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OFF-FARM INCOME AND THE FARM-HOUSEHOLD
The Case of Kenyan Smallholders

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Summary

Although off-farm employment raises cash incomes and dimishes the time available for on-farm activities, no shift towards less labour intensive or more cash-intensive crops is observed in a survey, collected by Bevan, Collier and Gunning in Kenya in 1982. Increased use of purchased inputs, including hired labour, for tree crops and food production is, however, assessed. Family labour input into these activities is reduced due to time and income effects. A log-linear model shows the tendency of a trade-off between off-farm employment and the growing of cash-crops. Food production is hardly affected, unless women take up off-farm employment.

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1 Introduction

This paper deals with the effects that off-farm income can have on agricultural production and family labour input. By itself, more non-agricultural income should increase the demand for 'leisure' on the farm and reduce labour hours. If non-agricultural income is earned by supplying off-farm labour, on-farm labour supply is reduced further. Thus two of the endowments to the farm household are affected: cash resources increase and available family labour decreases. From an endowments point of view the cropping pattern should, therefore, change towards more cash-intensive and less labour-intensive crops. And to the extent that there was an actual cash-constraint facing the farmer, this is relieved by off-farm income. This should lead to direct adjustment of the use of purchased inputs.

Collier and Lal (1980, p.22) stress the need for more income.

> non-farm income is likely to be the most important element in the ability of smallholders to break the financial constraint, which inhibits both innovation as well as purchases of farm-inputs (to the requisite level).

They suggest a causal link, running from better education via more off-farm income to more input use and more profitable crop choice and, eventually,

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higher farm incomes. Their main focus is on off-farm income earned by farm family members who leave the farm and remit part of their income to the family. Higher farm incomes would follow from the adoption of hybrid maize, requiring more cash inputs, and of tree crops and improved cattle, requiring cash investments. Collier and Lal (1986) quote (p. 259) an overall production function estimation based on 1974/75 data to show that total crop production, besides being related to land, labour and other inputs and education, was indeed positively related to non-farm income.

The relationship between off-farm incomes and investments in agriculture, notably in tree crops was investigated by Bevan, Collier and Gunning (see Bevan *et al.*, 1989), using a survey held by them among smallholders in Central and Nyanza Provinces in Kenya in 1982. Reference to this book that also provides details on the sample will be abbreviated to 'BCG'.

The focus of this paper, using the same data base, is on the short term changes that are apparently resulting from enhanced off-farm earnings. Among these changes are the increased use of purchased inputs, resulting from a liquidity-constraint being relieved by extra income. In addition, the cropping pattern is expected to change towards crops that use more cash inputs and less labour per unit value of output. In Kenya, these are typically the characteristics of cash crops, including coffee and tea and tobacco, sunflower and sugar cane. Pyrethrum is another cash crop that uses little labour input, but also little cash inputs.

A change from food crops to cash crops would signify a change from a crop that is also consumed on the farm to one that can only be sold. Food crops are only sold in minor proportions. If this is due to the marketing environment of the farm, like high costs involved in marketing these crops, then a change towards cash crops, although rational in view of the change in endowments, may not be preferred by the household. The cash income from crops would be added to the cash income from off-farm sources. If cash is not believed to be readily exchangeable for food, or if the availability of consumer items in the market is limited anyhow, then the household may envisage a substantial decrease in marginal utility of cash income and opt not to go for cash crops. This may also result from a strategy to avert food-risks. If food crop yields are unexpectedly low, locally marketed surpluses tend to go down relatively more than production. If prices are dependent on local supply and demand, these tend to move up by an even higher percentage. In such environment, growing food crops may well have a higher expected utility than growing cash crops, even if these are on average more remunerative. Cross-section data as employed here do not provide sufficient information on farmers' expectations, however.

Table 1 provides a global overview of the differences between farms in the BCG-survey with off-farm income and those without. The off-farm incomes used here includes remittances and earnings from wage jobs and profits from business undertakings held by on-farm household members. From the Table it is clear that the households *without* off-farm income grow more cash crops (both tree crops and other), that the use of purchased inputs, including hired labour, for these crops does not differ much and that gross margins per unit labour or land tend to be higher for those without off-farm income. As to cereals and other food crops, the major difference appears to be a higher use of inputs on farms with off-farm incomes. These farms tend to sell more of their 'other food' production. Finally, although the share of food crops in total production value is much lower on the average farm without off-farm income, the frequency of occurrence of these crops (90 and 75 per cent) is not much reduced.

Limiting the population to the farms without any cash crop, forming about half the total population in the sample, leads to the surprising result that those without off-farm income use relatively more purchased inputs for food crops (12 vs. 7 per cent of pure-stand production values), without any other marked difference in the tabled variables.

At first sight, therefore, the use of inputs and a shift to crops that require more purchased inputs seems not positively correlated with off-farm income. In section 4 of this paper some estimates will be presented of the relationships between input use and off-farm earnings, where more variables than just income are taken into account. In section 5 the cropping pattern and its relationship to off-farm income will be investigated further.

Before that, the question is asked whether off-farm income can be considered as determining the cropping pattern or whether it is *vice versa*. One obvious explanation of the findings of Table 1 is that only the poor farmers have off-farm income. It will be shown in section 3 that this is not so. Off-farm income represents an important part of total farm income and off-farm jobs are more rewarding than growing almost any agricultural crop.

The results are summarized, and conclusions are drawn in section 6. First, section 2 discusses some basic theory.

Table 1: Farms without and with off-farm income

	without		with	
Shares in total crop production value and percentage growers				
cereals	28	(90)	41	(95)
other food	22	(75)	25	(71)
coffee, tea	27	(55)	20	(32)
other cash crops	23	(17)	14	(32)
cereals, pure stands				
percent* sold		24.0		17.0
percent* inputs pur'd		11.0		15.0
margin per hour fam lab (sh)		1.7		1.7
margin per hectare (sh)		664.0		610.0
other food, pure stands				
percent* sold		20.0		34.0
percent* inputs pur'd		7.0		14.0
margin per hour fam lab (sh)		1.5		1.7
margin per hectare (sh)		814.0		732.0
coffee, tea				
percent* inputs pur'd		35.0		34.0
margin per hour fam lab (sh)		1.8		1.8
margin per hectare (sh)		1692.0		1731.0
other cash crops				
percent* inputs pur'd		25.0		23.0
margin per hour fam lab (sh)		9.7		4.6
margin per hectare (sh)		3186.0		1764.0
all crops				
percent* inputs pur'd		23.0		22.0
margin per hour fam lab (sh)		2.3		1.9
margin per hectare (sh)		1252.0		873.0

* of corresponding production value

source: BCG survey 1982

2 Theory

Let the basic model be as given in Barnum and Squire (1980), but with the addition of non-farm income, and assuming 'leisure' to enter the utility function as the share of total time, rather than the absolute amount.

$$\max u(yr + f(\ell, a), \frac{t-\ell}{t}), \tag{1}$$

where t is total working time available, yr is unearned income, say from remittances and considered exogenous, and the value of agricultural production f is a function of ℓ, family labour and a, land. Family's relative leisure time $(t-\ell)/t$ enters the utility function as a second argument. The first-order condition is

$$u_1 f_1 - \frac{u_2}{t} = 0 \tag{2}$$

with subscripts denoting partial derivatives. This is a maximum if the second-order condition is met:

$$D = u_{11} f_1^2 + u_1 f_{11} - \frac{u_{12} + u_{21}}{t} f_1 + \frac{u_{22}}{t^2} < 0 \tag{3}$$

The optimal ℓ would change when yr, a, or t would change. The change is given by

$$\begin{aligned} d\ell &= -D^{-1}[(u_{11} f_1 - \frac{u_{21}}{t})dyr + ((u_{11} f_1 - \frac{u_{21}}{t}) f_2 + u_1 f_{12})da + \\ & (\frac{u_{12}}{t} f_1 - \frac{u_{22}}{t^2} + \frac{u_2}{t\ell})\frac{\ell}{t} dt] \end{aligned} \tag{4}$$

Equation (4) shows that ℓ would decrease when yr increases, unless the change in marginal utility of leisure, given by u_{21}/t, is highly positive. On farms with surplus labour u_{21} tends to be low and t is relatively high, so that in general we would expect ℓ to decrease for increasing yr. The effect of a change in a on ℓ is f_2 times the income effect, augmented by the effect of a change in the marginal product of labour, weighted by the marginal utility of income. As the latter effect tends to be positive and large compared to the former term, the sign of da is likely to be positive. A change in t, finally, would induce a change in ℓ, probably dominated by the term containing u_2 and therefore positive.

