If we transform this equation in a manner which maximizes the constant term and writes the row and column effect as deviations from the constant term, it is possible to express the equation as follows:

$$\ln (m_{ij}) = u + u_{i(1)} + u_{j(2)}$$

where u is the constant term and $u_{i(1)}$, and $u_{j(2)}$ are the terms due to row and column effect respectively. The latter terms are constrained by the following equations:

$$\sum_i u_{i(1)} = \sum_j u_{j(2)} = 0$$

These terms or coefficients are used to define a particular model. The equation above states in a quick and elegant fashion the model in which variation in the expected values

is due to a row effect, a column effect, and no interaction between the two. Log linear equations of this type are directly analogous to analysis of variance equations. In the two-dimensional case of Table 1, eight different log-linear models are possible. These equations are listed in Table 3 with an abbreviated notation for each model and a 2 X 2 table which fits the model exactly.

A model is comprehensive if the defining equation contains terms involving every variable under consideration. In a complete model a higher order interaction between variables occurs only if all possible lower order terms involving those variables also occur. For example, only models 4 through 8 are comprehensive and only models 1, 2, 3, 7, and 8 are complete. Although theoretically possible, models which are not complete are of little practical interest, since it is not often that interaction involving a variable occurs without that variable having any effect by itself. The method of hierarchical log-linear equations involves only those models which are both comprehensive and complete.

Furthermore, models will be examined only as they appear in hierarchies. A hierarchy of models is a set of models in which each successive equation involves one more term than the one it supersedes. For example, equations 1, 2, 7, and 8 form a hierarchy whereas equations 1, 2, 3, 7, and 8 do not. However, only equations 7 and 8 are both complete and comprehensive. These two form the only possible hierarchy in two dimensions possessing all of the appropriate properties. These two models correspond to the two choices in a standard test of hypothesis for a contingency table in two dimensions--that is, the choice between independence and dependence of the two variables.

In the case of three or more variables, the selection of a hierarchy is much more complex. For example, in the case of three variables there are six possible hierarchies, starting with the model of complete independence of variables. One such hierarchy is given by the equation in Table 4. The notation to the right of each equation is again the abbreviated notation for each model. For example,

Table 3. Examples of Log-Linear Models

Equation	Notation	Example		
1. $\log (m_{ij}) = u$	none	25	25	50
		25	25	50
(no effect)		50	50	100
2. $\log (m_{ij}) = u + u_{i(1)}$	[1]	15	15	30
		35	35	70
(row effect)		50	50	100
3. $\log (m_{ij}) = u + u_{j(2)}$	[2]	15	35	50
		15	35	50
(column effect)		30	70	100
4. $\log (m_{ij}) = u + u_{ij(1,2)}$	none	15	35	50
		35	15	50
(interaction)		50	50	100
5. $\log (m_{ij}) = u + u_{i(1)} + u_{ij(1,2)}$	none	16	24	40
		36	24	60
(row effect + interaction)		52	48	100
6. $\log (m_{ij}) = u + u_{j(2)} + u_{ij(1,2)}$	none	16	36	52
		24	24	48
(column effect + interaction)		40	60	100
7. $\log (m_{ij}) = u + u_{i(1)} + u_{j(2)}$	[1][2]	9	21	30
		21	49	70
(row effect + column effect)		30	70	100
8. $\log (m_{ij}) = u + u_{i(1)} + u_{j(2)}$	[12]	15	25	40
$+ u_{ij(1,2)}$		45	15	60
(row effect + column effect + interaction)		60	40	100

Table 4. **A Hierarchy of Models**

1. $\log (m_{ijk}) = u = u_{i(1)} + u_{j(2)} + u_{k(3)}$ [1][2][3]

2. $\log (m_{ijk}) = u + u_{i(1)} + u_{j(2)} + u_{k(3)} + u_{ij(1,2)}$ [12][3]

