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Structure and Patterns of Employment in African Horticultural Value Chains: A case of Nigeria

[version 1]

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Abstract

Employment along Africa's agri-food value chains is central to economic development and poverty reduction, yet research has primarily focused on farm-level production. This study examines employment patterns and drivers across two rapidly expanding horticultural value chains—tomatoes and green leafy vegetables (GLVs)—in two economically and culturally distinct regions of Nigeria. Using data from over 4000 micro, small, and medium-sized enterprises (MSMEs), we investigate three research questions: the extent of employment generation, variation in hiring decisions by gender, region and market factors, and the substitutability of casual and permanent labor. Findings reveal that both value chains provide significant employment, and casual and permanent labor are generally substitutes. However, hiring decisions and labor substitutability vary by gender, location and market conditions. Policy interventions should recognize the opportunities along Nigeria's horticulture value chains and consider gendered constraints, enterprise scale, and regional market structures to promote inclusive labor systems.

Keywords

Agrifood systems, employment, value chain



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1. Introduction

Employment in Africa's agri-food sector remains a cornerstone of economic development and a vital pathway for poverty reduction.^{1,2} While there is growing recognition of the importance of off-farm employment—such as input supply, food processing, and food trade—the academic literature has largely concentrated on farm-level production and labor productivity. As a result, the role of off-farm activities in supporting access to decent work and full employment (SDG 8) remains underexplored.^{3–8} Among the limited studies on off-farm employment, the majority are either qualitative or narrowly focused on specific value chain nodes. For example,⁹ examined employment and wage dynamics among horticulture exporting firms in Senegal, Ghana, and Peru, while¹⁰ conducted a qualitative analysis of youth employment opportunities across various horticultural value chains in Rwanda. However, these studies fall short of providing empirical insights into the patterns and drivers of employment across the full spectrum of value chain activities.

This study empirically examines employment opportunities and drivers across multiple nodes of two rapidly expanding horticultural value chains—tomatoes and green leafy vegetables (GLVs)—in two distinct regions of Nigeria: the economically disadvantaged North and the more affluent South. Specifically, we investigate three research questions. (1) To what extent do the tomato and GLV value chains in Nigeria generate employment? (2) How does employment vary by gender of enterprise owner/manager, and by region of the country? (3) What role do market factors—particularly output and input (labor) prices—play in shaping hiring decisions, and to what extent are casual and permanent labor types substitutes or complements? We draw on a rich primary dataset comprising over 4,000 micro, small, and medium-sized enterprises (MSMEs) operating across the tomato and GLV value chains in Nigeria, Africa's largest tomato producer and most populous nation. Our sample includes input suppliers, producers, transporters, processors, wholesalers, and retailers.

Our findings reveal that both value chains are significant sources of employment for Nigerian men and women. Most farmers hire labor, averaging 144 and 114 man-days per season for tomatoes and GLVs, respectively. Off-farm enterprises employ an average of 2 permanent staff and 5 casual laborers per month. Hiring decisions vary by gender and between Nigeria's northern and southern region. Female tomato plot managers are more likely to hire labor but hire fewer man-days on average, all else equal. Off the farm, we find that females are less likely to hire labor but their numbers hired do not significantly differ from numbers hired by males. Both on and off the farm, hiring is typically more in the relatively poorer northern region compared to the south. We find that casual and permanent labor are generally complementary, although this relationship varies by value chain node and geographic location.

This paper makes three key contributions to the literature. First, it is the first we are aware of to comprehensively characterize employment opportunities across six nodes of two distinct horticultural value chains—tomatoes and GLVs—that are expanding across Africa. Second, it provides novel insights into gendered and regional patterns of entrepreneurship and labor hiring across different segments of these value chains. Third, it offers the first empirical analysis of the interplay between casual and permanent labor in multiple off-farm agri-food value chain employment in developing regions.

The remainder of the paper is structured as follows: Section 2 reviews the existing literature on agri-food system employment in developing regions. Section 3 outlines the materials and methods. Section 4 presents the key findings and discussion, and Section 5 concludes.