If yr is not exogenous, but consists – at least in part – of income that is earned by allocating time to a wage job that is competitive with farm work, the model becomes

$$\max u(yr + w\ell_j + f(\ell_f, a), \frac{t - \ell_j - \ell_f}{t}). \tag{5}$$

where ℓ_j is the time allocated to the off-farm job and w the wage rate. The optimum allocation of labour results from the first-order condition that $w = f_1$, which does not depend on the parameters of the utility function. Changes in labour allocation to farming, given the exogenous wage w, would be due only to changes in area

$$d\ell = -\frac{f_{12}}{f_{11}}da \tag{6}$$

If there are two crops and land and labour are optimally allocated over the two, the optimizing model is

$$\max u(yr + w\ell_j + f(\ell_f, a_f) + g(\ell_c, A - a_f), \frac{t - \ell_j - \ell_f - \ell_c}{t}), \tag{7}$$

where g represents the production value of the second crop to which ℓ_c is allocated and A is total area. First order conditions for ℓ_j, ℓ_f and ℓ_c and a_f lead to

$$d\ell_f = -\frac{f_{12}\Gamma}{g_{11}\Phi + f_{11}\Gamma}dA \tag{8}$$

$$d\ell_c = -\frac{g_{12}\Phi}{g_{11}\Phi + f_{11}\Gamma}dA \tag{9}$$

where Γ and Φ are the determinants of the matrix of second-order derivatives of g and f, respectively. For concave production functions (and two inputs) these determinants are positive, and g_{11} and f_{11} are negative, so that for positive cross-derivatives, both ℓ_g and ℓ_f increase when total area increases. Here, w has been kept fixed. Total available time or exogenous income do not influence the labour allocation, as its marginal product is fixed by the wage rate w.

For households without off-farm employment opportunities, or when total available employment is less than the optimal amount, so that ℓ_j is restricted (to 0 is the first case and to ℓ_j^r, say, in the second case), the model simplifies to one with exogenous income (yr in the first case and $yr + w\ell_j^r$ in the second) and only three first-order conditions remain

$$\begin{aligned} u_1 g_1 &= u_2/t \\ u_1 f_1 &= u_2/t \\ u_1 g_2 &= u_1 f_2 \end{aligned}$$

from which ℓ_f and ℓ_c cannot be solved without involving parameters and arguments of the utility function.

As indicated by the optimisation over the area allocation, the model assumes perfect land mobility. Often this is not the case. Examples are land under tree crops or land with specific soil characteristics. Then the first-order condition for the allocation of land need not hold in a particular year. Some farmers may be in the process of switching toward such cash crops, others may regret their original allocation of land to tree crops but find it unprofitable to uproot the area now, because of the cost of uprooting or because there is hope for higher profits in future. In these cases, only the first-order condition for labour allocation provides a link between the allocation of labour to each crop. When the two crops do not require labour effort in the same season, however, even this last link is rather weak and household characteristics and endowments play a role in the allocation of time in a way specific to each crop.

In the first argument of the utility function all sources of income appeared in an additive manner, implying that they are perfect substitutes. If there is a margin between buying and selling prices of food crops or if the revenues from producing one crop are more uncertain than those of another crop or of non-farm income, then this will not hold.

In the former case the marginal rate of substitution between cash income and food will not be equal to the market price of food in those cases, where the optimum allocation of the resources is the corner solution with shadowprices lying in between the buying and selling prices.

In the latter case the uncertainty in food yields or selling prices may induce a shift towards the more certain off-farm income, but if this is restricted, then the effect of uncertainty on the time allocated to food production is ambiguous: the more risk averse the farmer is, the greater the probability that more resources will be allocated to food production. When risk aversion decreases with income, this effect will be stronger for those without off-farm income than for those with substantial (exogenous) income. Both cases, the price gap between buying and selling of food and uncertain yields, lead to household considerations having an impact on resource allocation.

Finally, cash incomes and the value of food production may not be considered as full substitutes, because the process is different. Food production takes time and expenses for inputs such as seed, fertilizer and hired labour for ploughing are incurred months before harvest time. In the absence of a credit market, availability of off-farm employment or the growing of a cash crop enhances the opportunities to purchase or hire these inputs. This can be incorporated in the models above if food production is considered differently from wage employment. Consider the following model

$$\max u(w\ell_j - m, f(\ell_f, a, m), \frac{t - \ell_j - \ell_f}{t}), \tag{10}$$

where m is purchased inputs and food production is now a different argument in the utility function. The first-order condition for optimal m is

$$-u_1 + u_2 f_3 = 0, \tag{11}$$

so that m will be used up to the point where its marginal product equals the marginal rate of substitution between cash income and food. Optimal allocation of labour implies that $u_1 w = u_2 f_1$, from which follows that $f_1 = w f_3$. This establishes a condition for the input of family labour and purchased inputs in which the parameters of the utility function do not appear. But only if cash income and the value of food production are complete substitutes will both inputs be independent of these parameters.

If off-farm employment is restricted to ℓ_j^r, say, then, at that point, $u_1 w > u_3/t$, with u_3/t being the marginal value of leisure, and since $\frac{u_3}{t} = u_2 f_1$, $f_1 < w\, u_1/u_2$. If this restricted income also restricts the use of inputs, $-u_1 + u_2 f_3 > 0$ so that $u_1/u_2 < f_3$, and certainly $f_1 < w f_3$. Thus, marginal products of labour input will be lower and that of purchased inputs higher than in the case with no restriction. The effect on the amount of food produced depends on the relative sizes of the changes and the shape of the production function. In this case, it was assumed that the marginal utility of input use is positive but its use is restricted by the availability of cash. We should expect that as soon as income increases, m would increase. Another case in which m will be restricted to zero is the condition that at $m = 0$, the marginal utility of its use is negative, or $-u_1 + u_2 f_3 < 0$, due to a very high marginal utility of income or a low marginal return to input use. In this case, an increase in income (say through an increase in $w\,\ell_j^r$) would not immediately lead to positive m. Although u_1 should go down, it may take a substantial increase in income before the marginal utility of input use is positive at $m = 0$. This would certainly be so if u_2 would go down as well, which would occur if cash income and food production are close substitutes.

Summarizing the above discussion, farm production will not depend on parameters of the utility function if off-farm work is available at given wage rates or if other farm inputs are available and the household is indifferent between food production and cash income. In both cases, an additional condition is that there is no uncertainty in farm production and no relevant gap between buying and selling prices of food. The two alternative conditions for input use being restricted can simply be stated as "there is no money" and "the money is more urgently needed for other purposes".

In the following sections evidence will be provided on the impact of off-farm income. This will be done by first investigating the exogeneity of off-farm income in section 3. In section 4 the estimates will be presented of the impact that exogenous off-farm income has on the use of hired labour, fertilizer and the use of family labour and in section 5 its impact on the crop choice will be assessed. In section 6, reference will be made to the formulas used here and it will be discussed to what extent the underlying assumptions were corroborated or refuted by the evidence.

Throughout this paper, off-farm employment will be used to denote remunerative employment outside the farm by household members that are resident on the farm. Remittances from those that have left the household to seek employment elsewhere will be considered as given.

3 The nature of off-farm employment

The survey by Bevan, Collier and Gunning includes 783 farms, located in Central Province and Nyanza in Kenya. The survey distinguishes 4 types of off-farm job, viz. wage employment, own business, work on other *shamba*'s (plots of arable land), and work on estates or commercial farms. Table 2 presents the percentages of persons involved in off-farm employment and the numbers of persons in each job type and age class, weighted by their sample weights, which average to unity.

Table 2: Persons employed off-farm

			Male				
age	*number*	*% off-farm*	*wage*	*bus's*	*shamba*	*est's*	*comb's*
01-20	1621	1	1		8		
21-30	268	22	15	6	11	19	8
31-40	196	44	41	16	16	16	7
41-50	143	41	23	12	8	12	5
51-60	132	30	9	12	11	1	7
61+	164	20	3	9	4	7	9
all	2524	12	92	55	58	55	36
21+	903	33	10%	6%	6%	6%	4%
			Female				
01-20	1505	2	3	2	9	9	
21-30	351	14	8	6	24	7	3
31-40	270	25	11	16	20	18	3
41-50	253	17	8	8	15	7	6
51-60	147	18	1	8	14	3	1
61+	130	13		5	8	3	1
all	2656	9	31	45	90	47	14
21+	1151	18	2%	4%	7%	3%	1%

source: BCG survey 1982

No less than 33 per cent of the men above the age of 20 and 18 per cent of the women are involved in some kind of off-farm work. Although relatively more men than women are participating in off-farm work, the share of women is by no means negligible. About a quarter of all women on the farm between thirty and forty are engaged in off-farm work, against 41 per cent of the men of that age group. Note that there are more women than men on the farm in the age groups between 20 and 60, due to the fact that men, more often than women leave the farm to work elsewhere. The

Table 3: Earnings per day (Sh)

sex	*wage*	*bus's*	*shamba*	*est's*
Male	34	282	11	12
Female	42	27	12	12

source: BCG survey 1982

dominant off-farm occupation for men is wage employment, in which 36 per cent of all off-farm working men are engaged. The percentage for women is only 14. Their most frequent off-farm job is that of agricultural work on other farms, in which 40 per cent of them are involved, whereas only one in every five off-farm working men does *shamba* work. Some 20 per cent of both sexes are engaged in some form of business, which includes transport services and trading.