3. $\log (m_{ijk}) = u + u_{i(1)} + u_{j(2)} + u_{k(3)}$
   $+ u_{ij(1,2)} + u_{ik(1,3)}$ [12][13]

4. $\log (m_{ijk}) = u + u_{i(1)} + u_{j(2)} + u_{k(3)}$
   $+ u_{ij(12)} + u_{ik(13)} + u_{jk(23)}$ [12][13][23]

5. $\log (m_{ijk}) = u + u_{i(1)} + u_{j(2)} + u_{k(3)}$
   $+ u_{ij(1,2)} + u_{jk(2,3)} + u_{ik(2,3)} + u_{ijk(1,2,3)}$ [123]

[12][23] designates the model in which interaction occurs between variables 1 and 2 and between variables 2 and 3, but not between variables 1 and 3.

A test of a particular model involves the computation of the expected values under that model and uses the likelihood ratio statistic G^2 as a measure of fit. G^2 is in most cases close to the standard chi-squared statistic, but unlike the chi-squared statistic it can be partitioned analogously to the partitions of the sum of squares in the analysis of variance. To compute expected values in models involving three or more variables, it is almost mandatory that a computer be available. The procedure for carrying out the computations can be found in Fienberg (1977), Reynolds (1977), or Bishop, Fienberg and Holland (1975). Various statistical packages such as the UCLA Bio-Medical Package include log-linear analysis.

Although the G^2 statistic and its significance level are computed for each model, it is of equal importance to compute a G^2 statistic for each difference between the successive equations in a given hierarchy. In this way it can be determined if the addition of an interaction term significantly reduces the differences between the observed data and the expected values. Because these differences are important to the choice of the final model, the choice of the hierarchy to be examined is important. Reynolds (1977) suggests that the choice of hierarchies be based on theories about the variables involved. Fienberg (1977) also suggests that, at least in the three variable case, one should look at all possible hierarchies and discern whether each results in the same selection of a final model--or if not, choose the hierarchy which explains the data in the most parsimonious fashion, i.e., the one with the fewest terms. Goodman (1978) describes several stepwise procedures which apply to only four or more variables. In the analysis presented here the methods of either Fienberg or Reynolds result in the same final model.

Data Analysis

The raw data for the log-linear analysis appear in Table 5. Table 6 gives the value of G^2, the likelihood ratio statistic, for each of the possible models starting with the model of complete independence, as well as the degrees of freedom and the significance of each. Variable C is the degree of female participation in crop tending, variable M the degree of polygyny, and variable P the presence or absence of the plow.

In normal hypothesis testing, the null hypothesis consists of a model which is accepted or rejected on the basis of a test statistic. If the test statistic is found to have a significance level of less than some value, say .05, then the null hypothesis is rejected; and if the significance of the test statistic is larger than .05, the null hypothesis is not rejected. In log-linear analysis the null hypothesis is analogous to a model as represented by its particular equation. However, what is different in this analysis is that the acceptance of a particular model is not simply determined by the significance of the test statistic computed for that model. This difference is illustrated by the results presented in Table 6. Note that the significance of the model represented by c) is P = .0686, which by normal standards would not be rejected. If the analysis stopped at this point, the conclusion would have to be that there is no relationship between the degree of polygyny and female participation in crop tending, when controlled for the presence of the plow. But, as indicated earlier, the analysis must include a calculation of the difference between models in a given hierarchy. This procedure also involves the partitioning of G^2 into its various components.

