Family and Hired Labour in Tanzanian Smallholder Crop Production: Evidence on Labour Input Interaction

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ABSTRACT

This study examined whether family and hired labour function as substitutes, complements, or independent inputs in Tanzanian smallholder crop production. Using data from 2,768 households in the 2022/23 Annual Agricultural Sample Survey, a translog production function with region fixed effects and an inverse hyperbolic sine (IHS) transformation was estimated. Results show hired labour ($\beta = 0.0533$, $P < 0.01$) and family labour ($\beta = 0.0380$, $P < 0.05$) contribute positively to output, but their interaction is insignificant ($\beta = -0.0065$, $P = 0.571$), indicating that the two labour inputs operate independently rather than as substitutes or complements. Land is the strongest driver ($\beta = 0.7031$, $P < 0.01$), followed by inorganic fertiliser ($\beta = 0.6377$, $P < 0.01$) and pesticide use ($\beta = 0.0919$, $P < 0.10$). Female-headed households ($\beta = -0.1706$, $P < 0.01$) and older household heads ($\beta = -0.0868$, $P < 0.01$) are associated with lower output, while capital, organic inputs, irrigation, education, and agricultural training are insignificant. Labour-hiring households record higher average output ($\ln Y = 6.707$) than non-hiring households ($\ln Y = 5.930$). The findings remain robust under a Cobb–Douglas specification and the labour-hiring subsample. The study concludes that improving access to labour markets and reducing seasonal labour constraints may enhance smallholder agricultural productivity in Tanzania.

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1.0 Introduction

Labour remains a central input in smallholder agriculture across Sub-Saharan Africa (SSA), where low levels of mechanisation make crop production highly labour-intensive (Binswanger-Mkhize, 2012; Diao *et al.,* 2021; FAO, 2023). At the same time, the rural labour system is rapidly changing. Agricultural commercialisation, nonfarm employment growth, and increased labour mobility are reshaping traditional household labour arrangements. As family members diversify their income sources or engage in non-farm activities, many farm households experience labour shortages during peak production periods. In response, they increasingly rely on hired workers for labour-intensive and time-sensitive tasks, such as land preparation, planting, weeding, and harvesting (Dillon & Barrett, 2017; Abay *et al.,* 2022).

From a production economics perspective, families and hired labour may relate in different ways. They may act as substitutes when hired workers replace unavailable household labour; as complements when both labour sources are jointly required to expand production or complete tasks on time; or as independent inputs when allocated to separate activities or production stages (Varian, 1992; Chambers, 1988; Blackorby *et al.,* 2007; Stiglitz, 1989). Empirical evidence remains mixed and context-specific. Some studies find a substitution between family and hired labour when household labour is scarce, while others report complementarity in more commercialised farming systems. Additional studies identify weak or insignificant relationships, suggesting that labour-input interactions depend on crop systems, labour markets, and seasonal production conditions (Abay *et al.,* 2022; Bedemo *et al.,* 2013; Herrmann *et al.,* 2018; Kilic *et al.,* 2020; Diao *et al.,* 2021; Bachewe & Minten, 2022).

Tanzania reflects this broader pattern. The agricultural sector remains the largest employer, accounting for more than 65% of the national workforce and contributing substantially to domestic food supply (United Republic of Tanzania [URT], 2023; National Bureau of Statistics [NBS], 2023). Several crops in Tanzania generate a strong seasonal labour demand due to the time-sensitive nature of farming operations. Hired labour is particularly common in labour-intensive and commercial crops, such as tobacco, cotton, rice, maize, sugarcane, and horticultural crops, where delays in land preparation, planting, weeding, or harvesting can reduce yields and profitability (NBS, 2023b; URT, 2023). While hired labour can help ease seasonal production bottlenecks, it also introduces wage costs, supervision requirements, and exposure to imperfect rural labour markets, which may influence how households allocate and combine family and hired labour in production (Bardhan & Udry, 1999).