Table 3 provides details on the wages earned in these occupations by men and women between 30 and 40 years old. For business undertakings the profits per day were taken. The extremely high value for business profits for men are not representative. Average profits from business, taken over all participants, amount to 124 shillings per day for men and 35 sh. for women. Wages in the other occupations do not deviate much from the figures in Table 3. No age-effect, nor sex-discrimination in wages was recorded. Compared to farm work, earnings in wage occupation are much higher, but those in the third and fourth categories are approximately equal to average earnings per day on the own farm: the average production value of coffee per hour of family labour is 2.2 sh., that of tea 3.9 sh. and of local or hybrid maize about 1.7 sh (cf. Table 1).

From these figures it appears that wage employment, and business undertaking would 'always' be preferred to farm work. Not only are the earnings higher, they are often earned throughout the year, providing many well paid days of employment. Those that have one of these occupations, tend to spend 290 days per year in a wage job, 230 days in a business type of job, 135 days for men and 85 days for women in shamba work and 260 days in estates work. Thus, apart from shamba-work, these appear to be full time occupations. With earnings being so high, the question arises why only some have these jobs and others do not. If this is not because of a trade-off against farm work, other reasons must account for this. For wage jobs, the survey contains some details on qualifications needed and on the number of years a job was held. In some 30 per cent of the cases, no qualifications seemed to be needed. The wage level in these jobs was about half the average wage in this type of employment. Another 20 per cent reported that only experience was required and in these jobs wages were 30 per cent below average. The other 50 per cent of the wage earners held jobs requiring qualifications like training and education and paying above average wages. To these jobs access is limited to those meeting these qualifications. Some 35 per cent of the wage earners stated that they had their jobs for 2 years or less. This indicates that there is substantial mobility among these employees, so that those meeting the qualifications can expect to get a job rather quickly.

Most of the jobs held are full time occupations. Yet, many of the persons involved in off-farm jobs, devote important parts of their time to the work on the farm itself. In the age category between 30 and 40, the percentage of men doing farm work in addition to off-farm work varies between 55 for those in wage employment to 80 for those having shamba-work as off-farm occupation. For women and for the older age categories, these percentages are even higher. And if farm work is done next to off-farm work, some 100 to 150 days (with on average 4 hours per day) are spent on it per year.

The separation between farm and off-farm work can therefore not be as strict as suggested by the differential in earnings and the number of days per year that are spent in these occupations. The trade-off between working on the own farm and elsewhere is made by many people on many days of the year. If the two types of employment (on and off-farm) were considered almost equally remunerative, we would expect to find that those persons who spend less time off-farm, would spend more on the farm. A simple correlation analysis was used to test this. Only in jobtype 4, that of estates work, significant negative correlation coefficients were found between days in that job and on the own farm at levels of around 0.50. For other job types, mildly negative correlation coefficients resulted, apart from shamba-work which is positively correlated with work on the own shamba (though not significantly so). Lack of correlation may be due to one variable being rather constant, like e.g. the number of days in wage jobs, suggesting that work in this job is predetermined compared with farm work. Negative correlation does not imply a trade-off between the two jobs, as hours or days employed may very well be restricted to only a few for some but many for others, enabling the former to do more farm work than the latter. This could well apply to the seasonal work typically done on estates.

Even though many off-farm workers spend time on the farm itself, their contribution to farm earnings would only be marginal if these farm days are added to many farm days by relatives not having off-farm jobs. Table 4 provides some evidence on the importance of farm work done by those that have off-farm jobs. The figures in the table apply to farms on which at least one person has off-farm employment.

The sample weights in column (2) of the table show that a considerable

Table 4: Farm and off-farm days on farms with off-farm workers

(1) number of workers	(2) sample weight	(3) off-farm days	(4) farm days off-workers	(5) farm days farm-workers	(6) (4) in % of (4)+(5)
1	72	269	69	0	100
2	130	360	106	72	60
3	59	317	160	177	47
4	68	319	180	350	34
5	24	453	83	544	13
6	8	311	95	315	23

source: BCG survey 1982

number of farms have only one or two workers, whose contribution to farm work is of substantial importance. Even on farms with three workers, with at least one having off-farm employment, almost half of the working days are provided by the off-farm worker.

For the average farm with at least one person in off-farm employment, the findings can be summarized as in Table 5. In this table, the number of farm days made by 'unknown' persons are observed on farms where more than four persons do farm work. For these persons, personal characteristics, like sex, were no longer recorded.

The interpretation of the table is, for example, that on the average farm, women make 286.6 hours, consisting of 110.5 farm hours made by women without off-farm employment, 56.5 farm hours made by women who have off-farm jobs and 119.8 hours worked off the farm. Thus, on these farms, 53 per cent of the days is spent in off-farm work, and the rest on farm work,

Table 5: The average farm with off-farm worker(s)

	farm days by farm worker	farm days by off-farm worker	off-farm days	total
men	54.3	63.6	215.4	333.3
women	110.5	56.5	119.8	286.6
unknown	29.6			29.6
total	164.8	120.1	335.2	649.7

source: BCG survey 1982

including 18 per cent which is provided by persons who have off-farm jobs. This shows that the contribution made by off-farm working persons to farm work is substantial.

For farms with more than the average number of workers, the share of persons, employed on the farm only, will increase. As far as the share of off-farm workers in farm work is concerned, there are no great differences as to the type of off-farm job held. Farms with some person employed in wage work tend to be smaller in number of workers and have more male workers, in line with male dominance in this type of job. The relatively few farms with people involved in work on estates are rather odd in that they are very small, both in area and in number of workers. On no less than 59 per cent of these farms all the farm work is done by the person who is also employed on the estate.

It should be remembered, however, that the figures are given for a sample of farm households, which by definition must be engaged in agricultural production.

The BCG survey includes information on the relatives (husbands, wives, sons or daughters) of the farm family that have left. The 5180 persons living on the farms have 1043 relatives living elsewhere, of which 87 per cent are sons or daughters of the farm household head. No more than 5 per cent are the husband of the head of the farm household. In general they are not involved in farm decisions, but still 28 per cent of the elder sons state they take decisions on crop choice or farm inputs, and 78 per cent of the absentee husbands do so. Their earnings in the major types of employment, i.e. urban private companies or government employment, amount to some 1000 sh. per month, which is comparable to the average wage level earned by on-farm living but off-farm working persons. On average 18 per cent of their earnings is sent back to the farm family. The impact that their absence from the farm has on the labour capacity of the farm household is illustrated in Table 6, where for the average farm household the percentages are given that the off-farm living persons take in the extended household size in their age group. In the age categories that are important for the production capacity some 30 per cent of the family members have left the farm. But, given the low returns to agricultural labour and the money sent back by those that have left, the remaining farm household may well be better off. As noted earlier the on-farm population counts more women than men in the age group between 20 and 60 years. The major reason for this is the lack of adult males on female-headed households. As they do not turn up among the off-farm living persons, this may signify underreporting of those persons.

Important findings in this section are that the level of earnings in wage

Table 6: The average extended household

	males			females		
	number		out in %	number		out in %
age	in	out	of total	in	out	of total
01-15	1.75	0.06	3	1.59	0.05	3
16-30	0.63	0.38	37	0.80	0.38	32
31-45	0.33	0.14	29	0.48	0.16	25
46-60	0.26	0.03	10	0.31	0.05	13
61+	0.16	0.00	2	0.12	0.01	5
all	3.14	0.60	16	3.31	0.65	16

source: BCG survey 1982

employment and business are such that allocation of time to these activities can be considered as much more rewarding than that to farm work. Hence, income from these sources can be considered as predetermining the planning of farm activities. Nevertheless, persons employed in these off-farm activities make substantial contributions to farm work as well, but for these persons, and for all types of employment, apart from work on estates, hardly any correlation was found between the hours spent in the job, and those on the farm. Working on other farmers *shambas* tends to be done by persons, predominantly women, who devote many days per year to their own farm. This type of employment appears therefore to require agricultural skills. A check was made to investigate whether exchange labour was involved here, but this appeared not to be the case. These farms only hire out labour. They are relatively small and have substantial surplus labour. Jobs on estates or commercial farms appear to attract those that cultivate some land adjacent to large estates and perhaps are closely linked to the work on these estates or commercial farms. The fifth source of off-farm income are remittances from relatives that have left the farm household. In the age category 15-45 these relatives make up a third of the extended family size in the age group. Their earnings are comparable to those doing off-farm work, and their remittances are some 20 per cent of the earnings. Given the small number of days made by farm members doing farm work and their low income per hour, even this income stream may well be considered a good alternative to their staying on the farm.