To carry out this analysis, an appropriate hierarchy must be chosen. It is known that the presence or absence of the plow is a powerful determinant of many social variables. Therefore it is reasonable to hypothesize that the degree to which women participate in crop tending and the degree to which polygyny is present will both depend on the presence of the plow. A hierarchy of models which includes these two

Table 5.   Three-Way Contingency Table

Degree of Polygyny
No Plow

Division of Labor in Crop Tending*	Monogamy	Polygyny ≤ 20%	Polygyny > 20%
M	2	7	3
N	2	7	7
E	1	8	3
G	5	15	8
F	2	8	19

Plow

M	5	5	0
N	2	3	0
E	4	7	0
G	1	1	0
F	0	1	2

*M = Male Only; N = Predominately Male; E = Divided Equally; G = Predominately Female; F = Females Only

interactions before including any hypothesized interaction between polygyny and crop tending would be appropriate. Such a hierarchy would be the one as represented by models labeled a), b), c), d), and e) in Table 5.   Note that the G^2 for each successive model in this hierarchy is less than the preceeding one.   The difference between each successive G^2 is itself a G^2 statistic.   These differences and their significance levels are presented in Table 7.

The value of P for each of the first three differences is well below .05 and therefore significant.   The last difference has a significance of only .58.   These results show

*Table 6.   Log-Linear Analysis for Crop
Tending, Polygyny and Presence of Plow*

	Model	G^2	d.f.	P
a)	[C][M][P]	66.50	22	.0000
	[CM][P]	41.17	14	.0002
	[CP][M]	44.60	18	.0005
b)	[MP][C]	46.97	20	.0006
	[CM][CP]	19.27	10	.0369
	[CM][MP]	21.64	12	.0417
c)	[CP][MP]	25.07	16	.0686
d)	[CM][CP][MP]	6.59	8	.5817
e)	[CMP]	0.00	0	1.0000

C = Crop Tending

M = Marriage Form
      (Polygyny)

P = Presence of Plow

Table 7.   Differences among Log-Linear Models

Difference between Models	G^2	d.f.	P
(a) and (b)	19.53	2	.0001
(b) and (c)	21.90	4	.0002
(c) and (d)	18.48	8	.0179
(d) and (e)	6.59	8	.5817

that there is indeed significant interaction between the
presence of the plow and the degree of polygyny (difference
between models a and b, and there is additionally signifi-
cant interaction between the presence of the plow and the
degree of female participation in crop tending (difference
between b and c).   Furthermore, even after these factors
have been taken into account, there is significant inter-
action between the degree of female participation in crop

tending and the degree of polygyny (difference between c and a). The last difference is between the model of all two-way interactions and the model of all possible interactions and is clearly not significant. This result can be interpreted in the following way. It is not necessary to hypothesize a difference in the relationship between the degree of female participation in crop tending and the degree of polygyny for the two groups of societies, those with the plow and those without. Stated another way, while there is significant relationship between female participation in crop tending and polygyny, this relationship does not change with the presence or absence of the plow.

Regional Replication

The three variables are strongly clustered by region. The plow is found almost exclusively in the Circum-Mediterranean and East Eurasian regions. Africa has much higher rates of polygyny than the other major regions of the world. And female participation in crop tending is also regionally clustered, with especially high female participation in Africa and especially low female participation in the Circum-Mediterranean. The extent of regional clustering can be seen by dichotomizing the world into two macro-regions: (a) the Circum-Mediterranean and East Eurasia and (b) Africa, the Insular Pacific and the Americas. Using this dichotomization, the gamma coefficients between region and the three variables are:

Presence of the plow	-.93
Crop tending	.52
Polygyny	.51

The first macro-region includes all of the classical civilizations of the Old World--Europe, North Africa, the Mideast, South Asia, Southeast Asia, and East Asia. This macro-region, compared to the rest of the world, contains most of the plow agriculture, and has much lower levels of polygyny and of female participation in crop tending. Given such

strong regional clustering, the relationships described
above could be spurious. For example, it is possible that
the relationship between crop tending and polygyny is simply
a consequence of the fact that both variables covary across
regions. Such a spurious relationship would be an example
of Galton's problem (Naroll 1970; Schaefer 1974). In order
to validate the previous analyses, it is necessary to test
whether the observed relationships pertain within regions.