Despite the importance of agriculture in Tanzania, nationally representative evidence of the relationship between family and hired labour remains limited, as most existing studies are regional or crop-specific (e.g., Herrmann *et al.,* 2018; Sitko *et al.,* 2021; Bachewe & Minten, 2022). This study addresses that gap, using data from the 2022/23 Annual Agricultural Sample Survey and a translog production function framework to examine whether family and hired labour function as substitutes, complements, or independent inputs in Tanzanian smallholder agriculture. The study provides evidence relevant to current policy initiatives such as the Agricultural Sector Development Programme II (ASDP II) and the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), which prioritise commercialisation, productivity growth, and inclusive rural development (URT, 2023).

2.0 Materials and Methods

2.1 Data Source and Study Design

This study uses cross-sectional data from the Annual Agricultural Sample Survey (AASS) 2022/23, a nationally representative survey covering agricultural production, input use, labour, and household characteristics in Mainland Tanzania. The dataset provides detailed information on labour allocation, including months worked, days per month, and hours per day for crop farming activities; it does not disaggregate labour by specific crop types. Therefore, the analysis reflects aggregate crop production rather than crop-specific systems. In the AASS 2022/23, smallholders are defined as households cultivating 20 hectares or less, and this definition is adopted to ensure consistency with the survey framework and to maintain a focus on small-scale production systems.

2.2 Sample Size and Sampling

The Annual Agricultural Sample Survey (AASS) 2022/23 uses a stratified multi-stage design and covers 15,338 households nationwide. The sample is progressively restricted to smallholder households (≤20 hectares and positive land) (14,450), crop-producing households with linked output data (9,428), and a cleaned analytical sample with complete data on output, labour, land, and capital (8,559) in mainland Tanzania. The final estimation sample includes households with complete data for all inputs, covariates, and regional fixed effects required for the translog specification, yielding 2,768 observations. This sample is dominated by labour-hiring households (hire = 1; N = 2,746), which are essential for identifying family–hired labour interactions.

Table 1
Sample Size at Different Stages of Analysis

Stage	Description	N
Initial sample	All households in AASS 2022/23	15,338
Smallholder restriction	≤20 hectares and positive land	14,450
Crop-producing households	Linked to output data	9,428
Cleaned analytical sample	Complete data on key production variables	8,559
Hiring households (cleaned)	Hired labor (hire = 1)	3,454
Non-hiring households (cleaned)	No hired labor (hire = 0)	5,105
Final estimation sample (translog)	Complete data for all covariates and restrictions	2,768
Hiring households (estimation subsample)	Hired labor (hire = 1)	2,746

Note: The smallholder restriction follows the study definition (≤ 20 hectares). The cleaned sample excludes Mainland Tanzania observations with missing or implausible values for output, labour, land, or capital, and those lacking translog covariates such as interaction terms and regional fixed effects. Hiring status is based on positive hired-labour days.

2.3 Empirical Model Specification

To examine the relationship between family and hired labour, this study estimates a translog production function, which allows for flexible substitution patterns and interaction effects among inputs. To maintain parsimony, the specification includes only key first-order terms and the interaction between family and hired labour. Due to zero values in hired labour, a semi-translog specification is adopted using the inverse hyperbolic sine (IHS) transformation. The estimated model is given by:

$$lnY\_i = \beta_0 + \beta_1 \, lnL\_\{f\_i\} + \beta_2 \, IHS(L\_\{h\_i\}) + \beta_3 \, (lnL\_\{f\_i\} \cdot IHS(L\_\{h\_i\})) + \beta_4 \, lnA\_i + \beta_5 \, lnK\_i + \gamma' \, X\_i + \delta\_r + \varepsilon\_i$$

where:
Y_i is crop output, $lnL\_\{f\_i\}$ and$L_\{h_i\}$ denotes family and hired labour, A_i is land, K_i represents capital inputs; $X_i$is a vector of household and farm characteristics; δ_rcaptures region fixed effects. The inverse hyperbolic sine (IHS) transformation of hired labour is defined as:

$$IHS(L\_\{h\_i\}) = ln(L\_\{h\_i\} + \sqrt{}(L\_\{h\_i\}^2 + 1))$$

The interaction term β_3 captures the relationship between family and hired labour, where a positive (negative) coefficient indicates complementarity (substitution), and statistical insignificance implies no systematic interaction.

