SEASONAL LABOR CONSTRAINTS AND INTRA-HOUSEHOLD DYNAMICS IN THE FEMALE FIELDS OF SOUTHERN CAMEROON.

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ABSTRACT

Women's agricultural production is modeled as a sequential switching regression process determined by men's clearing labor capacity and women's harvest labor capacity. Results show that output was more often constrained by husband's clearing labor. However, men's economic contribution to household consumption is inversely related to women's agricultural output.

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Seasons in nature derive from the cycles of change in the earth's climate, resulting from our planet's positioning in the solar system. Seasonality also has its roots in the social and religious traditions of a people, and there is often little that can be done to change this–in the short run at least. An understanding of seasonality and its impacts on the agricultural household's economy is, nevertheless, fundamental. Seasonal variation in agricultural production is usually associated with unevenness in resource requirements and in the output flow. The exact nature and extent of this problem, however, depends largely on the farm setting. For households in the humid forest zone, the problem of inter-seasonal variability is mitigated by the presence of bimodal rainfall patterns. These rainfall patterns allow for two cropping seasons per calendar year, thus reducing the length of any 'hungry' period. Even with this natural advantage, it is still necessary for households to alleviate the effects of variations–at the intra-seasonal, if not inter-seasonal levels–on production and resource use potential. In pursuit of these ends, households have been known to deliberately vary production through such techniques as inter-cropping, staggering or extending the planting period on either side of the biological optimum, sacrificing apparent yield advantages in order to smooth the household's seasonal output flow.

A twelve-month survey of rural households in the IITA humid forest benchmark in southern Cameroon was used for this study. The survey period–July 1996, to August 1997–covers a typical cropping calendar, which consists of two cropping seasons. The groundnut field is cultivated under a multi-cropping pattern, with an average of seven crops. However, in addition to being the prestige crop in the women's field, groundnuts are also the major crop in terms of labor allocation. This role, and the importance of labor in the cultivation of the crop, is why the groundnut crop is used to examine sequential decision making for the case area. Production data were multiplied by the share of groundnut revenue in order to obtain a measure of groundnut production data.

Groundnut seed is the greatest production expenditure on the field; however, almost all of seed input comes from the previous season's production. Commercial fertilizer or pesticide use is negligible, even when compared to usage on other household commercial food crop fields. The production system follows traditional patterns of cultivation, in terms of control and management of the field. This is evident in the decision making processes within the households presented in Table 1. It is clear that, in general, the men have greater control over the early stages of production up to the planting stage. In the later stages of production, the care and responsibility of the field rests with the women.

Table 1. Decision making by women in the groundnut field[a].

	Full	Partial	Joint	Little	No
Field location	52	4	31	3	44
Field size	61	5	21	7	40
Timing of field clearing	14	2	9	14	95
Timing of tilling	45	3	20	5	61
Timing of planting	114	6	5	0	9
Choice of crops	90	14	10	11	10
Timing of weeding	120	1	4	0	8
Timing of harvesting	94	11	12	4	9
Control of market surplus	106	4	16	1	7
Control of crop revenue	88	3	39	0	7

[a] The level of control over the final outcome of the discussion

Number of households = 135.

Source: Elad 1997.

Labor Input Decisions in a Sequential Production Model

The econometric approach employed here follows that of Antle (1983), Halvorson (1984) and Skoufias (1994). To simplify the presentation, it is assumed that the major output–the groundnut crop–is the determining factor in the women's decision process. We capture the sequential nature of the women's agricultural production by dividing the cropping cycle into two periods. In the first period, land preparation and cultivation are carried out using the men's labor for land clearing and female labor for planting. The planting labor and seed allocated to the field will thus, depend on the area of land cleared for cultivation by male clearing labor.