2. Employment opportunities beyond the farm

In developing economies, employment in the agri-food system (AFS) is often used synonymously with farm-based work.¹¹ This explains in part the dominant focus on agricultural production in the employment literature.^{3–8} However, as economies evolve, employment opportunities increasingly shift off the farm—though they initially remain within the broader agri-food system.^{12,13} The AFS encompasses a wide range of activities, including input supply, food processing, wholesale, retail, and food services, and can serve as a major source of employment in poor countries.¹⁴ Jobs in Africa's agri-food system (AFS) are critical for tackling youth unemployment, especially given low interest in farming and limited adoption of technologies such as automation.^{15–18} Urbanization and rising incomes have shifted diets toward processed and nutrient-rich foods,¹⁹ spurring growth in value chains for animal-source foods and high-value horticulture.²⁰ With over 60% of Africa's population under 25, rural-to-urban migration is accelerating as youth seek work in off-farm AFS segments such as processing, logistics, and retail.^{21,22}

Though growing, the existing literature on off-farm employment tends to be broad, often failing to distinguish between value chains or specific segments within them.^{12,13,23,24} Few studies examine employment and labor demand among micro, small, and medium-sized enterprises (MSMEs) in domestic African value chains,^{10,11,19} and none (among the few that do) provide empirical estimates of the extent and drivers of job creation by value chain segment within specific value

chains. Thus, this study contributes to this strand of literature by addressing some of these gaps. More specifically, we examine the extent to which both farm and off-farm activities along rapidly expanding horticultural value chains are generating employment for Africa's workforce.

Agricultural wages in developing regions are typically lower than those in other sectors such as manufacturing.^{25–27} Consequently, farms have been noted to employ women and unskilled labor.²⁸ The development of off-farm nodes—such as food processing and services—can help narrow these cross-sectoral wage disparities. Yet, there is limited empirical evidence on wage levels in off-farm segments of the value chain. Recent studies^{12,13,23} have begun to address this gap by proposing frameworks for assessing job quality in the AFS globally. Our study contributes to this literature by analyzing wage variation across on-farm and off-farm employment within the tomato and green leafy vegetable (GLV) value chains in Nigeria.

Finally, employment in the AFS is often seasonal, which affects the quantity, nature, and quality of jobs available at different times of the year.²⁹ This seasonality is possible in both farm and off-farm activities. Accordingly, AFS jobs can be categorized as either permanent or casual. Permanent jobs are typically stable, with defined employment terms and structured pay. Casual jobs, by contrast, are seasonal and may vary in availability and remuneration depending on the time of year. Most existing literature does not provide a detailed characterization of off-farm jobs. To better understand the AFS's role in employment generation, it is essential to distinguish between job types and assess whether they function as substitutes or complements. This study contributes to this literature by examining differences in wages and hiring decisions for casual versus permanent workers among MSMEs at different segments of food value chains. We analyze hiring patterns among MSMEs operating at different nodes of the tomato and GLV value chains, investigating variation by value chain type (high-value tomato vs. lower-value and relatively more perishable GLVs), gender of enterprise owner, and local context—including agroecological conditions, market dynamics, and cultural norms. Finally, we assess the heterogeneous influence of market factors on employment decisions, disaggregated by gender, node, and region. Specifically, we evaluate how output and input (labor) prices shape hiring behavior and whether casual and permanent labor are substitutes or complements. To our knowledge, this is the first study to empirically examine these relationships within the employment literature on agri-food systems in developing regions

3. Materials and methods

3.1 Study context

Nigeria, Africa's most populous country, has experienced rapid growth in its horticulture subsector.³⁰ This expansion has significant implications for farmers—including women and youth—agrifood entrepreneurs, and consumers. Nigeria is the fourteenth-largest tomato producer globally and the second in Africa,³¹ and it grows a wide variety of green leafy vegetables (GLVs) across all regions.³² Tomatoes and GLVs are central components of a nutritious Nigerian diet. Although overall vegetable consumption remains below recommended levels, it is growing—particularly in the south, where per capita tomato consumption (11 kg) exceeds that of the north (7.7 kg).²⁰