2.4 Variable Measurements

The variables used in this study are constructed from the Annual Agricultural Sample Survey (2022/23) and capture key inputs in smallholder crop production, including labour, land, capital, and household characteristics. Variables' descriptions and their unit of measurements are presented in.

Table 2
Variable Descriptions and Units of Measurement

Variable	Description	Measurement / Construction
Dependent Variable		
ln Y	Crop output	Natural logarithm of total crop output value (TZS)
Labour Inputs		
ln L_f	Family labour	Natural logarithm of total household labour (person-days)
IHS(L_h)	Hired labour	ln(L_h + √(L_h² + 1))

Variable	Description	Measurement / Construction
Land and Capital		
ln A	Land	Natural logarithm of cultivated land area (hectares)
ln K	Capital inputs	Natural logarithm of total input value (TZS)
Input Use Variables		
inorganic_use	Inorganic fertilizer use	Dummy (=1 if used, 0 otherwise)
organic_use	Organic input use	Dummy (=1 if manure/organic inputs are used, 0 otherwise)
pesticide_use	Pesticide use	Dummy (=1 if pesticides are used, 0 otherwise)
irrigation	Irrigation use	Dummy (=1 if irrigation is used, 0 otherwise)
Household Characteristics		
female_head	Gender of household head	Dummy (=1 if female-headed household, 0 otherwise)
age_head	Age of household head	Categorical variable (1–4)
educ_head	Education level of household head	Categorical variable (0-3)
ag_training	Agricultural training	Dummy (=1 if training received, 0 otherwise)
δ_r	Region fixed effects	Set of regional dummy variables (one omitted as reference)

2.5 Estimation Strategy

The relationship between family and hired labour is examined using a translog production function estimated by Ordinary Least Squares (OLS). The translog form is preferred because it flexibly captures nonlinearities and interaction effects among inputs, allowing direct assessment of whether family and hired labour are substitutes or complements.

For interpretation, output elasticities are derived from marginal effects evaluated at sample means. These measure the responsiveness of output to changes in labour inputs and their relative contribution to production. All models include region fixed effects to control for spatial differences in agro-ecological conditions, infrastructure, and market access. Heteroskedasticity-robust standard errors are reported.

A potential limitation is endogeneity of labour inputs, since labour use and output may be jointly determined. More productive farms may both employ more labour and achieve higher output. Although the inclusion of controls and region fixed effects helps reduce bias from observable and spatial heterogeneity, endogeneity cannot be fully eliminated in cross-sectional data. The estimates should therefore be interpreted as conditional associations rather than causal effects. However, the consistency of results across alternative specifications and subsamples suggests that the main relationships are robust.

2.6 Diagnostic Tests

Several diagnostic tests were conducted to assess model validity. Diagnostic tests indicate low multicollinearity (mean VIF = 1.57) but the presence of Heteroskedasticity (Breusch–Pagan $\chi^2 = 53.09$, $p < 0.01$), for which robust standard errors are applied. The RESET test suggests possible misspecification ($F = 6.46$, $p < 0.01$), a common feature of cross-sectional data, partly addressed through the flexible translog specification and region fixed effects. Results are robust across alternative specifications, including a Cobb–Douglas model and a subsample of labour-hiring households. Selection bias is unlikely to be a major concern, as less than 1% of observations are non-hiring households, making a Heckman correction infeasible; however, the sample primarily reflects labour market participants.

3.0 Results and Discussion

This section presents and interprets the empirical findings on the relationship between family and hired labour in Tanzanian smallholder crop production. The analysis proceeds in seven steps: descriptive statistics, production function estimates, output elasticities, labour-hiring subsample analysis, labour input interactions, robustness checks, and regional effect.