In the second stage, all prior information is used to determine the input allocations for harvesting, as the women use actual observations of the first stage output (the mature crop stands), not the initial expectations. Sequential dependence arises as the decisions made in stage one affect stage two, such that the second-stage output is explicitly modeled on the first-stage output and second-stage inputs. It is assumed that in each production stage the information is updated with information from the previous stage. Thus, the labor input in period two would be chosen so as to maximize the expected net revenue from the second stage output only since the first-stage output known with certainty at this stage.

In agriculture, the first-stage output is the mature crop stands, and is thus unobservable to the analyst. However, we can substitute the first stage production function into the second stage production function and the profit-maximizing condition (as a function of its inputs). It is then possible to solve for the profit-maximizing first and second-stage input demand and output supply. This reduces the model into a system of simultaneous equations consisting of the two input demand and one output supply equation. The sequential production thus described is generally non-linear. However, by assuming the existence of functional separability between the two stages of production and a Cobb Douglas functional form, the implied additive errors allow for a tractable estimation of the equations (Antle, 1983).

LABOR CONSTRAINED PRODUCTION USING THE SWITCHING REGRESSION METHOD

The characterization of African farming systems as being one of low labor input utilization is at odds with the concern for manpower shortages expressed by most African farmers. This analysis, therefore, attempts to reconcile these concerns, with respect to the women's groundnut field. A two-stage switching regression with separation points unknown is employed to elicit production response to labor constraints at the different stages of farm production. To purge from the production function shocks and other "fixed effects", econometric results from the sequential production are used in the switching regression.

Under this scenario, observed output from the groundnut field is the minimum output associated with either clearing-labor constrained production (stage one) or harvesting labor-constrained production (stage two). Implicit in this presentation is the assumption that there is no substitution between the labor inputs to the two stages of production. The sequential and gender-differentiated nature of production ensures that our assumption holds. Using the log-linear Cobb-Douglas functional form, the model can be estimated using the maximum likelihood estimation procedure. The likelihood function is the unconditional normal density function of observed output, which is simply the sum of the normal density functions of output associated with clearing labor and harvesting labor, multiplied by their respective probabilities. The advantage of using a switching regression with unknown separation points is that the model itself determines the probabilities with which each observation of output is constrained by either land-clearing or harvesting labor.

RESULTS OF THE LABOR INPUT DECISIONS IN A SEQUENTIAL PRODUCTION MODEL

The major concern of this paper is with the allocation of labor to groundnut field production, the discussion on the sequential labor input decision will be limited to the labor input decisions equations. The shadow wages for male and female agricultural labor were constructed from an earlier estimation of the household production model for the humid forest zone, using the aggregate price indexes for male and female output (Elad, 1999). These shadow prices (indexes) of labor can be viewed as the proportional increase in the marginal value of labor to the i^{th} household, given the input and output price indexes and production technology of the sample mean. That is, the shadow prices can be viewed as implicit wage comparisons with production technology controlled to be equal.

Clearing Labor Input Decision

The impact of the field size variable was negative and significant, meaning that the time spent clearing the field decreases proportionately as the size of the field increases (Table 2). That is, larger fields generally require more time to clear from forest or fallow. By burning first, the labor required to clear the land is reduced considerably, allowing more time spent clearing cocoa fields or the men's own food crop fields. The inverse relationship between seed price and clearing labor implies that the inputs are complements rather than substitutes to the production process. Within the sequential decision making framework, the seed input price, as well as the "price" of clearing labor, are known in stage one (the pre-planting stage). Therefore, it is possible to adjust the demand for clearing labor input according to the level of seed input available.

The demand for male clearing labor was found to increase with its wage rate. The implicit shadow wage rate as defined in the previous section is the proportional increase in the marginal value of agricultural labor to the i^{th} household given the input and output prices and production technology of the sample mean. As the marginal productivity of men's agricultural labor increases, the time spent clearing women's fields becomes relatively expensive; hence, it would be reasonable to expect that men would allocate less time to women's fields and more time to their own fields. However, it has been observed that men's output response to increased output price revealed the "income" effect to outweigh the "substitution" effect (Elad, 1999). That is, increased revenue associated with higher prices would lead to greater consumption of leisure than an increase in labor input to men's agricultural production. It is, therefore, possible that the decrease in labor input to male production is reflective of an increase in male labor available to the women's fields.