Adding region to our model simply expands the log-linear
analysis from a three-way analysis to a four-way analysis.
Since East Eurasia and the Circum-Mediterranean region have
very similar distributions of the three variables, and since
the two Americas also have similar distributions of three
variables, we have reduced the number of regions to four by
merging these pairs. Our regional analysis has four cate-
gories: Sub-Saharan Africa; Europe, Asia, and North Africa;
Insular Pacific; and the Americas.

An increase in the number of variables in a multivariate
analysis has certain inherent difficulties. More variables
mean an increase in the complexity of the results, making
them more difficult to interpret. Also, for a given sample
size, more variables mean less observations per cell, which
in turn decrease the validity of the results. As we have
indicated, however, leaving out variables which may have
strong interactions with the variables already included may
result either in reporting spurious relationships or missing
valid relationships. Our examination of the bivariate
relationships between region and the other variables makes
it apparent that if we ignore regional effect we would be in
error.

With four variables there are 114 comprehensive and com-
plete models and far more hierarchies from which to choose.
A completely different strategy is necessary to choose from
among these models. There are a number of possible strate-
gies. The strategy followed here is one proposed by Bishop
et al. (1975). We consider models which include all terms
of a uniform order. The first of these models which fits
the data sufficiently serves as the starting point in a
second phase of the analysis. Next, we consider all models

which include only one less term than the starting model. For each of these new models we compute G^2 statistic along with its significance and we test the difference between the new model and the original for significance by computing the difference in the G^2 statistic.   If one or more of these differences is not significant, we eliminate the term with the least significance.   The analysis continues in the same manner, by testing this new model with all other models which include one less term than it does. We continue this procedure until a model is found in which no more terms can be eliminated.   We make a final check by attempting to add terms in the same manner in which they were deleted, only now we add them only if a significant reduction can be made in the G^2 statistic.   We select the model in which no further additions or deletions can be made as the final model.   This particular procedure has the disadvantage that the analysis must proceed through a number of stages and a large number of models have to be computed and inspected. It has the additional disadvantage that some models will never be considered.   For example, in an analysis which includes four variables numbered 1-4, the model represented by [123] [4] will never be considered.   It has the advantage, however, that the procedure is almost automatic and is easily followed.

This procedure is used to analyze the data with the inclusion of region as a fourth variable.   These data appear in Table 8.

Table 9 shows the first two models which include all terms of uniform order, with the G^2 statistic, and its significance. The labeling of the variables is the same as before, with R indicating region.

Note that the model which includes all two-way interactions fits the data very well. Table 10 shows that model along with all models which include one less two-way interaction.   After each such model the G^2 statistic of the difference between it and the first model is computed along with its significance.

From Table 10 it is apparent that only the term [CP]

Table 8. Data Disaggregated by Region

Region	Plow	Polygyny	Female Participation in Crop-Tending*				
			M	N	E	G	F
Sub-Saharan Africa	Absent	0%	0	0	0	0	0
		≤20%	0	0	2	1	0
		>20%	0	2	3	4	10
	Present	0%	0	0	0	0	0
		≤20%	0	0	0	0	0
		>20%	0	0	0	0	0
Circum-Mediterranean and Eurasia	Absent	0%	0	1	1	1	1
		≤20%	3	1	3	2	1
		>20%	2	2	0	1	0
	Present	0%	4	2	3	1	0
		≤20%	5	2	6	1	1
		>20%	0	0	0	0	2
Pacific	Absent	0%	0	0	0	2	1
		≤20%	1	0	0	6	6
		>20%	0	0	0	2	6
	Present	0%	1	0	0	0	0
		≤20%	0	1	1	0	0
		>20%	0	0	0	0	0

Table 8—continued

Region	Plow	Polygyny	Female Participation in Crop-Tending*				
			M	N	E	G	F
		0%	2	1	0	2	1
	Absent	<20%	3	6	3	6	1
		>20%	1	3	0	1	6
Americas							
		0%	0	0	1	0	0
	Present	<20%	0	0	0	0	0
		>20%	0	0	0	0	0