This paper leverages on data from two Nigerian states, Kaduna and Oyo. These states were purposively selected for two main reasons. First, because of their prominent roles in Nigeria's tomato production.³³ Kaduna State, located in the northwestern region, is a major supplier of tomatoes to markets nationwide, while Oyo State is a leader in regional production (for the south west) and primarily serves local and neighboring markets. Kaduna and Oyo also represent contrasting agroecological and market environments. Kaduna lies in the Guinea–Sudan savanna, which is well suited for vegetable cultivation, while Oyo's rainforest and derived savanna zones are less so but have seen rapid growth in tomato production.^{33,34} Kaduna is a net supplier of tomatoes, with long supply chains reaching southern markets over 600 km away.³² Oyo, by contrast, is a net consumer, serving shorter regional markets and relying partly on northern supplies. These structural differences are likely to influence labor demand and employment patterns along horticultural value chains.

Selecting two states (one in the north and one in the south) is important because the two regions differ in socioeconomic and cultural characteristics. The north has lower education levels, population density, and higher poverty (around 75%) compared to about 45% in the south.^{35,36} Cultural norms vary as well: in many northern states, patrilineal traditions and Islamic jurisprudence impose stricter gender roles, whereas southern states exhibit more flexible norms that support women's participation in trade, civic life, and local governance.^{37–40}

Finally, the study compares tomatoes and GLVs to assess whether employment opportunities and their drivers differ across crops. Tomato production typically involves longer and more spatially dispersed supply chains, whereas GLVs are relatively more perishable, widely cultivated, and characterized by shorter and more numerous production cycles and shorter market chains.³²

3.2 Sampling and data collection

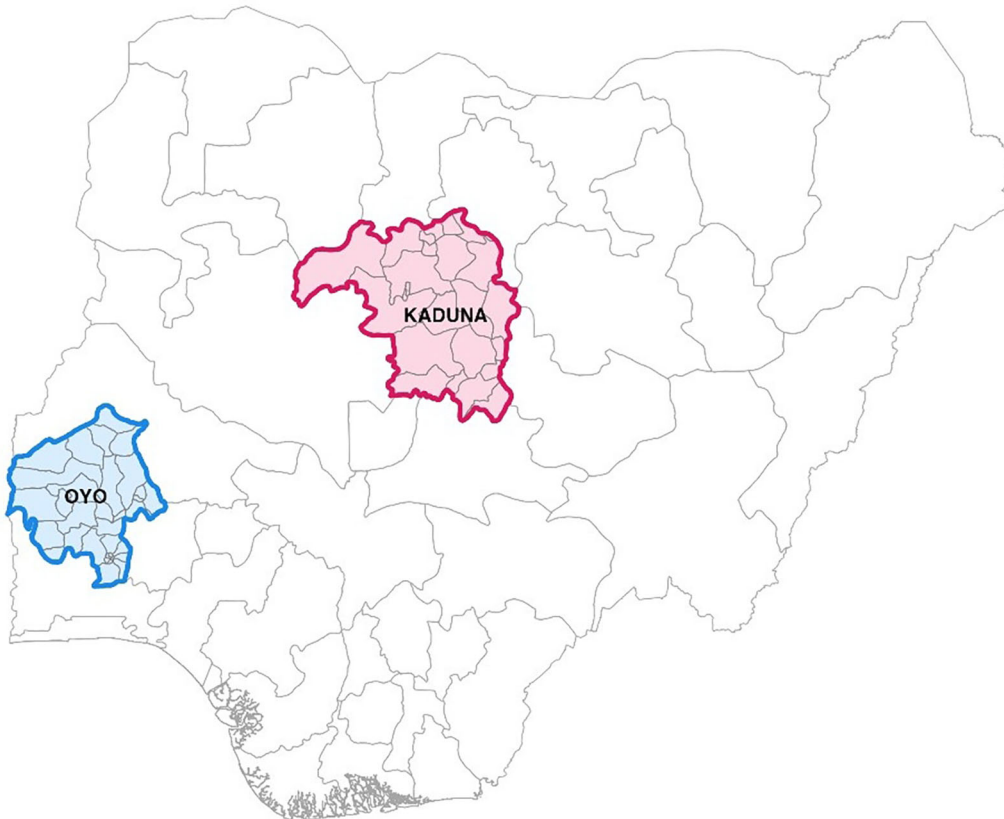
We leverage on primary data from over 4,000 micro, small and medium scale enterprises from the two study states; Kaduna and Oyo (Figure 1). Data were collected from MSMEs operating along the tomato and GLV value chains—producers, wholesalers, retailers, transporters, tomato processors and input suppliers.

