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Modelling seasonal farm labour demand: What can we learn from rural Kakamega district, western Kenya?

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Abstract

Seasonality of agricultural activities causes fluctuation in the quantity of labour consumed by these activities, and yet many rural labour studies in developing countries still treat labour demand in agriculture as if it is the same across different farm operations. To unearth the amount of information hidden by this aggregated analysis, labour demand for specific farm operations was estimated based on data collected from Kakamega District. This analysis shows that increasing household size increases labour demand for planting, weeding and harvesting. Increasing the share of elderly household members has a negligible effect on labour demand for farm activities except for land preparation, with which it is positively related. Participation of primary school-going children in farm activities is the highest in planting and harvesting. Participation in off-farm employment seems to increase labour demand only during peak seasons. The area planted appears to have an insignificant effect on labour demand for land preparation. Planting sugar cane appears to reduce labour demand for weeding and primary processing, but planting tea increases labour demand for planting. Mechanising land preparation only reduces labour demand for land preparation, but it seems to be offset by other labour-intensive farm operations. The distance from water source is positively related to labour demand for land preparation, but the distance to the market is negatively related to labour demand for weeding and harvesting. These observations point to the need for supporting and investing in technological and organisational innovations in agriculture.

Keywords: Modelling, Seasonal labour demand, Rural Kakamega district

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1. Introduction

Labour plays important economic and social roles in any economy. It is one of the key factors of production as well as a source of livelihood to billions of people worldwide, especially the 'absolute landless farmers' who are neither renting land nor sharecropping, but are endowed with physical labour power and skills accumulated over time through experience and traditions; the landless with smaller stock of livelihood assets supplemented by occasional engagement in non-farm activities and; the 'near-landless' owning and renting smaller pieces of land in addition to wage labour work they do during peak cropping seasons (FAO, 1986). The stock and quality of labour that households have in terms of their size, educational attainment, and know-how as well as health status constitute human capital, which can be allocated to different sectors of the labour market to meet livelihood and production needs of households as well as labour requirements for the production of goods and services by firms and states (Takane, 2008:1; Schneider, 2005:3).

The different sectors of the labour market in developing countries to which labour is allocated comprise formal and informal sectors of the urban labour market as well as agricultural and non-agricultural sectors of the rural labour market (Mazumdar, 1989:7).

The formal urban sector is characterised by medium to large private- and state-owned enterprises that produce tradable and non-tradable goods (Agénor, 2005:5; Agénor and Montiel, 1996:55-63). As Agénor also noted, this sector hires workers on formal contract basis; their wages are higher than those of their counterparts in the informal sector, and employers as well as workers are subjected to labour market regulations. Other than having higher wages, the formal urban sector differs from the informal urban sector in many aspects, including their employees. Employees in the informal urban sector comprise casual workers, wage workers in small enterprises and the self-employed. The casual workers are employed 'by the day'; they have no special 'attachments' to their employers and; their wages are more flexible and are competitively set by supply and demand (Agénor, 2005:5; Agénor and Montiel, 1996:55-63; Mazumdar, 1989:10). Whereas no particular attachments exist between the casual workers and their employers, the wage workers in small enterprises have long-term attachments to their employers, but their turnover rates are much higher than in large−scale enterprises (Mazumdar, 1989:10). For Mazumdar, the self−employed have widely varying levels of payment and institutional protection that range from low for traders and others to high for professionals like doctors and lawyers. Although the informal urban sector has the same geography as the formal urban sector, it is quite distinct from the formal urban sector in terms of its subsectors and workers. Instead, it is more similar to the non-agricultural sector of the rural labour market, despite, their geographical difference. Like the informal urban sector, the non-agricultural sector is made up of small−scale enterprises in manufacturing, trade, and services (Mazumdar, 1989:8). These enterprises hire workers or rely solely on the entrepreneur's efforts, but some of these employees, including the self-employed engage in agricultural activities as well (Agénor, 2005:5; Agénor and Montiel, 1996:55-63; Mazumdar, 1989:8). The non-agricultural rural sector together with the informal urban sector, account for the largest proportion of the overall non-agricultural sector of the labour market, which is basically anything outside agriculture (Agénor, 2005:7; Agénor and Montiel, 1996:55-63).

The agricultural sector of the rural labour market, as Mazumdar (1989:8) noted, comprises large−scale and small−scale subsectors. Mazumdar also observed that the large−scale subsector consists of plantations and large family farms, which depend heavily on hired labor, much as factories do; however, the small−scale subsector relies not only on hired workers, but also on the self−employed. The self−employed consists of 'owner−operators' and tenants, who often supplement their farm incomes by trading in environmental goods such as forest and other wild products and small-scale production of items such as furniture, baskets, mats, craft goods, and others (Arnold, 1994:1-20; Mazumdar,1989:8). These activities are labour intensive, and they greatly depend on entrepreneurs and members of their families for labour, but incomes they earn from these activities are particularly crucial during seasonal decline in the supply of food and cash-crop income and in periods of drought as well as other emergencies (Arnold, 1994:1-20). Whereas plantations and large farms usually employ labour on long-term contracts ranging from a season to many years, small farms hire on a 'casual', day−to−day basis (Mazumdar,1989:8). Mazumdar also argued that the enforcement of minimum wage laws is sometimes possible in the large−scale agricultural sector because some of their hired workers are organised, but such institutional influence is rare among wage workers in small−scale agriculture, where the labor market is mainly governed by the law of supply and demand and heavily influenced by social custom.