M = Males Only; N = Predominately Male; E = Divided Equally; G = Predominately Female; F = Females Only

Table 9. First Two Models, Log-Linear Analysis Including Region

Model	d.f.	G^2	P
[C][[P][M][R]	109	282.82	.0000
[CP][CM][CR][PM][PR][MR]	55	39.94	.9366

produces a non-significant increase in the G^2 statistic. The model without [CP] has a significance level of .8656 and therefore fits the data sufficiently well. Taking that model and first attempting to delete further terms, the analysis (not presented here) shows that no further deletions are non-significant. Since only one term has been deleted from the original model it is not necessary to attempt to add terms. The final model then is the model

*Table 10. Log–Linear Analysis Including
Region: Effects of Deletions*

Model*	d.f.	G^2	P
[CP][CM][PM][RP][CR][RM]	55	39.94	.9366
[CM][PM][RP][CR][RM]	59	47.20	.8656
Difference due to [CP]	4	7.26	.1230
[CP][PM][RP][CR][RM]	63	62.01	.5116
Difference due to [CM]	8	22.06	.0048
[CP][CM][RP][CR][RM]	57	46.49	.8386
Difference due to [PM]	2	6.55	.0379
[CP][CM][PM][CR][RM]	65	74.17	.2041
Difference due to [RP]	10	34.22	.0000
[CP][CM][PM][RP][RM]	68	73.59	.3008
Difference due to [CR]	13	33.64	.0014
[CP][CM][PM][RP][CR]	64	70.83	.2605
Difference due to [RM]	9	30.88	.0000

*C = Crop Tending; M = Marriage Form (Polygyny); P =
Presence of the plow; R = Region

represented in abbreviated form by [CM][PM][RP][CR][RM]--in
which region is related to all three other variables, mar-
riage form is related to both the plow and female participa-
tion in crop tending, but no relationship exists between the
presence of the plow and female participation in crop
tending. Our prior finding of such a relationship turns out
to be an artifact of the regional variation of these
variables.

This finding concerning the plow and female participation
in crop tending makes sense when we consider the results of
previous studies of the division of labor. These studies
have established that women never do plowing and that there
is an implicational relationship between female participa-
tion in soil preparation and female participation in crop
tending (Murdock and Provost 1973; Burton, Brudner and White
1977; White, Burton, and Brudner 1977). If women do soil

preparation, then they will do crop tending. These
implications can be restated in terms of male participation:
If men do crop tending, then they will do soil preparation,
and if there is the plow, then men will do soil preparation.
These statements together do not imply anything about the
relationship between plow agriculture and the sexual
division of labor in crop tending. Women are restricted
from soil preparation when plows are used because women do
not participate in tasks involving large domesticated
animals. However, crop tending does not involve large
domesticated animals, so there is no logical reason why plow
agriculture should have an effect on the sexual division of
labor in crop tending.

Conclusion

The bivariate relationship between crop tending and the
plow is an artifact of the regional distributions of those
variables. The Circum-Mediterranean and East Eurasia both
have high concentrations of plow agriculture combined with
low female participation in crop tending, and a low
incidence of polygyny. Without controlling for region,
then, it appears that there is a relationship between plow
agriculture and female participation in crop tending. These
two regions appear to have low levels of female participa-
tion in most activities. In Table 11 and 12 the relation-
ship between these two regions and the sexual divisions of
labor in harvesting and pottery making are tabulated. In
both cases, women have strikingly lower rates of partici-
pation in the Circum-Mediterranean and East Eurasian macro-
region than in Africa, the Insular Pacific, or the Americas.