Tomato and GLV Producers

Tomato producers were selected through a multi-stage process. In each state, the top two Local Government Areas (LGAs) for tomato production (in terms of volume produced) were identified with the help of a national research institute called the National Agricultural Extension and Research Liaison Services (NAERLS) and local extension agents, verified by field teams from the Federal Universities in each state. Next, the top two wards (in terms of volume of production) were identified within each LGA, and then the top two communities within each ward. All households and farms in these communities were listed. Using a finite population correction for simple random sampling,^{41,42} we calculated a minimum sample size of 384, assuming a 95% confidence level, 5% margin of error, and maximum variability ($p = 0.5$). To allow for robust comparisons, we targeted 400 tomato farmers per state. From a listing of 2,026 tomato-farming households, all female-managed and jointly-managed households were included. The remaining sample was randomly selected. Sample weights were applied to reflect household representation. Since major tomato-producing LGAs in Oyo and Kaduna also produce green leafy vegetables (GLVs), the GLV sample was drawn from the same household listing. We identified 535 GLV farmers across both states and included the entire population in the sample.

Tomato and GLV Wholesalers

We listed all tomato and GLV wholesalers operating in wholesale markets in both states. Wholesale markets were defined as locations with at least two wholesalers trading one of the study commodities. Additional wholesalers were identified



Boundaries: GADM via geodata (WGS84).

Figure 1. A map of Nigeria showing the study areas.

through a listing of wholesalers serving farming communities (i.e., farmer referrals collected during the listing of tomato and GLV farmers) to capture those wholesalers outside formal markets. This process yielded 587 GLV wholesalers, all of whom were included in our sample. For tomato wholesalers, we listed 2,517 in Kaduna and 601 in Oyo. All wholesalers serving rural communities were included, and additional wholesalers were randomly selected to reach a target of 400 per state. Sampling weights were calculated to reflect their distribution in the listing.

Tomato and GLV retailers

For selection of tomato (GLV) retailers we first did a listing of all retailers in all wholesale markets for tomatoes and GLV. We listed a total of 1537 tomato retailers listed in both states; 1145 in Kaduna and 392 in Oyo. From the lists a sample of 500 tomato retailers was randomly selected including 250 males and 250 females. We then listed 558 GLV retailers in both states and interviewed the universe of GLV retailers in the two states as our sample.

Tomato Processors

All identified tomato processors in both states were included. Initial listings from wholesale markets and processing clusters were supplemented with data from government agencies, agribusiness associations, and donor projects. A snowball sampling method was used to identify additional processors, resulting in a total sample of 317 (156 in Oyo, 161 in Kaduna). No GLV processors were identified in the markets nor any GLV processing clusters found.

Input Suppliers

Input suppliers were also identified from wholesale markets and community listings. In Oyo, fewer than 300 unique suppliers were found, and all were included in the study sample. In Kaduna, a sample of 500 was drawn, including all female suppliers and a random selection of others to reach a target of 400. Sampling weights were calculated to reflect the listing distribution.

Transporters

Transporters were also identified from wholesale markets and community listings. All transporters involved in tomato and GLV logistics were included in the sample. All identified transporters were male.