4 The impact on farm inputs

In the theoretical section, off-farm employment was considered to both require time and yield cash returns. In the previous section some evidence was provided for the considerable cash income which may result from off-farm employment, particularly from wage and business activities. At the same time, the impact on the available amount of labour was shown to be mitigated by the fact that many off-farm employed persons still devote a considerable amount of time to farm work.

In this section the effects of the increased income, and the reduced labour availability on the use of inputs will be shown for some crops. Throughout the analysis, the cash income from remittances, from wage employment and from business enterprise will be considered as predetermined for the choice on the use of inputs. In addition, land allocated to the tree crops coffee and tea will be considered as given. This appears permissible as some 70 per cent of the coffee growers are involved in this activity for more than 5 years.

The major inputs considered here are those of hired labour and fertilizer and the input of family labour. As income from off-farm activities increases the amount of cash available and reduces the time available for farm work, a fairly strong impact on the use of hired labour can be expected. With fertilizers being hardly a substitute for family labour, their use will not be affected so much by the labour availability but more cash income could encourage their use.

Off-farm employment is not the only source of cash income to many farms. About 50 per cent of the farms sell some food crops, but more importantly, many farms grow coffee or tea, providing them with cash revenues. In addition, some other cash crops are recorded in BCG's survey, viz. pyrethrum, cotton, tobacco, sugar cane and, on a few farms, sunflowers and wheat. Of all these crops, all production is sold.

Other crops, among which are the main food crops maize and beans, are only sold by a minority of farms. Of local maize no more than 14 per cent is sold, of hybrid maize 30 per cent and of beans 20 per cent. An exception is formed by the group 'other vegetables', of which 70 per cent is sold.

The average farm in the sample has an area devoted to crops of 2.9 ha. on which, including double cropping in 'long' and 'short rain' seasons, 3.1 ha. are cultivated. Total area, cultivated in pure stands, is 2.28 ha. of which the main crops are

0.46 ha. local maize
0.38 ha. hybrid maize

0.15 ha. beans
0.16 ha. millet
0.14 ha. cassava
0.20 ha. coffee
0.18 ha. tea
0.14 ha. sugar cane

The pure stands occupy about two third of all plots, the others being mixed cropped, predominantly with either local or hybrid maize combined with beans. Most of the cash crops, and some of the minor food crops appear to be specific for a region, as they are only reported for a minority of the clusters, used to sample the farms.

To study the impact of additional income on the use of inputs such as hired labour and fertilizer, a sufficient number of observations is needed on farms using these inputs and having off-farm income. For most of the crops these conditions were not met by this survey. The impact asssesment is therefore limited to coffee, tea and to an aggregate of food crops, comprising all crops other than those classified as cash crops above. The estimations are performed over a sub-sample, formed by the farms that grow the crop or crop-combination concerned.

As hired labour and fertilizer are not used on a great number of farms, it would not be correct to simply relate the amount of input to explanatory variables such as off-farm income. Instead a Tobit regression analysis was made that takes truncation of the dependent variable at zero into account.

The model has the form $y = \beta' x - \varepsilon$, under the condition that $y > 0$. The optimal β is found by assuming that a positive y is due to $\beta' x$, multiplied by the probability that $y > 0$, or that $\varepsilon < \beta' x$, where ε is assumed to be normally distributed.

Results for coffee were as follows.

$$\begin{aligned} HL &= -136.6 + 310.6^{*} lar + 0.27\, mat - 0.08^{*} time + 0.012^{*} yx \\ F &= 67 + 173^{*} area + 0.08\, mat + 0.23\, immat + 5.1\, educ + 0.006^{*} yx - 262^{*} dc \end{aligned}$$

and $HL \geq 0$ and $F \geq 0$,
where HL denotes hired labour (hours), *area* coffee area (ha) and *lar* its log, *mat* and *immat* the number of mature and immature trees, *time* the hours left to the family after subtracting the off-farm hours (wage and business) from the total time available, with the latter defined as the number of able household members multiplied by 1200; yx denotes exogenous income (shillings); F is the value of fertilizer used (sh), *educ* an indicator of the level of education of the household's head, and *dc* a dummy equal to one, if the farm has cattle. Hired labour was zero in 125 out of 183 cases, and

fertilizer was not used on 92 of these farms. An asterisk indicates that the coefficient is significant at the 10% level.

The equations indicate that the use of hired labour increases with area under coffee and with the number of trees. Linearity in the number of trees and log-linearity in area reflects hired labour being used for harvesting (proportional to trees) rather than for weeding. Time and income both had significant effects, with 100 hours off-farm work inducing only 8 hours of additional hired labour, which would also result from 667 shillings non-farm income. These effects would apply if hired labour were used. The average effect of such changes in time and income would be approximately one third of these values, as hired labour is used in about one third of the cases. This is because the effect of a variable in a Tobit model can be separated in the effect on the probability of the dependent variable being positive, multiplied by the mean value when positive, and the change in value if it is positive, multiplied by the probability of being positive. The former term is close to zero, and the latter is on average one third times the value of the coefficient. The fit of the equations was not so good in the sense that only 65 per cent of the zero-observations for fertilizer use was correctly predicted. For hired labour this percentage was about 90. The R^2 s of the equations measured over the positive observations were around 0.40.

Fertilizer use appeared to be related to the area under coffee and to the number of (im)mature trees, and fairly strongly, to level of education and income. The inclusion of the cattle-dummy accounts for the use of own manure, substituting for the purchase of fertilizer.

For tea only a rather weak relationship could be established for the use of hired labour.

$$HL = -318 + 0.035^{*} mat - 0.017\, time + 0.006\, yx; \text{ and } HL \geq 0$$

which shows much milder effects on the use of hired labour. This is not surprising as the peaks in labour requirements for coffee are much more pronounced than those for tea. Out of 111 farms included in this estimation, no more than 32 did actually use hired labour. According to this equation, 100 hours reduction in time induces 1.7 hours of hired labour (when used) and this would also result from 283 sh. income. Comparing the equations for coffee and tea, hired labour for tea thus appears less sensitive to endowments of the farm , but relatively more sensitive to income changes. In the case of coffee, an increase in the available time by one hour, combined with an *increase* of 7 shillings of the exogenous income leaves the use of hired labour unaffected, whereas such additional hour should be complemented by only 3 shillings in the case of tea to leave hired labour demand unaffected.

The aggregate of food crops which is considered next is a collection of crops dominated by maize and beans, but otherwise quite diverse for the various farms. Within 'maize' a distinction between hybrid and traditional maize can be made, the former requiring more purchased inputs, notably seed, but often also fertilizer, whereas local maize uses relatively large amounts of hired labour for ploughing. A change in the use of inputs should be interpreted as also including a change in the composition of the aggregate.

$$
\begin{aligned}
HL &= -772 + 37.6^{*}af - 0.62^{*}daysm + 0.4^{*}daysf + 0.016^{*}yxm + 0.037^{*}yxf \\
F &= -330 + 13.2^{*}af + 116^{*}ac + 21^{*}educ + 0.003\,yx \\
Sd &= -4 + 11.9^{*}af + 28.9^{*}ac + 4.2^{*}educ + 0.0004\,yx
\end{aligned}
$$

and $HL \geq 0, F \geq 0$, and $Sd \geq 0$,
where *daysm* and *daysf* indicate the days of adult males and females, avilable on the farm, respectively; *af* denotes the area under 'food'; *yxm* and *yxf* denote the off-farm income earned by men and women (sh), respectively and *ac* the area under coffee or tea (ha); *Sd*, in the third equation, represents purchased seeds in shillings.

Hired labour is used by 176 out of 718 farms, fertilizers by 299 farms and purchased seed by 473 farms. The use of hired labour for these crops is mostly for ploughing, rather than for harvesting as with cash crops. Ploughing with a pair of oxen is man's work, explaining the signs of the *daysm* and *daysf* variables in the first equation. Such gender-related determinants were not found for the tree crops discussed earlier.

More income and less capacity induce the use of hired labour substantially, with 100 shillings inducing bewteen 1.6 and 3.7 additional hours, conditional on labour being hired at all, and depending on whether it was male or female income. Compared to tea and coffee, this income effect on the hired labour demand is quite high.