The low rate of female participation in crop tending in
the Old World tends, then, to be a regional effect rather
than a direct consequence of plow agriculture. We think
this effect could be a consequence of the high rates of
female seclusion in Southern Europe, the Islamic world, and
the Indian sub-continent. Societies that seclude their
women by means of <u>purdah</u> or similar customs will have lower

Table 11. *Relationship between Region and
Sexual Division of Labor in Harvesting*

Sexual Division of Labor in Harvesting*

Region	M	N	E	G	F
Circum-Mediterranean and East Eurasia	8	20	16	7	1
Africa, Pacific, and Americas	2	17	18	27	25

Gamma = .65

Table 12. *Relationship between Region and
the Sexual Division of Labor in Pottery Making*

Sexual Division of Labor in Pottery Making*

| Region	M	N	E	G	F
Circum-Mediterranean and East Eurasia	8	3	4	1	14
Africa, Pacific, and Americas	6	2	2	5	60

Gamma = .60

* M = Males only; N = Predominately Male; E = Divided Equally; G = Predominately Female; F = Females Only

rates of female participation in activities outside of the immediate household. Whether the custom of female seclusion is itself a consequence of other social factors not included in this study, such as inheritance patterns (Goody 1976) or the presence of the state (Cohen 1969), or is due simply to the widespread diffusion in this region of religions that mandate female seclusion, or whether it is a combination of the two effects, awaits a future study. Use of network autocorrelation techniques (White, Burton and Dow 1981) should be helpful in solving that puzzle.

Our final model, then, appears in Figure 2. The log-linear model says nothing about the direction of relation-ships among variables. We have tentatively indicated directions of relationship. To summarize the current state of the theory: There are regional effects on the distribu-tion of all three variables. Controlling for those regional effects, we find that plow agriculture, as a form of inten-sive agriculture, leads to a shift from polygyny to mono-gamy, possibly through its effects on land ownership and inheritance, as was discussed by Goody (1976). In addition, high female participation in crop tending leads to higher rates of polygyny, as predicted by Heath (1958) and others. The two hypotheses about the causes of monogamy are not mutually exclusive, then, but both, in fact, appear to be true.

Figure 2. Final Model of Relationships among Variables
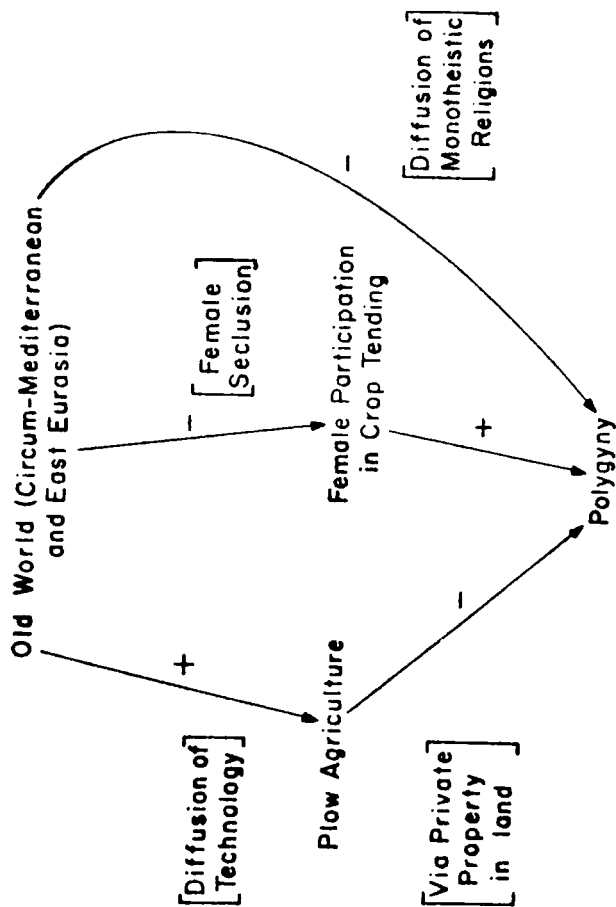
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