Unlike in the non-agricultural sector, labour allocation in the agricultural sector is greatly affected by seasonality of agricultural activities. This seasonality influences the quantity of labour consumed by agricultural activities and consequently, the wage rates of farm labour, but the more advanced an economy is, the less extensive is the seasonality because of more advancement and investment in technologies and organisational innovations, known for reducing seasonality like irrigation machinery and new institutional arrangements between farm and non-farm sectors that allow labour mobility (Engerman and Goldin, 1991:3). In spite of the clear effects of agricultural seasonality on labour, particularly in less advanced countries, many scholars continue to ignore seasonality in economic analysis of labour demand. Many writers consider labour demand for hired labour as being the same across different farming activities (Odoemenem and Odom, 2010: 323). And works of Babikir and Babiker (2007), Bowlus and Sicular (2003), and others are victims of this simplistic analysis. In their study, Odoemenem and Odom analysed farm labour demand for different farm operations, but their analysis was restricted to hired labour demand. They neglected key farm operations like land preparation and processing. Instead, they considered additional operations such as thinning and fertilizer application, which are less significant among small-scale farmers. This paper contributes towards bridging this information gap, and it analyses labour demand for land preparation, planting, weeding, harvesting, processing and marketing in the rural Kakamega District. The paper is organised into four major sections. Section one explores analytical framework of the rural labour market, section two discusses methods and materials used, section three presents results and discussions of the model estimation, and lastly, section four is the conclusion.

2. Analytical framework

Approaches for modelling rural labour demand draw a lot from the conventional neoclassical theory, but deviate from it in regards to the assumptions held about the market. According to the neoclassical perspective, prices are exogenous, farmers participate in the market, and the decisions pertaining to production and consumption are separately or recursively made. This implies that labour availability to farm production activities is not affected by time spent on leisure (Benjamin, 1992:290). Leisure comes after work. Therefore, the production problem of the product (q_k) with price (p_k); two variable factors x and l (labour) with prices p_x and w respectively and; fixed and farm characteristics (z^q) is profit maximisation expressed as $\max \pi = p_k\, q_k - p_x x - wl$ subject to production technology, $g(q_k, x, l; z^q) = 0$, and the reduced form of the production problem defines labour demand function (l) as, $l(p_k, p_x, x, z^q)$ (Sadoulet and de Janvry, 1995: 145). Under the same conditions, Sadoulet and de Janvry expressed the consumer problem with an agricultural good c_k and price p_k; manufactured good c_m and price p_m; disposable income y and consumer household characteristics z^c as a utility maximisation problem with a utility function $\max_{c_k, c_m} u(c_k, c_m; z^c)$ subject to budget constraint, $p_k c_k + p_m c_m = y$, and derived demand function for goods as $c_i = c_i(p_k, p_m, y; z^c)$, where $i = k, m$

At the same time, they considered a worker problem with home time c_l, time worked l^s, total time endowment available E and worker characteristics z^w as a utility maximisation problem with a utility function $\max_{c_l, y} u(c_l, y; z^w)$ subject to income constraint, $y = wl^s$, and time constraint, $c_l + l^s = E$ or full income $wc_l + y = wE$, and derived home time demand function as $c_l = c_l(w, E; z^w)$. They derived a combined consumption/work problem as a utility function $\max_{c_k, c_m, c_l} u(c_k, c_m, c_l; z^h)$ subject to full time constraint, $p_x x + p_m c_m + wc_l = \pi^* + wE$, and time constraint $c_l + l^s = E$, and generated a demand function of goods as $c_i = c_i(p_k, p_m, w, y^*; z^h)$, where $i = k, m, l$; $y^* = p_k\, q_k - p_x x - wl + wE$ and z^h are characteristics of the household.

However, when the market is imperfect, production and consumption decisions are no longer recursively (separately) made. Under this circumstance, production and consumption decisions are simultaneously made based on endogenous prices (p^*) as follows: $q = q(p^*, z^q)$; $\pi^* = \sum p_i^* q_i$; $c = c(p^*, y^*, z^h)$ and p^*, y^* depend on exogenous prices $\bar{p}$, household characteristics z^q, z^h, exogenous transfer T, and credit K in case credit is a constraining factor, and substitution for p^* and y^* generate reduced forms $q = q(\bar{p}, z^q, z^h, T, K)$ for production, and $c = c(\bar{p}, z^q, z^h, T, K)$ for consumption (Sadoulet and de Janvry, 1995: 145) .