The use of fertilizer and purchased seed are strongly encouraged, not so much by off-farm income, but by the presence of cash crops like tea and coffee. As will be shown in the next section, coffee and tea growers have a strong tendency to grow hybrid maize instead of traditional varieties. Education level also plays a significant role, inducing the use of fertilizers for food production much more than it does its use for coffee.

Summarizing, the estimated Tobit regression equations show that the use of hired labour in tree crops is affected by a shift to off-farm employment, revealing both a *time* effect and an income effect. Its use in food production is not so much affected by total time available but increases if less male time or more female time is available and does increase with off-farm income. The use of fertilizer is affected by education and income, with the latter playing a minor role only in the case of food crops, where a strong impact from the presence of tree crops on fertilizer use was found.

The major input in the production process of all crops is family labour. Theoretically, this input would be expected to decline when more off-farm work is adopted, both on account of the reduced availability of family labour and because of an income effect inducing the household to take more leisure. As indicated in the previous section, these effects may actually not be so strong however, in view of the frequent combination of well-paid jobs with on-farm work.

Estimations for the same major groups as above showed that such income effects are not substantial in the family labour input into coffee or tea growing, nor in the input into the food aggregate. The effect of the available time could be detected however.

The estimations were based on a simultaneous model of production and family labour allocation. For *coffee* the following model was estimated by three-stage-least-squares. The model is presented here without regional dummies, that were included.

$$
\begin{aligned}
lq &= 1.13 + 0.23 lwf + 0.05\, lwhh + 0.57^{*} lmat + 0.07^{*} lf \\
&\quad + 0.08^{*} led + 0.37\, dc \\
lwf &= 2.4 - 0.005\, lyx + 0.49^{*} lmat + 0.04\, limat - 0.04\, lwhh \\
&\quad + 0.2^{*} lt - 0.4^{*} dc - 0.09\, larr
\end{aligned}
$$

where *lq* is the log of produced quantity in kg, *lmat* the log of the number of mature trees, *limat* that of the number of immature trees (and zero when no immature trees), *lf* that of fertilizer (sh), *lwf* the log of family labour input in hours, *lwhh* the log of the *estimated* hired labour hours, *lyx* the log of exogenous income, *lt* the log of the time available in hours, *dc* a dummy for the presence of cattle and *larr* the log of the remaining area. Cross-equation correlation was 0.1 and system weighted R^2 was 0.53.

Family labour production elasticity is estimated to be 0.23 and that of (estimated) hired labour input 0.05. BCG report estimates of the production function for coffee, including both hired and family labour, with production elasticities of 0.06 and 0.36 for the two types of labour, respectively, in a homogeneous Cobb-Douglas model, and elasticities of 0.17 and 0.60, respectively, in a nested CES-form. As in general about 60 per cent of all labour is used for harvesting such models suffer from single-equation bias. And as production and labour input tend to be positively correlated, the bias in the estimated coefficients is upward. BCG mention constant (or decreasing) returns to scale for the C-D estimates and increasing (or constant) returns to scale for the CES-estimate. The production elasticities in the above model sum to 0.92 and this is not significantly different from 1.

Note however, that estimations, which are based on a cross-section of farms have the disadvantage that price impacts cannot be estimated. The cross-section of coffee prices shows not much price difference, and if there is, it may well be persistent and due to types of coffee being grown. Labour input is responsive to prices, and coffee supply is not price-inelastic. When measuring the relationship between labour input and area in one particular year, therefore, it is subject to the economic conditions prevailing in that year. If coffee prices in 1982 would have been much higher, the estimated production function would not be different, but the estimated labour supply equation would.

The estimated parameters show a significant impact of the time available to the household. A decrease in time of 100 hours, equivalent to 4 per cent induces a reduction of family labour input by around 0.8 per cent, which is – for the average coffee grower – equivalent to 7 hours. From the Tobit regressions, discussed earlier, an increase in the use of hired labour could be derived amounting to 8 hours, if hired labour were used, and to about a third of this on average. An actual increase in hired labour coincides with a decrease in the use of family labour, with an elasticity of 0.04. With average hired labour use at 73 hours, an increase by 3 would induce an additional 1.5 decrease in family hours ($0.04 * 4\% * 900$ hours). If the 100 hours reduction in *time* were used to generate income of, say, 500 shilling, an additional 6 hours labour would be hired (if hired) and on average an additional 2 hours hired labour would result. The extra income would induce an extra fall in family labour input of 0.7 hours. On balance, *time* reduction and income increase would lead to 6 extra hours of hired labour and induce a decrease of 9 hours family labour. This would induce an increase in production by 2 kg. In spite of its lower production elasticity the effect of the increased hired labour input exceeds that of the decreased family labour input. Thus, off-farm work in wage employment or business does not appear to affect overall labour input and coffee production much. Additional income stimulates the use of fertilizers. Of 500 shillings income, and conditional on its use, 3 shillings are spent on extra fertilizer, but this reduces to 1.5 shillings for the average coffee grower. The production relation above suggests that the additional 1.5 shillings (equivalent to 1 per cent of the average use) would increase production by 0.07 per cent or by 0.86 kg., worth 2 shillings.

For *tea* a similar system was estimated, but here constant returns to scale were imposed, so as to avoid an excessive scale elasticity. The restriction had an F-value of 0.5 so that it cannot be rejected statistically.

$$\begin{aligned} lq &= 4.1 + 0.22\,lmat + 0.61^{*}lar + 0.13lwf + 0.03lf \\ lwf &= 3.6 - 0.02\,lyx + 0.26^{*}lmat + 0.07\,limat + 0.15\,lt - 0.06\,larr \end{aligned}$$

where *lar* indicates log of area, and *limat* the log of the number of immature trees (and zero when this is zero). Correlation between the equations was 0, and system R^2 was only 0.24. Production elasticity of labour is estimated at 0.13, which is rather low as it would imply a marginal value product of labour not exceeding 0.5 sh per hour for the average farm. The elasticiticity of *time* in the labour supply equation is somewhat lower than the one for the labour input into coffee and a negative, but not significant impact of income is found. For a 100 hour reduction of *time*, labour input into tea growing is reduced by 5 hours. And if the 100 hours is used to earn 500 sh extra, labour supply is reduced by a further 4 hours. Additional hired labour input, however, appeared not to exceed 4 hours, including the effect of the additional 500 shillings income and conditional on its use. Overall labour input, therefore, will decline when more work is done and money earned outside the farm. Given the estimated low marginal product of labour, this does not make much difference for the production.

Finally, for the *food* aggregate, hired and family labour could be, and were included in the production function. Most labour input into these crops is in land preparation, sowing or planting and weeding. In view of the importance of these crops for the farm and because of the dominant role of women in the food production an effort was made to distinguish between male and female labour input. The frequent occurrence of zero observations for male labour input made a direct approach unattractive. The system was therefore expanded with a separate labour supply function for female labour, in addition to the total labour supply curve. The following system resulted, estimated without regional dummies, as these did not alter the coefficients significantly and had almost all impact on the intercept.

$$\begin{aligned} lq &= 4.47 + 0.30^{*}lar + 0.143^{*}lwff + 0.31^{*}lwf + 0.017\,lwh + 0.04^{*}lf \\ &\quad -0.48^{*}dh - 0.10\,dc + 0.04\,led - 0.13\,sexh \\ lwf &= 4.9 + 0.80^{*}lar - 0.025^{*}lyxf - 0.035^{*}lyxm - 0.01\,lrem + 0.35^{*}dh \\ &\quad +0.7^{*}dc - 0.4^{*}lac + 0.025\,ldf + 0.06^{*}ldm \\ lwff &= 1.08 + 0.97^{*}lar - 0.054^{*}lyxf - 0.047^{*}lyxm + 0.01\,lrem + 0.4^{*}dh \\ &\quad +1.9^{*}dc - 0.3^{*}lac + 0.34^{*}ldf - 0.05^{*}ldm \end{aligned}$$

where *lq* denotes here the total value of the production in shillings, *lwh* denotes the log of hired labour hours, *lwff* is the log of female labour hours, *dh* is a dummy, equal to one if land preparation is done by hoeing, and *lac* is the log of the area under coffee or tea. *ldf* and *ldm* represent the log of female and male hours (days times 6) available on the farm, *lyxf* and *lyxm* are logs of female and male off-farm income, respectively, and *lrem* is that of remittances; *sexh* represents the sex of the household head and takes the value of 1 when male, and 2 when female. System's R^2 was 0.35 and the cross-equation correlations were -0.41 between *lq* and *lwff*, -0.36 between *lq* and *lwf*, and 0.64 between *lwf* and *lwff*. To avoid bias due to endogeneity of the food area, the log of total area was used as an instrumental variable in the estimation.