3.1 Descriptive Statistics

Table 3 reports summary statistics for labour-hiring and non-hiring households. Clear differences emerge in production scale and input intensity.

Table 3

Descriptive Statistics by Labour Hiring Status

Variable	Non-hiring	Hiring	Total
Dependent Variable			
Output (ln Y)	5.930 (1.522)	6.707 (1.502)	6.244 (1.561)
Labour Inputs			
Family labour (ln L_f)	4.882 (1.191)	4.799 (1.322)	4.848 (1.246)
Hired labour (L_h)	0.000 (0.000)	154.371 (305.262)	62.297 (208.171)
Land and Capital			
Land (ln A)	-0.385 (1.278)	0.154 (1.094)	-0.168 (1.236)
Capital (ln K)	3.877 (5.333)	5.912 (5.826)	4.698 (5.626)
Input Use Variables			
Inorganic fertilizer use	0.242 (0.428)	0.364 (0.481)	0.291 (0.454)
Organic input use	0.239 (0.427)	0.271 (0.445)	0.252 (0.434)
Pesticide use	0.276 (0.447)	0.457 (0.498)	0.349 (0.477)
Irrigation	0.057 (0.232)	0.085 (0.278)	0.068 (0.252)
Household Characteristics			
Female-headed household	0.252 (0.434)	0.250 (0.433)	0.251 (0.433)
Age category	2.243 (0.967)	2.220 (0.954)	2.234 (0.962)
Education level (0–3)	0.884 (0.529)	1.045 (0.598)	0.951 (0.565)
Agricultural training	0.066 (0.248)	0.109 (0.312)	0.084 (0.277)
Observations	5,105	3,454	8,559

Notes: Values are means with standard deviations in parentheses. Dummy variables represent proportions. Education level is coded as 0 = no education, 1 = primary, 2 = secondary, and 3 = higher education.

Labour-hiring households exhibit higher average output (ln Y = 6.707) than non-hiring households (ln Y = 5.930). They also operate on slightly larger landholdings and use higher levels of capital inputs. In addition, it shows a greater adoption of inorganic fertilisers, pesticides, and irrigation. These patterns suggest that labour hiring is embedded in broader production intensification rather than an isolated input decision.

By contrast, differences in household demographic characteristics are relatively small. Gender composition and age structure are broadly similar across groups, suggesting that variation in output is more closely associated with resource endowments and input intensity than household composition alone. Overall, the descriptive evidence indicates that labour hiring is associated with more commercially focused and input-intensive production systems, motivating a formal econometric analysis.

3.2. Production Function Estimates

Table 4 presents an estimate of the translog production function for smallholder households in mainland Tanzania. The specification allows flexible input relationships without imposing restrictive substitution assumptions.

Table 4

Translog Production Function

Variable	Coefficient	Robust Std. Error	t-stat	p-value
Labour Inputs				
Hired labour (IHS, centered)	0.0533***	0.0144	3.69	0.000
Family labour (log, centered)	0.0380**	0.0191	1.99	0.046
Interaction (Hired × Family)	-0.0065	0.0114	-0.57	0.571
Production Inputs				
Land (log)	0.7031***	0.0249	28.28	0.000
Capital (log)	0.0033	0.0057	0.59	0.557
Household Characteristics				
Female-headed household	-0.1706***	0.0533	-3.20	0.001
Age category	-0.0868***	0.0243	-3.57	0.000
Education category	-0.0009	0.0066	-0.13	0.894
Agricultural training	-0.0005	0.0754	-0.01	0.995
Input Use Variables				
Inorganic fertilizer use	0.6377***	0.0650	9.80	0.000
Organic input use	0.0731	0.0469	1.56	0.119
Pesticide use	0.0919*	0.0544	1.69	0.091
Irrigation	0.1271	0.0802	1.59	0.113

Notes: Observations = 2,768, $R^2 = 0.496$, Region fixed effects included (not shown). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

The results indicate that the model explains a substantial share of the variation in crop output (R^2 = 0.496). Both family members and hired labour contribute positively to output. Hired labour is positive and statistically significant at 1%, while family labour is positive and significant at 5%. The larger coefficient and stronger precision of hired labour suggest a relatively greater marginal contribution to production, particularly in relieving seasonal labour constraints during peak farming periods (Kilic *et al.,* 2020; Abay *et al.,* 2022).