Based on this theoretical framework and the works of Benjamin (1992) and Bowlus and Sicular (2002), the model for assessing factors affecting farm labour demand was specified as: $LnL = \beta_0 + \beta_1 lnH_s + \beta_2 lnH_c + \beta_3 H_e + \beta_4 lnA + \beta_5 K + \beta_6 C_e + \beta_7 O_e + \beta_8 D_m + \varepsilon$, where, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ are model parameters and ε is the error term. L is labour demand defined as the total person days spent working on cultivated land by both the household members and hired labour; H_s is the household size defined as number of persons in a household, and a household is considered as a group of people 'eating from a common pot or cooking on the same hearth' (Berman and colleagues (1994:207). H_c is the household composition and it is computed as a proportion of household members who are children (0-15years), active males (16-55 years), active females (16-55 years) and the elderly (56 and above); H_e is the household education level computed as a fraction of household members with no formal education, with primary education, secondary education and those with tertiary education, including vocational, college and university education. A is the area planted or cultivated measured in acres. K is capital expenses measured as expenses in hiring animal traction or tractor services. C_e is the crop enterprise. Main enterprises considered are tea and sugarcane growing enterprises measured as dummies. O_e is the participation in off-farm employment measured by asking whether household members are engaged in off-farm employment or not, D_m is the distance from the nearest market measured in metres, and ε is the error term.

3. Materials and methods

3.1. Area of study

This paper is based on a study conducted in Kakamega District, the provincial headquarter of western Kenya. The district has a bimodal rainfall pattern, which gives rise to two distinct seasons of long rains from March to June with a peak in May and short rains from July to September with a peak in August (Kilavuka, 2003:19). The drier period runs from December to February (Ibid). The district covers 1275 km^2 of arable land, 577 km^2 of cultivated area and 322 km^2 of gazetted forested land, which preserves water catchment areas and supplies wood fuels. The district has a population density of 522 people per square kilometre, with a birth rate of 44 per 1000 population, death rate of 14.3 per 1000 population and the total fertility rate of 5.1 percent (Ibid). Up to 62 percent of the population is engaged in agriculture, 8 percent in rural self-employment, 20 percent in wage employment, 2 percent in urban self-employment and 8 percent in other sectors (Kakamega District Development Plan, 2002). Major crops grown are maize, beans, tea and sugarcane. Other crops include bananas and horticultural crops. Main livestock kept are cattle, sheep, goats and poultry. The district was chosen because it was the location of BIOTA project under which this study was conducted. A sample population of 121 farm households was selected based on stratified random sampling. Four strata of Ikolomani, Shinyalu, Ileyo, and Lurambi divisions were generated based on local government administrative units. A simple random sampling was conducted within each of the strata to obtain the target sample size. These farm households comprised thirty BIOTA contact farmers and other ninety one households in the vicinity of the contact farmers.

3.2. Data collection

The model used primary data, which was collected using structured questionnaire. The data collected comprised household demographic as well as socio-economic, production and reproduction characteristics. Dependent variables consisted of labour used in land preparation, planting, weeding, harvesting, primary processing and the total labour consumed in the whole season. Values of these variables were transformed into natural logarithms, and their distributions are presented in Figures 1-6.