The resulting estimate of female labour production elasticity is now $0.14 + 0.31 * shf$, with *shf* the female share in the total family labour input. The higher the share, the larger the elasticity. This difference could be confirmed on farms with both sexes working, on which elasticities of 0.20 for women and 0.05 for men resulted. The production elasticity of men can be derived as $0.31 * shm$, with *shm* being the male share. Hired labour, itself being small, has an elasticity of 0.017, and fertilizer elasticity is 0.04. Scale elasticity is 0.82, showing decreasing returns to scale, though not significantly so. The female labour supply responds with an elasticity of one to a change in area, increases strongly when available female working force increases, but diminishes if more men are present.

Unlike the models used for coffee and tea growers, this model contains the total time available to men and women as explanatory variables, and not the time available after adjustment for off-farm work. This decreases the chances of *ldf* and *ldm* being endogenous, but complicates the interpretation of the income variables. A change in *lyxf* or *lyxm* now implies not only a change in income, but also a change in time allocated to off-farm work. The effects of an increase in male income by 500 sh (equal to 27 per cent of male and 20 per cent of total income) are to decrease *lwf* by 15 hours (1.2 %) and *lwff* by 11 hours, so that male labour supply to food crops decreases by 4 hours (*i.e.* 0.7 %). A similar change in female income (but here 500 sh equals 83 per cent of average female income), would lead to a decrease in female labour supply by 42 hours and an increase in male labour supply by 9 hours, so that overall supply would change considerably. Income changes do not only affect family labour supply, but also the use of hired labour. The effects are shown in the following table. As shown in Table 7, the increase in female working hours and hired labour hours compensate for the reduction in male hours available, so that food production is hardly affected. A similar reduction in female time would lead to reduced production, in spite of substantially more male working hours. This substitution of female working hours by male working hours explains the positive sign of the male response to increased female income. The enhanced income should reduce male working hours, but the loss of female farming time increases

Table 7: Food production, off-farm income and time

Cause	effects			
	dHL (hrs)	dwfm (hrs)	dwff (hrs)	d$prod$ (sh)
−100 hours male time available	+3	−10	+3	−0
−100 hours female time available	−2	+14	−16	−9
+500 sh male income from off-farm work	+2	−4	−12	−10
+500 sh female income from off-farm work	+5	+9	−42	−29

male participation. The changes in food production, following the change in income are calculated for the average farm and include the effects of increased use of hired labour and fertilizer. The effects of 500 sh extra income (plus the implied labour time effect) are stronger than those of just a reduction of time available by 100 hours. This suggests that the time needed to earn those 500 sh is more than 100 hours, as may well be the case for women, whose earnings from off-farm agricultural labour are about 2 sh per hour. Another interpretation is that the additional income strongly reduces labour input because the higher income induces households, and women in particular, to devote more time to other tasks than food growing.

This production function shows at mean levels marginal labour products equal to 0.50 sh/hr for men, 0.90 sh/hr for women and 0.63 sh/hr for hired labour per hour. (Average production value is 2521 sh, female labour hours are 912, male hours are 538, hired labour hours 68.) These are all fairly low, particularly for men. For hired labour this is understandable as only a quarter of the farms (richer, larger) do use this and the average farm is not representative for the hired labour using farm. For family labour it should be compared with the values for the *average* earnings for food crops. For cereals, grown in pure stands, these were around 1.7 shilling per hour. Mixed crops, which make up half the total production value of the food crops on the average farm have substantially lower average returns. With positive concave production functions, marginal returns are always below the average returns. Nevertheless, the low marginal products imply that hiring out of their labour, for example, would be much more profitable for many farm family members. The elasticities are calculated on the basis of production, valued against market prices. Only a minor part is sold, however. If most household value their own consumed food crops higher than indicated by the market prices, their own judgement of their marginal products is higher as well.

A shilling worth of fertilizer displays a marginal product of 0.96 at the mean levels, which is nearly its equilibrium value of 1.

Combining the main results of this section, demand for hired labour increases due to the change in income by 1.2 hours per 100 shillings for coffee growing, 0.6 hours for tea growing and 2.0 hours for the cultivation of the food aggregate per 100 sh off-farm income. These figures apply to farms that do hire labour.

The total amount of yx for the average farm is 3654 sh., comprising 1058 sh from remittances, 1804 sh from wage employment and the rest from business profits. If the above effects on hired labour would hold for all this off-farm income, about 5 per cent would be used to hire labour, which amounts to 183 sh. Actual hired labour bill of the average farmer amounts to 245 sh., equal to 6.7 per cent. The same average farmer enjoys an income from work on other shamba's, equal to 248 shilling, so that almost all hired workers must be farmers. (Average revenues from work on estates and commercial farms that were not included in BCG's survey frame amounted to 504 shillings.) If it is permissible to use the coefficient of about 5 per cent of the income as a whole, non-farm income accounts for some 75 per cent of all hired labour. As mentioned in section 3, about 20 per cent of off-farm working men and 38 per cent of off-farm working women are engaged in this type of work. If the off-farm income from remittances, wage employment and business supports 75 per cent of these incomes, then this income provides employment for about 5 per cent of all women and men, considering that (see Table 2) about 20 per cent of the women and 35 per cent of the men do off-farm work. This is a major contribution of the off-farm income from these sources.

On farms that hire labour, the effect of a reduction in the family time available for farm work by 100 hours, was estimated at 8 hours additional hired labour demand for coffee growing and 2 hours for tea growing. For the food aggregate, a response of 10 hours was found when available male time changed. Aggregation of these effects under the assumption that 100 hours off-farm work yields 500 sh extra income leads to additional demand for hired labour of 14 hours for coffee, 5 hours for tea and 8 hours for food.

Demand for fertilizer was also found to respond positively to a change in income, but often even more to changes in level of education or the area under tree crops. The income effect amounts to 0.6 sh per 100 sh income change for coffee, and 0.4 sh for food, which should be reduced to a half and a quarter of these figures to account for the non-users.

Family labour input hardly decreases when income increases. Nevertheless, the total time availability has a profound impact on the time allocated to the crops. The elasticities with respect to time were 0.22 for coffee and

0.15 for tea. For food crops the outcomes differ according to whose time is involved. Male labour input into food production responds to changes in male and female time available with elasticities of 0.24 and −0.50, respectively. Female labour input shows elasticities of 0.34 to female time available and −0.4 to male time available. A decrease in time of 100 hours would result in a reduction of labour input into coffee or tea production by 9 hours and family labour input into food production would decrease by 7 hours, if the reduction was in male time available, and by only 2 hours if the reduction was in female time available. Composition of the labour input changes, however.

Combining the effects on hired and family labour input, it appears that coffee growers do not reduce total labour input, unlike tea and food producers where total labour input declines, following a reduction of time with a simultaneous increase in income at 5 sh per hour. The elasticities by which male and female labour input into food production respond to changes in off- farm earnings are as follows. As shown in Table 8, these

Table 8: Family labour supply to food crops
response elasticities to off-farm earnings

	male income	female income
male input	−0.03	+0.02
female input	−0.05	−0.06

elasticities are all quite low.

The final effects on the production of the crops is difficult to measure but appears to be negligible for coffee and tea. The food aggregate is hardly affected by a reduction in male time, but decreases by 9 sh per 100 hours reduction in female time available. Extra male off-farm income of 500 sh coincides with a reduction of 10 sh in food production, and 29 sh reduction would result from 500 sh extra female off-farm income. These estimated changes in production value do not include the extra costs of hiring labour and using fertilizer.

5 Impact on crop choice

In the previous section, the areas under the various crops were considered given. As argued earlier, this seems appropriate for the tree crops, in view of the fact that most coffee growers had been growing coffee for many years, and in view of the capital requirements to move into or out of these crops, but food area may change when off-farm work is taken up. In addition, no analysis has yet been made of the adoption of cash crops of shorter duration. In this section some results are presented on the choice of crop or crop combination and on how this is affected by income and time.

Farms consist of one up to 10 plots on which a large variety of crops can be grown. The major crops have been indicated in the previous section. This section presents a methodology to describe the change in the pattern of crop choice that can be ascribed to differences in off-farm income. The various crops can be characterized by their nature, food crops or cash crops, the former being sold only in a minority of cases, the latter always sold. But cash crops need to be distinguished in perennial tree crops and crops of shorter duration, among which pyrethrum is counted, having a lifetime of some three years. As the data from the BCG survey give a cross-section of farms, it cannot be considered as describing crop choices that have a bearing on periods of up to thirty years, like coffee and tea, but can be assumed to contain fairly well the determinants on choices for crops having a shorter life cycle. Other relevant characteristics of the crops are their intensity of use of purchased inputs and of family labour and land. Table 9 provides a survey of the crops in terms of their input intensities. The figures are derived from the average use of inputs for pure stand plots. Hired labour was added to family labour.