Harvest Labor Input Decision

At the harvesting stage, seed input price and weeding labor supplied to the field were the only factor inputs that were significant in determining the labor use. In this stage, harvest labor is based on the level of inputs previously invested in the field. Thus, a direct association would be expected between the outlay of weeding labor and the harvest labor. Relative to clearing labor, the harvest labor response to weeding labor is more elastic. Thus, despite the fact that weeding takes place during the period when there is the least number of conflicts on female labor, it is still an important activity in the farming process. If harvest labor can be considered as an implicit measure of measure of output, then a one percent increase in weeding labor is associated with approximately a 0.5 percent increase in harvest labor.

The demand for harvest labor was observed to decrease with seed input price, just as did the demand for clearing labor in response to seed input price. A negative association would be plausible because the initial outlay of clearing labor is expected to be directly related to the level of harvest labor in the second stage. The magnitude of this harvest labor response to increase in seed input price is noteworthy (Table 2). The change in seed input prices generates the largest response in the demand for harvest labor. A one percent change in seed input prices being associated with an almost one percent decrease in harvest labor. This reduction in harvest labor can be expected to have a considerable negative impact on the household's total yields. Further, unlike the clearing labor (male) shadow wage, the female (harvest) wage rate was found to have no effect on harvest labor. This relative lack of importance of female labor relative to male labor is in line with other studies that find the marginal value of female agricultural labor to be relatively lower than that of men (Tshibaka, 1992; Singh, 1988).

The husband's contribution to the household's cash consumption is hypothesized to relax of the woman's labor constraints, as fewer work hours are required to meet household consumptive needs. Its positive estimated impact on harvest labor, however, indicates the contrary. Higher levels of contribution are directly associated with higher income from the men's activities–primarily agricultural. Thus, the larger the scale of agricultural activities the men are involved in, the less time will be available to participate in harvesting in the women's fields. The required labor for harvesting will then have to be supplied by women through longer work hours. The fields cultivated by households with land surplus, the demand for harvest labor is significantly lower for households in a relatively more resource-constrained environment. This further supports the earlier findings that the perception of land surplus is associated with low resource pressure and hence less intensive production (Elad, 1999).

RESULTS OF LABOR-CONSTRAINED PRODUCTION USING THE SWITCHING REGRESSION METHOD

The model was estimated first with the assumption of no correlation between clearing labor-constrained production and harvesting labor-constrained production, and then with the assumption of correlation between both equations. The correlation factor was significant throughout; therefore, only the results of the models in the presence of correlation are reported. Ordinary Least Squares (OLS) estimates were used as starting values in the maximum likelihood estimation (MLE) after which, the probability that clearing labor is a constraint to output on the groundnut field was calculated for each observation. This was simply the probability that the observed output belongs to the clearing labor-constrained production model.

In evaluating the results of the labor constrained production model, we start by allocating the probability associated with each observation on output to either the clearing labor-constrained production or the harvest labor-constrained production. On the basis of $\pi < 0.5$ indicating the observation belongs to the clearing labor-constrained production equation, on 179 fields, production was constrained by clearing labor (81.36 % of the sample). MLE results are presented in Table 3. The switching regression likelihood function can be viewed as a disequilibrium likelihood function that allocates sample observations to different regimes based on their likelihood of occurrence within the particular regime (Portes and Winter,1980). If one regime dominates another in a particular scenario, then the alternative regime is, in effect, estimated on a small subset of the observations. Consequently, estimates of the coefficients associated with the recessive regime will be relatively poorly determined. This further lends credence to the fact that modeling production as sequential decision making is a superior alternative to the single-stage modeling of agricultural production decisions on the groundnut field.