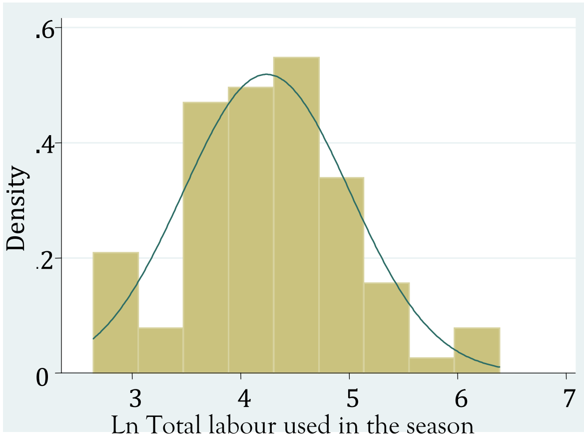

Figure 1. Histogram and density plot for total labour used in the season

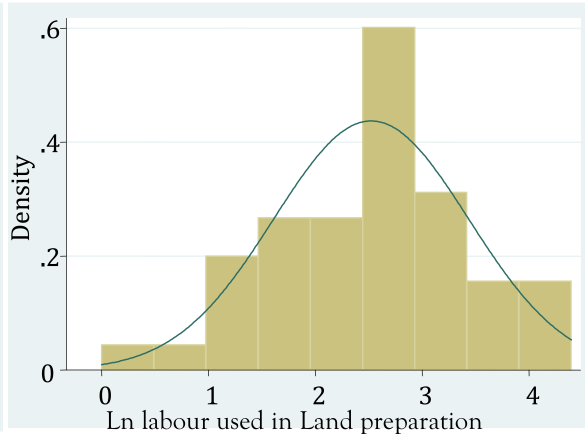

Figure2. Histogram and density plot for labour used in land preparation

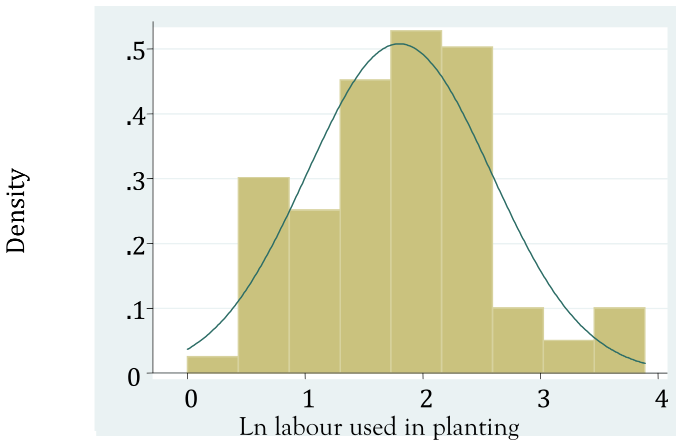

Figure 3. Histogram and density plot for labour used in planting

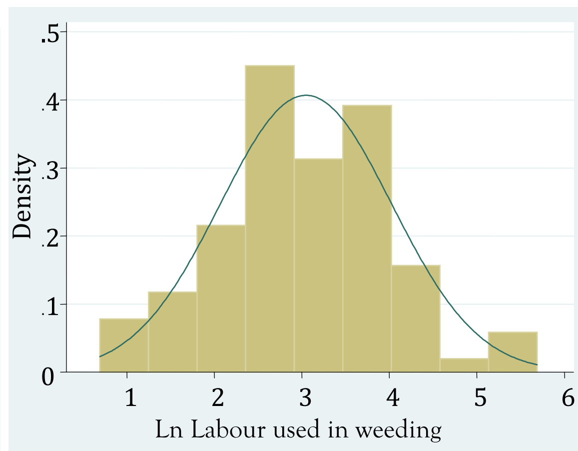

Figure 4. Histogram and density plot for labour used in weeding

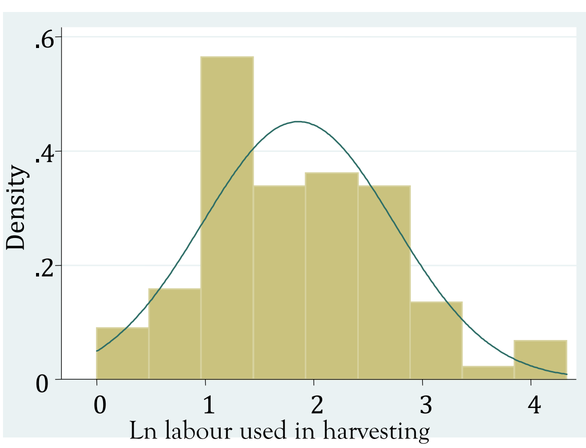

Figure 5. Histogram and density plot for labour used in harvesting

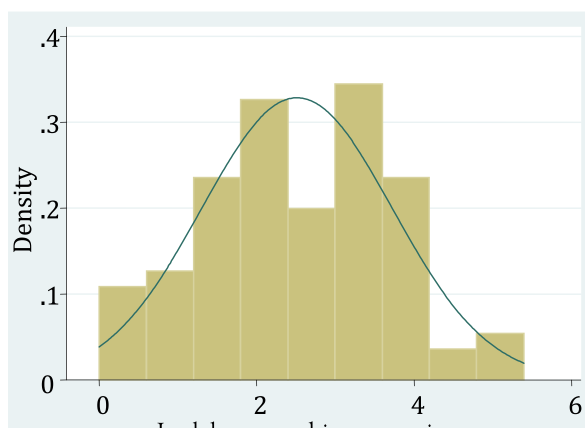

Figure 6. Histogram and density plot for labour used in processing

The data was summarised as descriptive statistics and presented in Tables 1a and 1b below.

Table 1a. Descriptive Statistics of Endogenous (Dependent) Variables.

Variable	Mean	STD	Min	Max
Total labour used in the season (in person-days)	95.12	97.71	14.00	594.00
Ln (Total labour used in the season)	4.24	0.77	2.64	6.39
Labour used in land preparation	18.24	17.20	1.00	81.00
Ln(Labour used in land preparation)	2.52	0.91	0.00	4.39
Labour used in planting	8.42	8.44	1.00	49.00
Ln (Labour used in planting)	1.80	0.79	0.00	4.89
Labour used in weeding	34.22	44.33	2.00	296.00
Ln (Labour used in weeding)	3.05	0.98	0.69	5.69
Labour used in harvesting	9.75	11.84	1.00	76.00
Ln (Labour used in harvesting)	1.86	0.88	0.00	4.33
Labour used in primary processing	24.48	36.02	1.00	220.00