3.3 Theoretical framework and empirical strategy

Theoretical framework

During the structural transformation, employment within the food system transitions from predominantly on-farm production to market-oriented non-farm activities, such as agro-processing, food services, and wholesale and retail trade.²³ Applying the economic theory of the firm, we explore how micro, small, and medium-sized enterprises (MSMEs) along our study value chains—tomatoes and green leafy vegetables (GLVs)—in Nigeria make decisions regarding production and resource allocation to maximize their expected profits.⁴³ Tomato and GLV farms are treated as business enterprises due to the highly commercial nature of tomato and GLV cultivation (90% and 86% of the tomato and GLV farmers in our sample respectively), in contrast with staple crops, such as maize. We assume that enterprises at various segments of the two value chains are price takers and that solving their expected profit maximization problems yields conditional factor demand functions.⁴⁴

More specifically, we assume that value chain MSMEs use two main kinds of inputs (labor (l) and capital (k)). Enterprises face a production function $y = f(l, k, z)$ where y is the amount of the goods or services produced from l and k . $f(l, k, z)$ is the production function, k is a vector of capital inputs such as machinery and z is a vector of public factors such as infrastructure, firm location, access to extension, agroecological conditions and firm enterprise characteristics. w is the market price of labor and r is the vector of market prices of capital inputs. p is the market price of the firm's output. We focus on the short run where z and capital will be fixed ($k = \bar{k}, z = \bar{z}$) and only labor will vary.

The enterprise manager's problem then is to maximize profits by choice of l - the amount of labor to be hired. The enterprise manager in this study refers to the plot managers on the farm, and the owner of the enterprise for off-farm.

$$\max_l pf(l, \bar{k}, \bar{z}) - wl - r\bar{k}$$

Taking the derivative of the profit function with respect to l and setting it to zero, yields the standard first-order condition

$$pf_l(l, \bar{k}, \bar{z}) - w = 0 \tag{1}$$

From Equation (1),

$$pf_l(l, \bar{k}, \bar{z}) = w \tag{2}$$

However, $f_l(l, \bar{k}, \bar{z})$ is the marginal product of labor (MP_l). Therefore, $pMP_l = w$, which implies that the value of marginal product of labor (increment in revenue associated by hiring one more unit of labor) is equal to the cost of hiring an additional unit of labor. The solution to the profit maximization problem yields the optimal factor demand function for labor (l^*) for the enterprise that is a function of factor prices, output price, and firm, manager, and location factors, i.e. $l^* = l^*(p, w, z)$.

Empirical strategy

Drawing from the theoretical model, we model the hiring decision of an enterprise using a double hurdle model. First, the enterprise decides whether to hire labor or not and second; conditional on hiring, they decide how much labor to hire. In our data, employment is captured differently on and off the farm. For producers, the two hurdles above apply directly. However, as noted earlier, we further distinguish between casual labor and permanent employees for the off-farm enterprises. Thus, we model employment for the off-farm enterprise as a triple hurdle problem because, first, they decide whether to hire labor or not, second, conditional on hiring, they decide whether to hire casual labor or permanent labor or both, and third, conditional on hiring casual labor, how many casual employees to hire and/or conditional on hiring permanent labor, how many permanent employees to hire (Figure 2).

For both on and off-farm enterprises, the employment decisions are driven by socio-demographic factors, market factors and enterprise/manager characteristics presented earlier (see Figure 2).

To estimate the determinants of employment on the farm, we estimate the double hurdle model as follows. We use the probit model in the first stage (hiring non-family labor or not) and estimate the Inverse Mills Ratio (IMR) following.⁴⁵