Land contributes positively and is highly statistically significant at the 1% level, with a comparatively large coefficient that underscores its role as the most important productive asset in smallholder farming systems (Gollin & Udry, 2021). Inorganic fertiliser use has a strongly positive and highly significant association with output at the 1% level, highlighting the importance of input intensification (Sheahan & Barrett, 2017; Abay *et al.,* 2022). Pesticide use is also positively associated with output and weakly significant at the 10% level, suggesting potential gains through improved crop protection, though the effect is less robust.

Female-headed households are associated with significantly lower output at the 1% level, while older household heads are negatively associated with production and significant at the 1% level. These patterns may reflect unequal access to labour, land, capital, and modern inputs (Palacios-López & López, 2015). In contrast, capital inputs, organic inputs, irrigation, education, and agricultural training do not show statistically significant direct effects in this specification, suggesting that productivity returns may depend on quality, scale of use, or complementary factors not fully captured in the model.

These findings are illustrated in Figure 1, which presents the estimated coefficients and their confidence intervals, providing a clearer visual comparison of the magnitude and statistical precision of the results.

Figure 1
Estimated Coefficients from the Translog Production Function (95% Confidence Intervals)

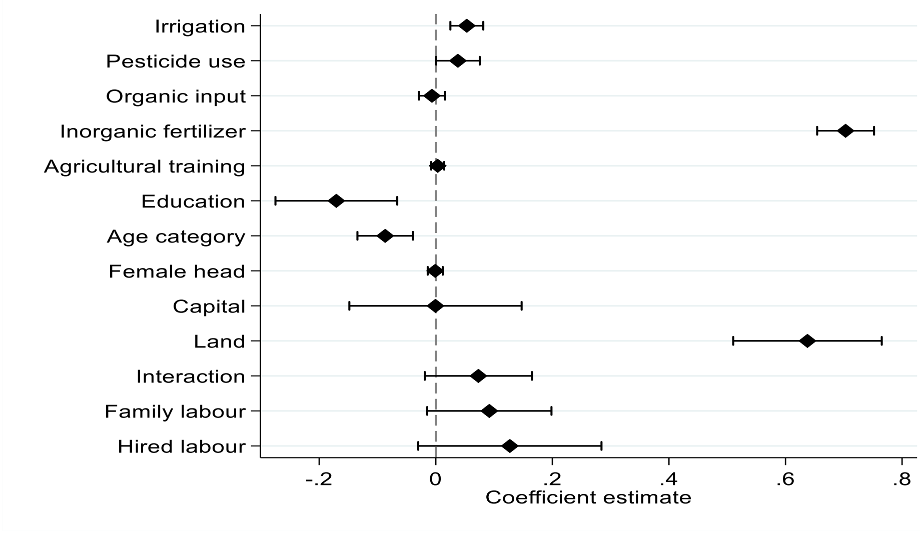

Figure 1 shows that land and inorganic fertiliser have the largest positive effects on output. Both hired and family labour also contribute positively and significantly to production, although their estimated effects are relatively smaller. In contrast, several variables, including capital, education category, organic input use, and irrigation, display confidence intervals that overlap zero, indicating statistically insignificant effects.

3.3 Output Elasticities

Table 5 reports output elasticities evaluated at sample means, providing an interpretable measure of how crop output responds to changes in key input.