Table 1b. Descriptive Statistics of exogenous (independent) variables

Variable	Mean	STD	Min	Max
Household Size (#)	6.58	2.51	2.00	14.00
Ln (Household Size)	1.80	0.42	0.69	2.64
Age of HH head (years)	48.25	13.73	21.00	85.00
Ln (Age of HH head)	3.83	0.30	3.05	4.44
Children, 0-15 years old (#)	0.31	0.25	0.00	0.79
Share of active female HH members,16-55 years old	0.35	0.17	0.00	0.80
Share of active male HH members, 16-55 years old	0.29	0.17	0.00	0.80
Share of Elderly HH members, 56 and above	0.05	0.11	0.00	0.67
Share of HH members with no formal education	0.10	0.15	0.00	0.50
Share of HH members with primary education	0.61	0.28	0.00	1.00
Share of HH members with secondary education	0.21	0.24	0.00	1.00
Share of HH members with tertiary education	0.08	0.16	0.00	0.80
Participation in off-employment (Dummy)	0.70	0.46	0.00	1.00
Total land size (Acre)	2.84	2.27	0.00	15.00
Ln (Total land size)	0.82	0.66	-1.39	2.71
Area Planted (Acre)	2.08	2.08	0.25	15.00
Ln (Area Planted)	0.41	0.80	-1.39	2.71
Expenses on hiring tractor or ox-plough in KES*	555.98	1503.75	0.00	10000.00
HH planted sugar cane=1; otherwise=0	0.34	0.46	0.00	1.00
HH planted tea=1; otherwise=0	0.70	0.46	0.00	1.00
Distance from the market (m)	4903.26	4204.69	100.00	16000.00
Ln (Distance from the market)	8.12	0.98	4.61	9.68

Number of observations=92 and KES is Kenya Shillings

4. Results and discussion

This section presents and discusses the results of the model estimation and test. The models were estimated and tested for misspecification, endogeneity and heteroskedasticity problems as well as seperability assumption. The levels of multicollinearity were also measured. These statistical operations were conducted in STATA.

4.1. Model estimation and test

Model misspecification is a source of bias, which causes a serious model problem, if not detected and mitigated. This bias arises from the omission of key independent variables or their functions, and it leads to bias and inconsistent ordinary least square estimators (Wooldridge, 2009: 300). For this reason, the estimated labour demand models were subjected to a specification test. Firstly, demand models of labour used in land preparation, planting, weeding, harvesting, primary processing, and the total amount of labour consumed during the season were estimated as functions of household size, share of elderly household members, shares of household members with primary and tertiary education, off-farm employment, acreage planted, expenses on animal traction and tractor services and cash crops grown. Secondly, these models were subjected to Ramsey Reset Test of Model Specification. However, the test failed to reject null hypotheses that the estimated labour demand models had no omitted variables, except in land preparation labour demand model (Table 4). Land preparation labour demand was then specified as a function of household size, access to credit, the share of elderly household members, the share of household members with tertiary education, expenses on hiring animal traction and tractor services, and the distance from the main road, water source as well as interaction between the age of household head and soil type in the study area.

The levels of multicollinearity were also measured. Multicollinearity is one of the assumptions of classical linear regression. It arises when regressors have perfect linear relationships between them. Multicollinearity increases standard error leading to inaccurate hypothesis testing. This analysis used Variance Inflation Factor (VIF) command to test for the degree of multicollinearity. The test found that the level of multicollinearity was far below the critical level. All model variables scored tolerance level higher than 0.6 and model VIF of 1.35 and below (table 2). Therefore, the models seem to be free of the multicollinearity problem.

Endogeneity is another source of bias tested for. Based on past research work, household size and area cultivated were known to be possible sources of endogeneity bias. These variables can pose serious risk of endogeneity when their measurements are not done well, but endogeneity is also a problem when other key variables are omitted from the model (Bowlus and Secular, 2003: 565; Wooldridge, 2009: 300). These variables were, therefore, tested for exogeneity using Hausman test, and the test confirmed their exogeneity (Table 3).

Table 2. Multicollinearity Test for Cropping Activity Labour Demand Model

Variables	**VIF**	**1/VIF**	**Variables LPD Model**	**VIF**	**1/VIF**
HH members- tertiary educ.	1.66	0.603	HH members- tertiary educ.	1.39	0.718
Ln (Area Planted)	1.56	0.639	Share of the elderly	1.29	0.775
Planted sugar cane	1.51	0.662	Cost of hiring ox. & tractor	1.27	0.788
Cost of hiring ox. & tractor	1.43	0.702	Ln (Age household head*Alfisol)	1.18	0.849
HH members-primary educ.	1.38	0.723	Ln (Distance to main road)	1.09	0.914
Ln(Distance to market)	1.29	0.773	Receive credit	1.03	0.969
Planted tea	1.25	0.797	Ln (Distance to water source)	1.02	0.977
Share of the elderly	1.09	0.913	Ln (Household size)	1.02	0.981
Ln (Household size)	1.09	0.913			
Participate in off-employment	1.07	0.932			
	Mean VIF=1.35			Mean VIF=1.16	