Clearing Labor-constrained Production

By the definition of the switching regression process, negative parameter estimates imply that the corresponding variables are “over employed” in the particular regime. Conversely, the positively signed parameters correspond to variables that are “underemployed”(Halvorson, 1984). It is, therefore, not surprising that the clearing labor is underemployed in the clearing labor-constrained production regime. The highly elastic output response to clearing labor (supplied by the men) supports the fact that the men have more control and flexibility over the use of their labor. It could also be said that the amount of male clearing labor employed in the women’s fields is such that each additional unit provided results in more than a proportionate increase in output. Field size is directly related to clearing labor; therefore, the parameter estimate for field size demonstrates a similar impact on output as did that of clearing labor. The results also demonstrate that, under clearing labor-constrained output, weeding labor and seed input are “over-employed”.

With respect to the household decision variables, the husband’s contribution to daily consumption, as expected, was inversely related to output, reflecting the competing demands on men’s clearing labor. Substitution of male children’s labor for male adults’ labor tends to occur as the women (men) get older. This seems to be associated with a negative effect on output in the clearing labor regime. The parameter estimates associated with perception of land surplus reveals a positive shift effect on output; that is, when output is constrained by clearing labor, households in a perceived land surplus environment could increase output by increasing the clearing labor. Given that land surplus is associated with low resource use, this result is to be expected, as men are less likely to feel the need to intensify production.

Harvest Labor-constrained Production

The negative sign of the field size parameter implies that the variable is "over-employed" (or larger than the woman can effectively harvest) in the harvest labor-constrained regime. Output response to harvest labor is, however, of great interest. The fact that the harvest labor-constrained production regime presents the impact of the explanatory variables when harvest labor is limiting would imply that harvest labor is underemployed in this regime. But the negative and highly significant response of output to harvest labor indicates that, despite the fact that output is limited by the amount of harvest labor available for production, the use of harvest labor is such that the marginal value of its output is less than the marginal value of harvest labor. The results also reveal that for households living in a land surplus environment, harvest labor is more of a limiting factor than clearing labor. The same can be said when women supply most of the labor to their fields.

CONCLUSION

The results demonstrate that variables typically excluded from household production analyses, such as the gender-based sequencing of agricultural activities and intra-household resource allocation patterns are in fact crucial determinants of household economic activity. These same variables, in particular sequential application of household agricultural labor, represent features of the household most likely to be influenced by economic change. The issue of seasonality and food production capacity of the household is similar to that of the chicken-and-the-egg. From an economic point of view, it is difficult to put a high price on a person's time when it is rather obvious that it is not very valuable. Nonetheless, it is necessary to respect human time and potential if it is to be nurtured through investments to foster economic development. Our findings demonstrate that such nurturing should start with investments in labor-saving technologies tailored towards the production systems of rural households, especially in land clearing and harvesting and post-harvesting technologies. These technologies, when targeted towards improving the returns to seasonal labor as well as efficient use of other inputs, would go a long way towards increasing the productivity of all household members agricultural labor.

The mention of investments always brings up the question of who pays for what. However, increasing agricultural productivity is integral to overall economic growth. Different households would obviously have different production technologies, and different needs and capabilities, with respect to modifying their farming practices. An advantage of the benchmark approach is that it provides a one-shot view of the gradual effects of increasing resource intensification. By taking advantage of observable resource management domains, the benchmark offers a relatively less expensive method of streamlining technologies only to those that have both immediate and long-term benefits.

These technologies would not be attractive to the agricultural households, if there is no means for them to recover the benefits from increased productivity. The challenge for policy makers in the short-run, therefore, is to stimulate the household’s sales (and production) of food crops. Our multi-season structure provides significant insight into the household dynamics surrounding the allocation of household agricultural labor and the effect on production. Important implications for the design of policies include, in addition to a greater need for access to capital inputs, a more realistic measure of the household’s response to theses policies, especially when considered with the fact that gender roles impart serious rigidities on the total deployment of family labor.