Table 5
Output Elasticities (Evaluated at the Mean)

Input	Elasticity	Robust Std. Error	t-stat	p-value
Hired labour	0.0533***	0.0144	3.69	0.000
Family labour	0.0380**	0.0191	1.99	0.046
Land	0.7031***	0.0249	28.28	0.000
Capital	0.0033	0.0057	0.59	0.557

Notes: Elasticities are evaluated at the sample mean. Robust standard errors are reported. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5 shows that a 1% increase in hired labour is associated with a 0.053% increase in output, while a 1% increase in family labour increases output by 0.038%. Both labour inputs are productive, but the larger elasticity of hired labour indicates a relatively stronger role in marginal production increases, consistent with its use in easing seasonal labour bottlenecks (Dillon & Barrett, 2017; Kilic *et al.,* 2020; Abay *et al.,* 2022).

Land remains the most elastic input (0.703), reinforcing its status as the primary binding constraint in Tanzanian smallholder crop production. Capital has a very small and statistically insignificant elasticity, suggesting weak or uneven returns across households. Overall, the elasticity results confirm that labour matters for productivity, but land remains the dominant factor determining output. Figure 2 provides a visual representation of the findings reported in Table 5.

Figure 2
Output Elasticities Evaluated at the Mean (95% Confidence Intervals)

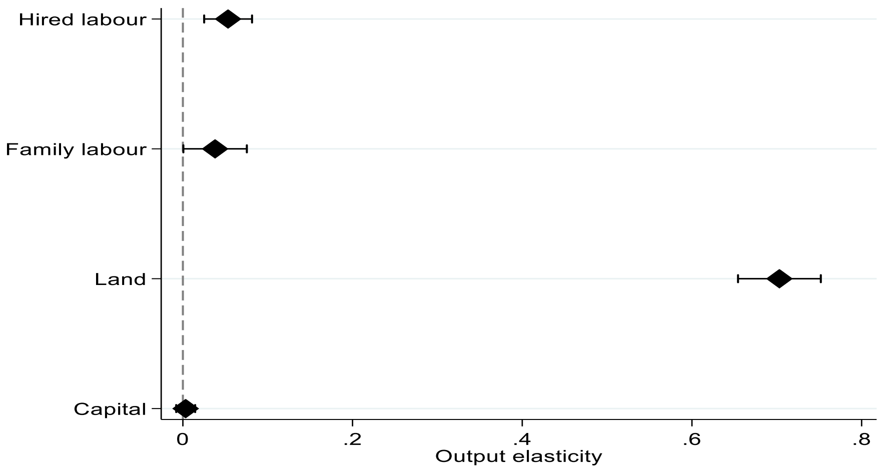

Figure 2 summarises the output elasticities in Table 4, showing that all inputs have positive effects, even though their magnitudes differ. Land is the most important factor, with the largest and most precisely estimated elasticity, confirming its dominant role in smallholder production. Hired labour has a strong and statistically significant effect, exceeding household labour and highlighting its role in easing peak-season labour constraints. Family labour is also positive but smaller, indicating a limited productive effect. Capital, by contrast, has a near-zero and insignificant elasticity, suggesting weak returns in this context.

3.4 Labour Hiring Households Only

To assess whether labour relationships differ among labour market participants, the model is re-estimated (Table 6) for only labour-hiring households (N = 2,746).

Table 6
Translog Production Function for Labour-Hiring Households

Variable	Coefficient	Robust Std. Error	t-stat	p-value
Labour Inputs				
Hired labour (IHS, centered)	0.0496***	0.0141	3.52	0.000
Family labour (log, centered)	0.0397**	0.0189	2.10	0.036
Interaction (Hired × Family)	-0.0045	0.0112	-0.40	0.689
Production Inputs				
Land (log)	0.7028***	0.0247	28.49	0.000
Capital (log)	0.0036	0.0057	0.63	0.527
Input Use Variables				
Inorganic fertilizer use	0.6337***	0.0650	9.74	0.000
Organic input use	0.0685	0.0469	1.46	0.144
Pesticide use	0.0882	0.0547	1.61	0.107
Irrigation	0.1352*	0.0797	1.70	0.090

Notes: *Observations = 2,746. R^2 = 0.499, Region fixed effects included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$*

The results closely mirror those for the full sample. Both hired labour (β = 0.0496, p < 0.01) and family labour (β = 0.0397, p < 0.05) remain positive and statistically significant, while the interaction term between family and hired labour remains statistically insignificant (β = −0.0045, p = 0.689).