Table 3. Hausman Test for Exogeneity

Variable	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**
Endogenous Variable	Ln HH size	Ln Total labour	Ln Area planted	Ln Total labour
Exogenous Variable				
Ln (Household size)	-	0.315	-	-
Ln (Area planted)	-	-	-	0.0539
Ln (Age of household head	0.0273***	-	-	-
Ln (Total land size)	-	-	0.765***	-
Residual1		0.191		
Residual 2	-	-	-	0.220
Cost of hiring ox. & tractor	-0.0000101	0.000286***	0.000138***	0.000231***
HH members- tertiary educ.	-0.413	-1.324**	-0.467	-1.474***
HH members-primary educ.	-0.112	-0.298	-0.339	-0.289*
Share of the elderly	-1.839***	1.452**	0.884*	1.538**
Planted sugar cane	0.171**	-0.191	0.433***	-0.297*
Planted tea	0.036	0.418**	0.177	0.405*
Participate in off-employment	0.0718	0.303**	0.086	-0.302
Ln (Distance to market	0.047	-0.145*	0.141**	-0.148*
Constant (Intercept)	0.193	4.373***	-1.463***	5.275***
R-Squared	0.471	0.387	0.656	0.368
Adjusted R-Squared	0.412	0.312	0.618	0.290
Prob. > F	0.000	0.000	0.000	0.000
#Observations	92	92	92	92

To test for the violation of equal variance assumption, Breusch-Pagan/Cook-Weisberg test for heteroskedasticity was used. All the estimated labour demand models passed the test, except for processing and weeding labour demand models (Table 4). They were then estimated using regression with heteroskedasticity-consistent standard errors approach.

The validity of the seperability assumption was also tested. Seperability assumption—which means the simultaneous making of consumption (labour supply) and production (labour demand) decisions by farm households—holds under perfect labour market conditions. However, it is widely known that labour markets in developing countries, like Kenya and others, are very far from being perfect, and the seperability assumption appears not to hold. Thus, the model was tested for this assumption. The test followed the methodology used by Benjamin (1992). This methodology is grounded on the premise that when labour market is imperfect, household composition becomes an important factor determining farm labour use. Therefore, by estimating labour demand model (5) and testing whether the effects of household size and household composition were jointly equal to zero, seperability assumption was not accepted, except for primary crop processing labour (Table 4). This appears to confirm labour market imperfection, and it implies that the conventional method of analysing labour demand may not be appropriate for this analysis.

4.2. Model explanation

This section explains how household size, household composition, household education, participation in off-farm employment, land cultivated, crop planted, capital expenses and location characteristics affect overall labour demand and labour demand of different operations in the cropping cycle.

Household size is significantly and positively related to labour demand for planting, weeding and harvesting, but insignificantly related to labour demand for primary processing and land preparation. An increase in household size by one percent increases labour demand for planting, weeding and harvesting by 0.439 percent, 0.531 percent, and 0.675 percent respectively. The magnitude of the coefficient increases from planting to harvesting, showing increasing labour demand from planting to harvesting time. The fact that labour demand is positively related to household size confirms earlier findings and the theoretical suggestion that when production and consumption decisions are simultaneously made, increase in household size drives down the cost of labour (shadow price) because of increased labour supply by farm households (Bowlus and Sicular, 2002:573). Household size has an insignificant effect on labour demand for primary processing and land preparation, probably because they are off-peak activities that require less household participation. Some household members may engage in off-farm activities, but they concentrate on farm activities during peak periods, like harvesting or weeding time (Paris et al., 2009:174).

The share of household members of 56 years and above is significantly and positively related to labour demand for land preparation only. Increasing their share by one unit increases labour demand for land preparation by 2.602 percent. The positive linkage between labour demand for land preparation and the share of the elderly household members is probably because they are too weak to engage in energy-intensive land preparation activities. Instead, their care and the need to earn more income to feed them divert labour away from land preparation activities. The elderly are like young children as far as their demand for care and feeding is concerned. They are idle, but need care and feeding. As Bowlus and Sicular, (2002:574) noted, '…an extra child requires care and so may divert time from other uses, it also increases the number of mouths to feed and so may induce the parents to work more hours in the field'. However, they also suggested that such analytical results would be different if it was conducted separately for the healthy elderly household members, who actively participate in farm activities, and the unhealthy ones, who need care and divert labour from farm production (Bowlus and Sicular, 2002:574). Even though they may participate in other activities that require less strength, the labour demand model suggests that their labour contribution is negligible.

Primary and tertiary education are negatively related to labour demand of cropping activities, but the effects of primary education are only significant for labour demand for planting and harvesting. This is probably because majority of household members are primary school-going children, who normally perform light tasks, like ferrying produce and others relevant to their capacity. This observation seems to confirm previous studies. For example, Ajoke and colleagues (2011:130) found that the majority of children supporting their family members with agricultural activities in Nigeria participate mainly in planting (96%) and harvesting (92%) as compared to other activities like processing (80%), weeding (76%), transplanting (52%), and thinning (52%). They maintain that the level of children's participation in a particular agricultural activity is indirectly proportional to the demand of that activity as far as strength, skill and safety are concerned.