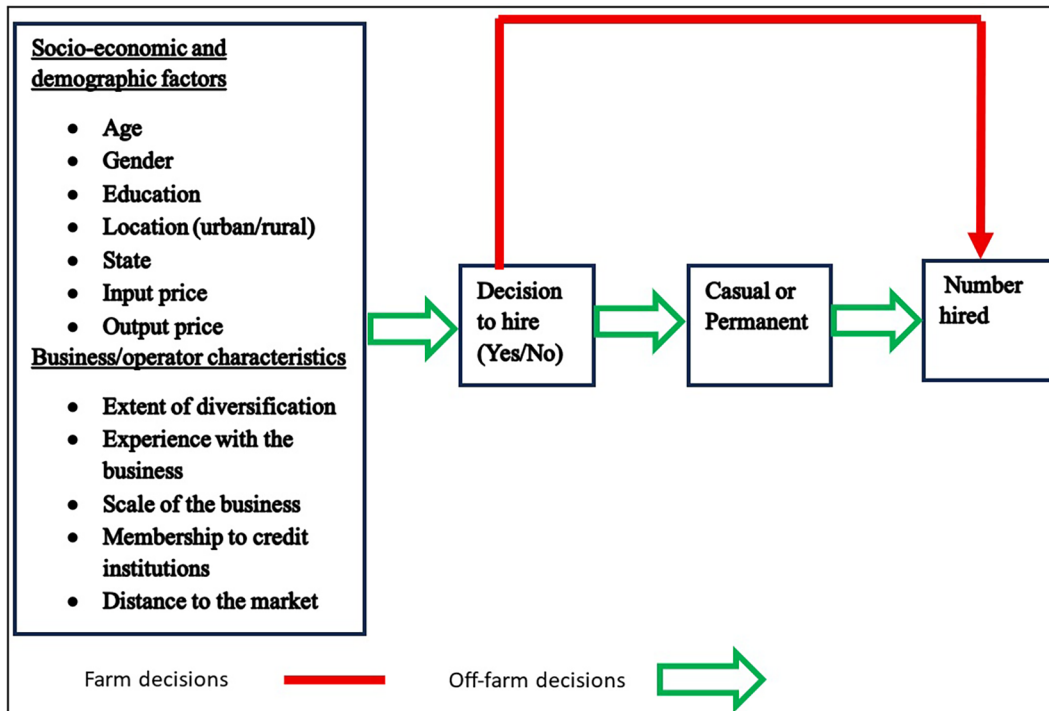


Figure 2. Key study variables.

Conditional on hiring, the drivers of the extent of hiring by tomato (GLV) plot managers is estimated using ordinary least squares which assumes conditionally uncorrelated errors and including IMR as one of the regressors. The null hypothesis that the first and second stage errors are conditionally uncorrelated is tested using the standard t -statistic for the coefficient estimate on IMR. If the coefficient estimate is statistically significant, we reject the null hypothesis and the model must be re-estimated to conduct valid inference.⁴⁶ If we fail to reject the null, we re-estimate second stage parameters excluding IMR.⁴⁷

Stage 1: Probit

$$P(Y_{i1} = 1) = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{wage} + \beta_5 \mathbf{Z} + \varepsilon_i \quad (3)$$

where; Y_{i1} is the probability of hiring labor, $\beta_1 - \beta_4$ are parameters to be estimated, associated with our key study variables on gender, location (north vs. south), output price and the price of labor, respectively. \mathbf{Z} is a vector of other enterprise characteristics and β_5 is a vector of parameters associated with these enterprise characteristics.

Stage 2: Ordinary Least Squares

$$Q_i = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{wage} + \beta_5 \mathbf{Z} + \beta_6 \text{IMR} + \varepsilon_i \quad (4)$$

where; Q_i is the number of person days hired by the tomato plot or GLV plot managers, \mathbf{Z} is a vector of other control variables and $\beta_1 - \beta_4$ and β_5 are as earlier defined. β_6 is the coefficient estimate on the IMR.

The off-farm decisions would ideally be modeled using a triple hurdle. However, in our sample, all wholesalers and retailers who choose to hire some labor always hire casual labor thus we have no variation for considering the decision to hire casual versus permanent, conditional on hiring. Therefore, we estimate the drivers of hiring labor for the off-farm node using a modified double hurdle model instead of a triple hurdle model. More specifically, we use a bivariate probit model for the first stage (to determine if the enterprise hires just casual labor, both casual and permanent labor or if the enterprise does not hire at all) and estimate the IMR. Then, conditional on hiring casual or permanent labor, we estimate the intensity of hiring using a Poisson regression model in the second stage with IMR as a regressor. Where IMR is not significant, we estimate the model without it. A Poisson model is preferred in the second stage since the dependent variable (number of casual employees or permanent employees) is count data.⁴⁸

Probit model

$$P(Y_{is1} = 1) = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{Casual wage} + \beta_5 \text{Permanent wage} + \beta_6 \mathbf{Z} + \varepsilon_i \quad (5)$$

where; Y_{is1} is the probability of hiring labor by enterprise manager i , at off-farm value chain node s , $\beta_1 - \beta_5$ are the parameters associated with our key study variables (and hypothesis) noted above and β_6 is a vector of parameters associated with our vector of other firm characteristics \mathbf{Z} .