Table 9 shows the familiar picture of food crops being land and labour intensive and money extensive relative to cash crops. A change in one of the resources, land, labour or cash should induce a shift of the crops into the direction in which best use is made of the scarce resource. Those with least cash available should grow relatively more traditional maize and sorghum, whereas those with little land and labour but sufficient cash should aim for sugar cane, pyrethrum or one of the other cash crops.

Decisions on growing each of the crops are not independent. Some familiar mixtures are hybrid or local maize with beans, or sorgum, beans and local maize, whereas a combination of traditional with hybrid maize, or coffee and tea on the same farm is rare. With so many crops, and so little information on soil and other determinants of suitability for certain crops, it is difficult to state which combination of crops is more attractive. The procedure followed here is to first describe the cropping pattern, including the interaction amomg the various types of crop, and then proceed to relat-

Table 9: input-output ratios of crops

crop	*labour*		*land*		*pur'd inputs*	
	hr/100 sh	rank	m^2/sh	rank	sh/100 sh	rank
trad. maize	55	13	17	16	1	3
hybr. maize	65	15	13	14	13	11
beans	38	10	10	12	7	9
millet	52	12	13	13	1	2
sorghum	37	8	9	10	1	1
cassava	112	17	25	18	4	6
sw. potato	142	18	22	17	15	12
peas	209	19	229	19	22	16
sukuma wiki	59	14	6	7	5	7
other veg	96	16	16	15	16	13
coffee	33	6	3	3	25	18
banana	32	5	4	6	3	4
tea	32	4	4	5	22	15
tobacco	20	2	4	4	12	10
cotton	37	9	8	9	6	8
pyrethrum	26	3	3	2	4	5
sunflower	34	7	10	11	41	19
sugar cane	8	1	3	1	23	17
other	39	11	8	8	17	14

source: BCG survey 1982

ing the parameters of this pattern to explanatory variables. The method used is a *log-linear model*, which allows interaction of discrete choices at any level, in addition to main effects, which is the name for crop specific effects.

The starting version of the model, as yet excluding explanatory variables, is that the log of the probability of growing a certain combination is assumed to be a linear function of crop dummies and all interaction terms. In the application here, four activities were distinguished:

1 growing traditional maize (pure or mixed);
2 growing hybrid maize (pure or mixed);
3 growing other non-cash crops;
4 growing non-tree cash crops.

As before, the area under tea or coffee was assumed given.

First the internal structure of these four crop choices was investigated by estimating a fully saturated model, including all first, second and higher order interaction terms, and then deleting those terms that were not significant. What remained were the four main effects, plus the traditional/hybrid maize interaction term (with a strongly negative sign) plus the second-order interactions between either traditional or hybrid maize and other food crops and cash crops. Thus, the probability of finding a combination $(\delta_1, \delta_2, \delta_3, \delta_4)$, where $\delta_i = 1$ if the i^{th} activity is undertaken and $\delta_i = -1$ if not, can be written as (Maddala, 1983 p. 103)

$$\begin{aligned}\log P(\delta_1, \delta_2, \delta_3, \delta_4) &= u_0 + u_1\,\delta_1 + u_2\,\delta_2 + u_3\,\delta_3 + u_4\,\delta_4 + \\ &\quad u_5\,\delta_1\delta_2 + u_6\,\delta_1\delta_3\delta_4 + u_7\,\delta_2\delta_3\delta_4\end{aligned}$$

where u_0 is such that all probabilities sum to unity.

For example, the log of the probability of finding a pattern, consisting of traditional maize and other non-cash crops only, is

$$\log P(1, -1, 1, -1) = u_0 + u_1 - u_2 + u_3 - u_4 - u_5 - u_6 + u_7,$$

and the log-probability of growing hybrid maize and other non-cash crops is

$$\log P(-1, 1, 1, -1) = u_0 - u_1 + u_2 + u_3 - u_4 - u_5 + u_6 - u_7.$$

In the next step, the u_i-terms were made dependent on four explanatory variables, viz. total area, area under tea or coffee, time and exogenous income. To reduce the computational burden the variables were expressed in dummies taking the value of one for a) cropped area larger than 3 ha; b) area tea plus coffee positive; c) time available for farm work more than the equivalent of 2 years; and d) farms with positive off-farm income from

Table 10: LLM estimates

coef	const	time	tot area	income	tree area
u_1	−0.70*	−0.133	+0.320*	+0.063	−0.085
u_2	−0.28*	−0.056	+0.246*	+0.127*	+0.502*
u_3	−1.10*	−0.172*	−0.011	−0.180*	−0.007
u_4	+0.82*	+0.269*	−0.074	+0.193*	+0.230*
u_5	−1.16*	−0.055	+0.467*	−0.122*	−0.163*
u_6	−0.56*	−0.231*	+0.132*	−0.043	−0.057
u_7	−0.48*	−0.092	+0.077	−0.034	−0.154*

* denotes significance at 10%

remittances, wage employment or business. The dummies were equal to minus one otherwise. The resulting estimates are given in Table 10.

From the above two relations, the ratio of the two probabilities can easily be derived as

$$\log \frac{P(1,-1,1,-1)}{P(-1,1,1,-1)} = 2\,(u_1 - u_2 - u_6 + u_7)$$

which, using the coefficients of Table 10, leads to

$$\log \text{P-ratio} = -0.34 + 0.062\,t + 0.019\,a - 0.055\,y - 0.684\,c.$$

This shows that the odds in favour of traditional maize *versus* hybrid maize in combination with other food crops increase with time t and with total area a, but decrease with income y and, in particular, the presence of tree crops, denoted by the dummy c. This corresponds to the earlier finding of a large effect of tree crop area on the use of purchased seeds in the 'food' aggregate of section 4. The negative signs of the income dummy for the three u's associated with cash crops indicate that less of these crops will be grown when there is more off-farm income; similarly, income from tree crops discourages the growing of other cash crops. Only expansion of the area would stimulate the growing of these cash crops.

Table 11 presents an overall picture of the resulting probabilities of crops being grown, either as the only crop or together with others on the same farm.

The rows of the table refer to one of the configurations of the exogenous variables, the frequencies of which are given in the first column. The most populated groups are of which the code for *tayc* equals t0y0 and t000, which are those with little land (less than 3 ha) (a=0) and without tree crops (c=0), but with more than two man years of working capacity; they

Table 11: Probability of crops being grown in %

frequency (numbers)	code	trad. maize	hybrid maize	other crops	cash crops	sum
42	tayc	16	88	94	12	211
83	tay0	58	38	87	20	204
74	ta0c	19	83	88	19	208
76	ta00	54	31	75	30	191
50	t0yc	13	87	94	3	197
104	t0y0	54	35	85	6	180
67	t00c	14	78	85	6	183
153	t000	41	24	66	10	141
7	0ayc	18	88	88	11	206
22	0ay0	59	37	70	23	190
0	0a00	56	28	52	33	170
19	00yc	13	87	89	2	191
50	00y0	47	35	71	5	150

t=much time; a=much land; y=exog. income; c=tree crops; 0=not

differ only as to whether or not they have off-farm income. The difference between these two groups show the effect of such income on the cropping pattern: without income, less maize will be grown, but relatively more traditional maize, less other food crops and more cash crops. In as far as the sum in the last column is a good indicator, total land use intensity appears to decline as well.

Comparison of other groups shows that hybrid maize is particularly closely connected to the growing of a tree crop. Their presence increases the probability for hybrid maize being grown by about 50 percentage points. At the same time, the growing of cash crops is discouraged by the growing of tree crops, and particularly favoured by farm size.

Focussing now on the impact of income, from the Table the average differences were calculated between two groups that are similar but for the income dummy. The observed frequencie were used as weights. This establishes an average indicator for the impact of off-farm income on the cropping pattern. A similar calculation was made to find an indicator for the impact of time. Here groups are compared that only differ in family labour availability ($t = 0$, or $t = t$). The results are given in the next table, from which can be seen that the occurrence of all crops, except the cash crops, increase with more income or more time available. These are average values where the average is taken over combinations of t, a, y and c.

	trad. maize	hybrid m.	other cr.	cash cr.
average probability	0.382	0.496	0.806	0.125
income-induced change	0.063	0.104	0.170	−0.780
time-induced change	0.018	0.008	0.141	−0.010

Not shown in this average is that traditional maize would not be adopted more often, despite more income, when tree crops are grown. Similarly, when there is abundant labour available, a further increase would lead to a decline in the adoption of traditional maize. Hybrid maize, as shown earlier, increases relatively more than traditional maize when income increases, reflecting its higher input-output ratio for monetary inputs.