Increasing the share of household members with tertiary education by one unit reduces labour demand for land preparation, planting, weeding, harvesting, and processing by 1.048%, 1.361%, and 1.349%, 1.721%, 1.129%, and 1.829% respectively. The effects of tertiary education on weeding and primary processing labour demand are significant at 1% significant level, while for others they are significant at 5% and 10%. Households with the higher share of tertiary education graduates seem to be more effective in reducing labour demand for weeding and harvesting, probably because they are aware of and use chemical weed control techniques and primary processing equipment. This suggestion is consistent with the view that education enhances agricultural productivity because of its complementarily with new technologies (Lockerhead and Lau, 1980: 38). Education is related to access to information about new technologies (Illukpitiya and Gopalakrishnan, 2004:324), and there is a positive linkage between farmer's education and adoption of new technology (Strauss, 1990: 323).

Participation in off-farm employment has positive relationship with labour demand for all cropping activities, but significant effects were registered for only weeding and processing labour demand. Household participation in off-farm activities increases labour demand for weeding and processing by 0.363% and 0.442% respectively. Compared to other farm activities, descriptive statistics show that weeding and primary processing consumed more labour, but participation in off-farm employment diverts labour from the farm, and for that reason, they are affected the most. This observation agrees with earlier finding by Bowlus and Sicular (2002:572), which points at off-farm employment as a key factor behind relative labour shortage**.**

Table 4: Test for model misspecification, heteroskedasticity and seperability assumption

Model	***Ramsey Reset Test of Model Specification Ho: model has no omitted variables***	***Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity Ho: Constant variance***	***Seperability Test Ho: test ln(household size)= Share of the elderly=0***
Ln (Total labour used in the season)	F(3, 78) = 0.78; Prob > F = 0.51	chi2(1) = 1.54; Prob > chi2 = 0.21	F(2, 81) = 5.68; Prob > F = 0.0049
Ln (Labour used in primary processing)	F(3, 78) = 0.19; Prob > F = 0.91	chi2(1) = 3.53; Prob > chi2 = 0.06	F(2, 81) = 2.06; Prob > F = 0.13
Ln(Labour used in harvesting)	F(3, 78) = 0.37; Prob > F = 0.78	chi2(1) = 0.02; Prob > chi2 = 0.90	F(2, 81) =8.82; Prob > F = 0.0003
Ln (Labour used in weeding)	F(3, 78) = 0.03; Prob > F =0.99	chi2(1) = 4.19; Prob > chi2 = 0.041	F(2, 81) = 4.00; Prob > F = 0.022
Ln (Labour used in planting)	F(3, 78) = 1.13; Prob > F = 0.34	chi2(1) = 0.02; Prob > chi2 = 0.89	F(2, 81) = 4.34; Prob > F = 0.016
Ln(Labour used in land preparation)	F(3, 78) = 5.12; Prob > F =0.0027	chi2(1) = 0.15; Prob > chi2 = 0.70	F(2, 81) = 3.62; Prob > F = 0.031
Ln (Labour used in land preparation after testing for heteroskedasticity	F(3, 80) = 2.00; Prob > F =0.12	chi2(1) = 0.65; Prob > chi2 = 0.42	F(2, 83) = 5.57; Prob > F = 0.0054

Area cultivated is positively related to labour demand, but it has an insignificant effect on labour demand for land preparation. Increasing the area planted by one percent increases labour demand for planting by 0.225%, for weeding by 0.203%, harvesting by 0.194% and processing by 0.287%. This finding is expected and has theoretical consistency. The area planted has an insignificant effect on labour demand for land preparation, probably because land preparation is an off peak farm operation. Related to land preparation is the interaction between soil type and the age of the household head. This interaction reduces labour demand for land preparation. This is probably because of the ease of cultivating alfisol, which encourages participation of even the elderly. Meanwhile, ultisol is difficult to work for the elderly, and so this discourages their participation.

Growing sugarcane is negatively related to labour demand, but the effects are only significant with respect to labour demand for weeding and processing. Meanwhile, planting tea is positively related to labour demand, although with only significant effects on labour demand for planting. Planting sugar cane reduces weeding labour demand by 0.435% and primary processing labour by 0.701%, but growing tea increases labour demand for planting by 0.684%. Planting tea increases labour demand because its harvesting is labour intensive. According to Gwyer (1973: 401), tea harvesting takes place all year round. Therefore, it has critical influence on labour demand. Unlike tea, sugar is not harvested throughout the year: its processing is not done on the farm, but in the factory, and weeding is much reduced as it spreads and suffocates weeds. Sugar cane was found to have even lower labour demand compared to annual crops like cassava (De Vries et al., 2012:30). Therefore, its negative relationship with labour demand is not surprising.