Stage 1: Bivariate probit

$$P(P_{is1} = 1) = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{Casual wage} + \beta_5 \text{Permanent wage} + \beta_6 \mathbf{Z} + \varepsilon_i \quad (6)$$

$$P(C_{is1} = 1) = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{Casual wage} + \beta_5 \text{Permanent wage} + \beta_6 \mathbf{Z} + \varepsilon_i \quad (7)$$

where; P_{i1} is the probability of hiring permanent labor by enterprise manager i , at off-farm value chain node s , C_{i1} is the probability of hiring casual labor by enterprise manager i , at off-farm value chain node s , \mathbf{Z} is a vector of other control variables.

Stage 2: Poisson model

$$Q_{isp} = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{wage} + \beta_5 \mathbf{Z} + \beta_6 \text{IMR}_p + \varepsilon_i \quad (8)$$

$$Q_{isc} = \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{State} + \beta_3 \text{Price} + \beta_4 \text{wage} + \beta_5 \mathbf{Z} + \beta_6 \text{IMR}_c + \varepsilon_i \quad (9)$$

where; Q_{isp} is the number of permanent employees hired by enterprise manager i at off-farm value chain node s , Q_{isc} is the number of casual employees hired by enterprise manager i at off-farm value chain node s , \mathbf{Z} is a vector of other control variables and IMR is the inverse mills ratio a.

3.4 Study hypotheses and measurement of key variables

Drawing from the theoretical framework above, this study focuses on two key employment metrics among value chain actors: (1) the decision to hire labor, captured as a binary variable (1 if labor is hired, 0 otherwise), and (2) the extent of hiring, measured by person-days per hectare for producers and number of employees for off-farm enterprises. For off-farm nodes, we further distinguish between casual labor (task-based) and permanent employees (regular hours and fixed monthly salary, with or without benefits).

We explore three key hypotheses around employment along the two study value chains.

Gender and hired labor: We assess whether the gender of the enterprise owner influences labor hiring decisions and intensity. Our key explanatory variable here is the gender of the enterprise owner. Prior literature suggests existence of performance gaps such as employment growth differences between men and women entrepreneurs,^{49,50} as a result women entrepreneurs are less likely to hire external labor for their businesses, relying more on self or family labor. Women entrepreneurs mitigate the work-family conflict through role-sharing⁴⁹ by delegating business and some family roles such as child care to relatives. Women entrepreneurs also mitigate the work-family conflict by setting up their businesses at home or very close to home.⁵⁰

Regional Employment Differences: We test for employment variation between Kaduna and Oyo. Contrary to expectations that employment opportunities are more prevalent in the relatively more affluent South, recent data show lower unemployment in the North (4.3%) compared to the South (6.6%).⁵¹ We investigate whether this trend holds within the tomato and GLV value chains and across different segments, using a state dummy variable (1 for Kaduna, 0 for Oyo).

Market Incentives: We explore how labor wages and product prices affect employment decisions. To address endogeneity concerns with self-reported data, we use average wage rates and prices at the Local Government Area (LGA) level. We distinguish between casual and permanent employees in this paper. Additional controls include firm and owner characteristics, summarized in Table 1.

Our analysis relies on cross-sectional data. While we control for a rich set of explanatory variables to reduce the risk of omitted variable bias, we cannot rule out the presence of unobserved factors that may be correlated with some explanatory variables (e.g., enterprise scale, specialization, and commercialization decisions). Therefore, we do not interpret our findings as causal estimates. Instead, we view them as informative associations that provide insights on key correlates of hiring decisions.