This indicates that, even among households actively participating in rural labour markets, there is no evidence of systematic substitution or complementarity between family members and hired workers. Labour market participation appears to affect the scale of production but not the structure of labour interactions, which is consistent with contexts where labour is widely used and task-differentiated (Tsiboe *et al.,* 2018). Land remains dominant, capital remains insignificant, and the positive effect of inorganic fertiliser persists.

3.5 Labour Input Interactions

The interaction term between family and hired labour is negative but statistically insignificant across all specifications (baseline: β = −0.0065; labour-hiring subsample: β = −0.0045). These findings indicate that households and hired workers operate independently rather than as substitutes or complements in Tanzania's smallholder crop production. The results imply that one type of labour's contribution does not change with the use of another. Increases in family labour are not associated with significant changes in the productivity of hired labour and vice versa.

This pattern is consistent with task-specific labour allocation in smallholder farming systems, where family labour is often used for routine and supervisory activities while hired labour is concentrated in seasonal and labour-intensive operations such as land preparation, weeding, and harvesting (Diao *et al.,* 2021; Abay *et al.,* 2022). Measurement limitations, including recall errors in labour reporting and the absence of task-level labour disaggregation, may weaken the estimated interaction effects. In addition, cross-sectional aggregation may mask variation across crops and production stages. Nevertheless, the consistent insignificance of the interaction term across alternative specifications suggests that strong substitution, or complementarity, is not a dominant characteristic of labour use in this sample.

3.6 Robustness Assessment

3.6.1 Cobb–Douglas Specification

To assess sensitivity to functional form, a Cobb–Douglas specification is estimated. The results are highly consistent with the translog model.

Table 6

Cobb–Douglas Production Function

Variable	Coefficient	Robust Std. Error	t-stat	p-value
Hired labour (IHS)	0.0530***	0.0144	3.69	0.000
Family labour (log)	0.0378**	0.0191	1.98	0.048
Land (log)	0.7042***	0.0249	28.29	0.000
Capital (log)	0.0034	0.0057	0.61	0.543
Female-headed household	-0.1700***	0.0533	-3.19	0.001
Age category	-0.0861***	0.0243	-3.55	0.000
Education (years)	-0.0008	0.0066	-0.13	0.898
Agricultural training	-0.0004	0.0754	-0.01	0.995
Organic input use	0.0725	0.0469	1.55	0.122
Inorganic fertilizer use	0.6367***	0.0650	9.79	0.000
Pesticide use	0.0917*	0.0544	1.69	0.092
Irrigation	0.1265	0.0802	1.58	0.115

Notes: Robust standard errors reported. Region fixed effects included but not shown. Observations = 2,768. *** p < 0.01, ** p < 0.05, * p < 0.10.

Hired labour remains positive and highly significant (β = 0.0530, $p < 0.01$), as does family labour (β = 0.0378, $p < 0.05$). Land continues to dominate production, while capital remains insignificant. The positive effects of inorganic fertiliser and other input-use variables are robust, confirming that the main findings are not driven by functional-form assumptions.

3.6.2 Heckman Selection Model

A Heckman selection model was considered to examine potential selection bias in labour hiring. However, of 2,768 observations, 2,746 (99.2%) hire labour and only 22 (0.8%) do not hire labour, so the dependent variable is effectively always observed. This extreme imbalance precludes reliable estimation of the selection equation in Stata, and selection bias is unlikely to be a major concern. The consistency of results across the translog, Cobb–Douglas, and subsample specifications further supports the robustness of the findings.