Table 2. Parameter estimates for the labor demand equations from the non-linear Cobb-Douglas sequential production model.

Variable	Clearing labor Parameter estimates[a]		Harvest labor Parameter estimates[a]	
Constant	4.69**	(1.84)	-3.03	(3.73)
log of field size	-0.42**	(0.12)	0.06	(0.34)
log of weeding labor	0.02	(0.17)	0.50**	(0.19)
Log of clearing labor	–	–	-0.19	(0.77)
log of clearing wage rate	0.57***	(0.23)	–	–
log of harvesting labor	0.41[1]	(0.35)	–	–
log of harvest wage rate	–	–	0.27	(0.29)
log of clearing wage rate	0.57***	(0.23)	0.73***	(0.26)
log of seed input price	-0.52*	(0.29)	-0.95**	(0.48)
Clearing date	0.03	(0.05)	-0.08	(0.07)
Cropping density	0.06[1]	(0.04)	0.01	(0.07)
Cropping season	-0.18[1]	(0.16)	0.24[1]	(0.20)
Husband's contribution	-1.85E-04	(3.69E-03)	6.41E-3	(0.01)
Household size	-0.02	(0.03)	-0.01	(0.04)
Owner's age	3.57E-03	(0.01)	7.74E-03	(1.04E-02)
Land surplus	0.14	(0.23)	-0.52**	(0.27)
Owner supplies most labor	-0.1	(0.18)	0.24	(0.26)

[a] standard errors in parentheses. ***implies significant at 1 %; ** implies significant at 5 %; * implies significant at 10 %.

[1] implies not statistically significant but of economic importance.

Table 3. Parameter estimates for labor-constrained production from the switching regression model.

Variables	Ordinary Least Squares Parameter estimates[a]		Maximum Likelihood Parameter estimates[a]	
Clearing Labor-constrained Production				
Constant	-6.52***	(1.02)	-8.59***	(1.22)
Log of field size	0.85***	(0.08)	1.12***	(0.10)
Log of seed input	-0.10	(0.09)	-0.38***	(0.14)
Log of clearing labor	2.08***	(0.08)	2.57***	(0.15)
Log of weeding labor	-0.41***	(0.04)	-0.50***	(0.06)
Husband's contribution	-9.46E-03***	(1.48E-03)	-1.13E-02***	(1.97E-03)
Owner's age	-2.51E-02***	(3.79E-03)	-3.17E-02***	(5.75E-03)
Land surplus	0.20***	(0.09)	0.48***	(0.14)
Owner supplies most labor	-1.41E-03	(0.10)	0.16[1]	(0.15)
F-value	84.71***			
R-sqr	0.75			
sigma(1)-clearing			0.57***	-0.07
Harvest Labor-constrained Production				
Constant	5.37***	(1.82)	8.06***	(2.10)
Log of field size	-0.04	(0.14)	-0.36***	(0.15)
Log of seed input	0.29	(0.19)	1.16***	(0.22)
Log of harvest labor	0.10	(0.16)	-0.80***	(0.15)
Log of weeding labor	-0.04	(0.10)	0.19*	(0.11)
Husband's contribution	-1.26E-03	(3.12E-03)	-5.67E-03**	(2.47E-03)
Owner's age	-2.20E-03	(7.49E-03)	1.24E-02[1]	(8.65E-03)
Land surplus	-0.34*	(0.20)	-0.62***	(0.18)
Owner supplies most labor	-0.16	(0.21)	0.02	(0.15)
F-value	1.52*			
R-sqr	0.02			
sigma(2)-harvest			0.70***	
RHO			-1.00***	
Log-likelihood			-153.05	

[a] standard errors in parentheses. ***implies significant at 1 %; ** implies significant at 5 %; * implies significant at 10 % .

[1] implies not statistically significant but of economic importance.

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