Table 5. Labour demand model estimation results

Dependent Variable	**Ln (household size)**	**Share of the elderly**	**HH members-primary education**	**HH members-tertiary education**	**Participate in off-farm employment**	**Ln (Area Planted)**	**Planted sugar cane**	**Planted tea**	**Cost of hiring ox. & tractor**	**Ln (Distance to market)**	**Intercept**	**R^2**
	Independent (Exogenous) Variables											
LnTotal labour used in the season	0.399**	1.426**	-0.264	-1.361**	0.284*	0.159	-0.287*	0.367*	0.000251***	-0.151*	4.597***	0.402
Ln Labour used in planting	0.439**	0.915	-0.732**	-1.349**	0.232	0.225**	-0.121	0.684***	-0.0000542	-0.0251	1.427*	0.361
Ln Labour used in weeding	0.531**	1.284	-0.235	-1.721***	0.363*	0.203*	-0.435**	0.372	0.000346***	-0.214***	3.628***	0.3990
Ln Labour used in harvesting	0.675***	1.156	-0.552*	-1.129*	0.206	0.194*	-0.156	0.297	0.000289***	-0.0305	0.905	0.4583
Ln Labour used in primary processing	0.405	1.419	0.133	-1.829***	0.442*	0.287*	-0.701*	0.287	0.000339***	-0.322***	3.995***	0.2897

Variable	**Ln (household size)**	**Share of the elderly**	**Received credit**	**HH members-tertiary education**	**Ln (Distance to main road)**	**Ln (Area Planted)**	**Ln (Distance to water source**	**Ln (Age of household head)*Alfisol**	**Cost of hiring Ox-plough & tractor**	**Cont**	**R^2**
LnLabour used in land preparation	0.261	2.602***	-.2406	-1.048*	-.07366	0.0705	0.134*	-.00648*	-0.000227***	1.988***	0.336

Expenses on hiring animal traction and tractor services is positively and significantly related to labour demand for weeding, harvesting and processing, but is negatively and significantly related to labour demand for land preparation. It is also positively related to planting, but with insignificant effects. Increasing capital expenses by 1000 Kenya shillings reduces labour demand for land preparation by 0.227%, but it increases overall labour demand by 0.251%, labour demand for weeding by 0.346%, harvesting by 0.289%, and for primary processing by 0.339%. Reduction of labour demand as a result of using animal traction and tractor conforms to production theory, which points to the substitution effect of capital use on labour. The use of tractor and animal traction as mechanization technologies displaces labour and reduces labour-to-land ratio (Viegas, 2003:37, 42). Meanwhile, a positive relationship between capital expenses and labour demand in other farm activities suggests that the use of animal traction and tractors is restricted only to land preparation and to some extent planting. This observation seems to be supported by the work of Panin (1994:206). Panin noted that increased tractorisation was equally accompanied by increased labour use because tractor use was limited to land preparation and planting, where labour saving was realised, but offset by manually operated labour intensive activities of weeding, harvesting, and threshing.

The distance from the market is negatively related to labour demand, but the relationship is insignificant as far as labour demand for planting and harvesting is concerned. However, the distance from the water source is positively and significantly related to labour demand for land preparation. Increasing the distance to the market by 1% reduces labour demand for weeding by 0.214% and for harvesting by 0.322%. However, increasing the distance from water source by one percent increases labour demand for land preparation by 0.134%. The negative effect of the distance from the market on labour demand for land preparation suggests that the closer households are to the market, the more likely that they are to engage in off-farm activities, leading to labour diversion from farm activities. Babikir and Babiker (2007: 341) and Anim (2011: 28) found **s**imilar effect in their studies of labour demand in Sudan and South Africa respectively. They attribute this effect to a greater possibility in working off-farm, which diverts labour from farm activities. The positive linkage between the distance from water source and labour demand is attributed to the fact that the further the water source, the more time is diverted from farm activities.

5. Conclusion

This paper estimated labour demand functions for cropping stages. These functions show how labour demand for land preparation, planting, weeding, harvesting, and primary processing activities are affected by household size, household composition, household education, participation in off-farm employment, area planted, crop planted, capital expenses and location characteristics.

Increasing household size was found to increase labour demand during peak periods of planting, weeding and harvesting only. Increasing the share of household members of 56 years and above seems to have negligible effect on labour demand for all the cropping stages except for land preparation, with which it is positively related, mainly because the elderly household members withdraw labour for their care and direct it to other activities done to support them. Participation of primary school-going children in farm activities seems to be the highest in planting and harvesting, which demand less from them in terms of strength and skills. Participation in off-farm employment seems to increase labour demand only during peak seasons. Area planted appears to have an insignificant effect on land preparation labour demand, probably because it is an off-peak farm operation. Labour demand for land preparation appears to be influenced by factors associated with human strength. Planting sugar cane appears to reduce labour demand for weeding and primary processing, but planting tea increases labour demand for planting. Mechanising land preparation only is not enough, because labour saved from its mechanization seems to be offset by other labour-intensive farm operations. The distance from water source is positively related to labour demand for land preparation, but the distance to the market is negatively related to labour demand for weeding and harvesting.

These observations have implications for both technological and organisational innovations. The government and other development agencies might need to promote and support appropriate technologies that deepen farm mechanization from land preparation to primary processing using appropriate technology or other labour-reducing technologies. Less time-dependent activities may need to be planned for off-peak seasons and new institutional arrangements may need to be established between farm households and off-farm enterprises so that surplus labour available during slack periods can be absorbed in off-farm activities.

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