3.7 Regional Fixed Effects and Spatial Heterogeneity

Regional fixed effects were included to capture spatial heterogeneity in agricultural productivity across Tanzania, reflecting differences in agro-ecological conditions and cropping systems. Table 7 presents the estimated regional effects from the baseline translog model.

Table 7

Regional Fixed Effects (Baseline Translog Model)

Regions	Coefficient (SE)	Region	Coefficient (SE)
Arusha	-0.315*** (0.119)	Rukwa	0.253** (0.122)
Kilimanjaro	-0.779*** (0.142)	Kigoma	-1.578*** (0.287)
Tanga	-0.309*** (0.093)	Shinyanga	-0.290** (0.115)
Morogoro	-0.649*** (0.118)	Kagera	-1.096*** (0.183)
Pwani	-0.757*** (0.137)	Mwanza	-0.057 (0.114)
Dar es Salaam	-0.836** (0.330)	Mara	-0.223 (0.171)
Lindi	-1.175*** (0.153)	Manyara	-0.653*** (0.144)
Mtwara	-1.123*** (0.245)	Njombe	0.440*** (0.132)
Ruvuma	-0.129 (0.112)	Katavi	-0.345 (0.270)
Iringa	0.048 (0.114)	Simiyu	-1.637*** (0.306)
Mbeya	0.030 (0.115)	Geita	-0.538*** (0.130)
Singida	0.176** (0.089)	Songwe	-0.098 (0.119)
Tabora	-0.077 (0.090)		

Notes: Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05. Base region (Dodoma) is omitted.

The results show substantial regional variation in productivity relative to the omitted base region (Dodoma). Several coastal and southern regions, including Lindi, Mtwara, Pwani, and Kigoma, have negative and statistically significant coefficients, indicating lower productivity levels compared to the reference region.

In contrast, regions such as Njombe, Rukwa, and Singida show positive and significant coefficients, suggesting relatively higher productivity. This pattern may reflect differences in production conditions across regions. Some regions, including Ruvuma, Iringa, Mbeya, Mwanza, Mara, Katavi, Songwe, and Tabora, do not differ significantly from the reference region after controlling for other production factors.

Including regional fixed effects improves the robustness of the labour estimates by controlling for unobserved regional differences. The relatively stable pattern of coefficients across specifications suggests that the estimated labour relationships reflect broader production dynamics rather than regional clustering.

3.7.1 Regional Effects across Other Specifications

Regional fixed effects were estimated for all model specifications, including the labour-hiring subsample and the Cobb–Douglas model. The coefficients are consistent in sign and statistical significance with those reported in Table 7, indicating stable spatial patterns across specifications.

4.0 Conclusion

This study provides nationally representative evidence on the relationship between family and hired labour in Tanzanian smallholder agriculture using a translog production-function framework. The results indicate that both family and hired labour contribute positively to agricultural output, with hired labour exhibiting a larger, more precise estimated effect. However, no statistically significant interaction is found between the two inputs, indicating that they operate independently rather than as substitutes or complements.

These findings suggest that labour allocation in smallholder agriculture is shaped more by seasonal labour requirements and production conditions than by direct substitutions between labour sources. Hired labour appears to function primarily as a seasonal adjustment mechanism, helping to ease labour bottlenecks during peak periods rather than as a direct productivity complement to family labour.

5.0 Recommendations

From a policy perspective, the results indicate that improving the functioning of rural labour markets is critical for enhancing agricultural productivity. Policies that reduce transaction costs, improve worker mobility, and facilitate timely access to hired labour, especially during peak agricultural periods, support more efficient farm operations. In addition, strengthening market integration and supporting smallholder commercialisation may further increase the effectiveness of hired labour in crop production.

A key limitation of the analysis is the potential endogeneity of labour inputs, as input use and output are jointly determined. The estimates should therefore be interpreted as conditional associations rather than causal effects. Future research using panel data or instrumental variable approaches could better understand the causal relationship between family and hired labour in smallholder agriculture.

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8.0 Conflict of Interest

The author declares no conflict of interest.

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