A decrease of income, or a decrease in time is associated with an increase in the growing of cash crops. As to the effect of time, and in view of Table 7, this can be ascribed to the reduced labour requirements per shilling output. The decrease along with more off-farm income is, however, of a different nature. Here, it is not the endowment reasoning that applies, because most cash crops have relatively high purchased input requirements. Rather, it seems that there is substitutability on the output side, with off-farm income substituting for cash income from these crops or vice versa. This reflects a decreasing marginal utility of cash income.

Most cash crops yield returns that are quite favourable compared with food crops (cf Table 1), at least at the prevailing market prices. The average hourly returns vary from around 1.5 sh per hour for sunflowers to 3.7 sh per hour for pyrethrum and 9.6 sh for sugar cane, of which only the latter is higher than the average hourly earnings in wage employment. Growing sugar cane is, however, limited to certain areas where processing capacity is available.

Using the estimated average probabilities of growing the four types of crop as weights, and taking as average hourly gross margin of traditional maize 1.8 sh, of hybrid maize 1.4 sh, of other food crops 2.5 sh and of cash crops 4.5 sh per hour, an average margin per family hour can be calculated, which comes out as 2.1 sh per hour. The effect of more income on the cropping pattern would work out in such a way that this average decreases to 2.0 sh per hour. This is because the decrease in cash crops is not compensated by the increase in the other crops. Hence the change in cropping pattern by itself, holding the inputs per shilling of each crop constant, does not increase the shadow price of labour on the farm.

For a decrease in working capacity, the same calculation also yields lower average returns to family hours, inspite of the increase in the adoption of cash crops. This increase is not enough to compensate for the decrease in 'other food crops'. This aggregate is, however, too crude for this purpose. One of the major crops within the aggregate is cassava, the area of which strongly declines when off-farm income rises or when labour capacity falls.

Summarizing this section, a log-linear model was used to describe the cropping patterns including the interaction effects. Dominant interactions were between traditional and hybrid maize (negative) and between either one combined with other food crops and cash crops, also with a negative sign. Parameters of the main and interaction effects were related to time, area, income and the presence of tree crops to establish the association between these exogenous variables and the cropping pattern. Hybrid maize was found to be closely related to the presence of tree crops, and otherwise positively related to income and negatively to area and labour capacity. Cash crops were shown to be seen as substitutes for off-farm employment and for other sources of cash income, such as tree crops. Average impact of an increase in income was to increase the adoption of food crops, notably vege tables and hybrid maize. The effect of decreased labour capacity was to increase the growing of cash crops and decrease food crops, notably vegetables. Keeping input-output ratios for the crops constant, no increased returns to labour resulted from either more income or less working capacity.

6 Conclusions

Off-farm income changes the endowments of a farm-household in two ways. Its availability of family labour for on-farm activities is reduced and it has more cash at its disposal. This should relieve liquidity constraints that farms might have and induce them to grow crops that are more dependent on purchased inputs and to use relatively more of these inputs for the existing crops. The reduced labour force should encourage the growing of less labour intensive crops. As Table 7 showed, most of the cash crops fall in this category.

To investigate this hypothesis, use was made of the survey, held by Bevan, Collier and Gunning among smallholders in Kenya in 1982. A cursory look at these data revealed (Table 1) that in general farms with off-farm income do *not* grow more cash crops, do *not* have higher on-farm earnings per hour family labour and even do not use more purchased inputs per unit of output.

The analysis made in section 4, in which more determining variables are taken into account, showed that hired labour use responds positively to off-farm earnings and negatively to available family labour hours. A separate analysis of the use of inputs for food production revealed that hired labour use is a substitute for male family labour and complementary to female family labour: a reduction in the latter leads to reduced use of hired labour. Fertilizer use for coffee and food crops is higher when off-farm income is higher, but more profound impacts were found to come from education and – in the case of food crops – from the growing of tree crops. For the average food-growing farm, the marginal value product of hired labour is below its market price, indicating that it is not a liquidity constraint that precludes its use. This also holds, but to a lesser extent, for the use of fertilizer.

Family labour input into coffee or tea production shows mildly negative responses to off-farm earnings and are also negatively affected when available family labour is reduced. Family labour input into food production was distinguished into male and female labour, with the latter showing both higher production elasticities and higher marginal value products. Female off-farm income appears to affect food production most, followed by male off-farm income. Changes in available male family hours did not affect food production, as these were compensated by changes in the use of female and hired labour. A change in female time available on the farm does affect food production more, even though the opposite change in input of male labour is of about the same size as the change in female labour input.

Off-farm earnings have a direct negative impact on the input of family labour into food production through the reduction in available time, an indirect negative impact through the enhanced overall income, inducing the family to take more 'leisure' (and more so for women than for men), and an indirect positive effect on food production through both time and income on the use of hired labour and other purchased inputs. Such profound impacts of available time and income on the use of family labour should not be found when this input would be governed by equality of marginal value products and wage rates, as neo-classical theory with perfect markets would suggest (see section 2). The low marginal value products of family labour suggest that the hiring out of labour would have been profitable to many, but apparently this is possible for only a few. This may indicate that Kenyan smallholder agriculture is still a labour surplus economy. Rural wages do not go down enough to bring equilibrium in this market, which may be due to costs involved in travel and communication. As shown in section 4, the increased adoption of off-farm work (by men) increases the demand for hired labour to such extent that 75 per cent of all hired labour use by smallholders can be considered as induced by off-farm income.

The same infrastructural argument may explain the emphasis on the growing of food crops, which when evaluated at selling prices appears not so profitable. Using buying prices, including transportation costs for these crops might render them quite attractive. This would also occur if, due to considerations of food-risk aversion, the certainty-equivalent food prices are much higher then the recorded prices.

Crop choice is affected by the presence of off-farm earnings. As shown in section 5, the growing of (non-tree) cash crops is strongly negatively affected by off-farm earnings (or *vice-versa!*). Among the other annual crops, a shift towards hybrid maize and vegetables is noticeable. As the average earnings per hour of family labour are by far the highest for the short-term cash crops such as pyrethrum and sugar cane, this explains why the average farm with off-farm income has a lower farm-income per hour of family labour than the average farm without off-farm income. The question arises, however, why only a few farmers grow these highly profitable crops. Reasons appear to be shortage of education and land and, perhaps, the lack of an adequate marketing structure.

The growing of food crops comes out as the major priority for almost all farms, even for those that enjoy high cash earnings from off-farm work or cash crops (cf. BCG, page 102). Differences between buying and selling prices as such may account for this, but marketing margins as given in Casley and Marchant, based on data from the mid-seventies, do not exceed 15 per cent for the major food crops. They do note however sizeable differences of prices in different markets and different seasons. Although such differences were not found in BCG's survey of 1982, the certainty-equivalent prices, as seen by the growers, may well be much higher than recorded in the survey and explain the popularity of growing food crops.

Turning now to the suggestion by Collier and Lal that more education may lead *via* more off-farm income to more farm income, what evidence was presented in the preceding sections? A direct influence was established for the use of fertilizer and modern seeds. Although not explicitly measured in the food aggregate that was used, this apparently was done with a view to higher returns. Cash crops such as sugar cane and also coffee and tea use substantial amounts of fertilizer (see Table 7), but also food crops like hybrid maize. The association between growing of hybrid maize and tree crops, that was found in section 5, also points toward an educational influence as the group of coffee growers has on average a higher education than, for example, the group of off-farm workers, whose average level is comparable to that of (non-tree) cash crop growers and much higher than that of the rest of the household heads.

There is sufficient evidence in the literature, for example BCG, pages 118 ff, that higher education enormously increases the chances to find off-farm employment and often is a determining factor of the wage that can be earned. It is not so sure that this will lead to substantial improvements in the income from farming, however. More off-farm income leads to more use of inputs such as fertilizer (section 4), it stimulates the adoption of hybrid maize, but it also discourages the growing of cash crops (section 5), as the income effect appears to dominate the *time* effect of off-farm work. The tendency to concentrate on food production, with only limited scope for improvement, restricts a profitable use of the additional revenues for farming, unless it is invested in tree crops like coffee or in improved livestock, as BCG argue. With the crops considered in this paper, there is not much evidence of off-farm income inducing more profitable farming. Nor is there a tendency to sell more of the food crops as off-farm income rises. Those without off-farm income are more inclined to do so in order to get the cash necessary for primary non-food needs.

The bottle neck may be the reliability of the food market. If cash income earners could rely on the market to satisfy their food needs, there would be a greater tendency to grow crops that are more in line with their endowments and provide more profitable cash returns than food does at the prevailing 1982 market prices.

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