Table 1. Key explanatory variables.

Variable	Description	Type of variable	Expected sign
Age	Age of the tomato and GLV enterprise manager, measured in complete years	Continuous	+
Education	Level of education achieved by the tomato and GLV enterprise manager. Enterprise managers that attained at least secondary education were compared to those who did not attain secondary education	Dummy	+/-
Diversification	Diversification was measured as the extent to which tomato and GLV enterprise managers are engaged in other businesses	Dummy	+/-
Business experience (Business exp)	Number of years tomato and GLV enterprise managers have been operating the tomato (GLV) businesses	Continuous	+/-
Size of the enterprise (Biz size/ plot size)	Plot size was measured in hectares for tomato (GLV) producer enterprises. For off-farm enterprises, scale was measured as volume (tons) handled in the last season	Continuous	+
Membership in an association	Whether a tomato (GLV) manager belongs to a trade/ business association	Dummy	+/-
Commercialization rate	What proportion of the total output is sold by tomato (GLV) plot managers (only for the farm node)	Proportion	+
Mechanization	Whether plot managers used any form of mechanization on the tomato (GLV) plots (only for the farm node)	Dummy	-

4. Results and discussion

4.1 Who is engaged in the tomato and GLV value chains?

Figures 3-5 characterize the study sample in terms of who is employed in the GLV value chain (enterprise managers) and the extent to which they are hiring labor. Four key points stand out.

First, there are significant gender differences among enterprise owners across our study states and value chains. Both value chains are significantly male-dominated in Kaduna; with over 90% of enterprise owners being male. The only

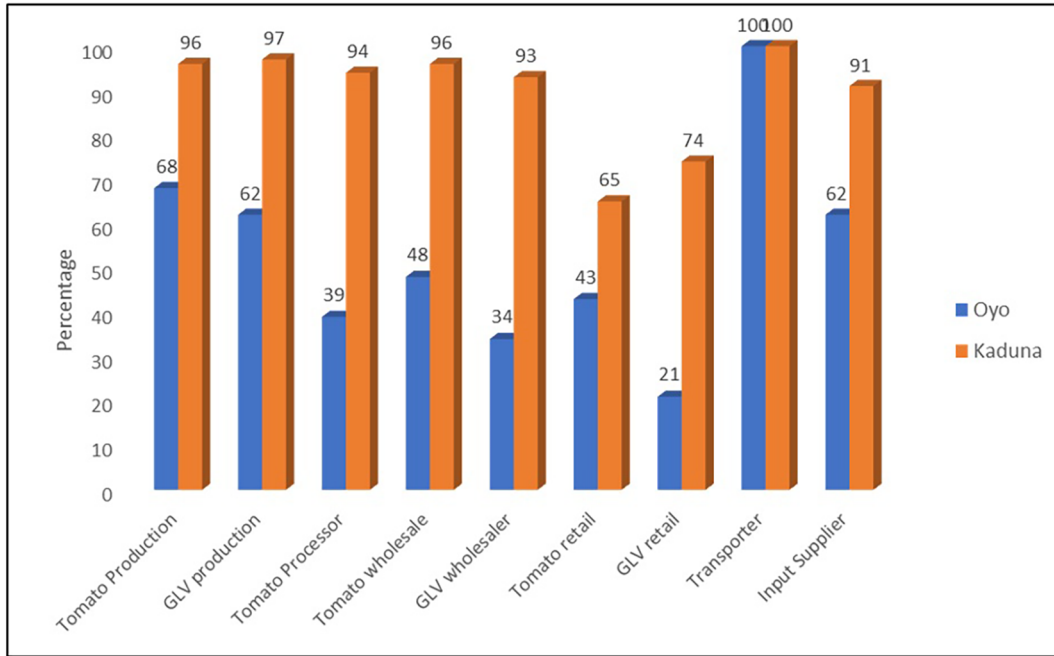


Figure 3. Gender (male) of enterprise managers by state and value chain.

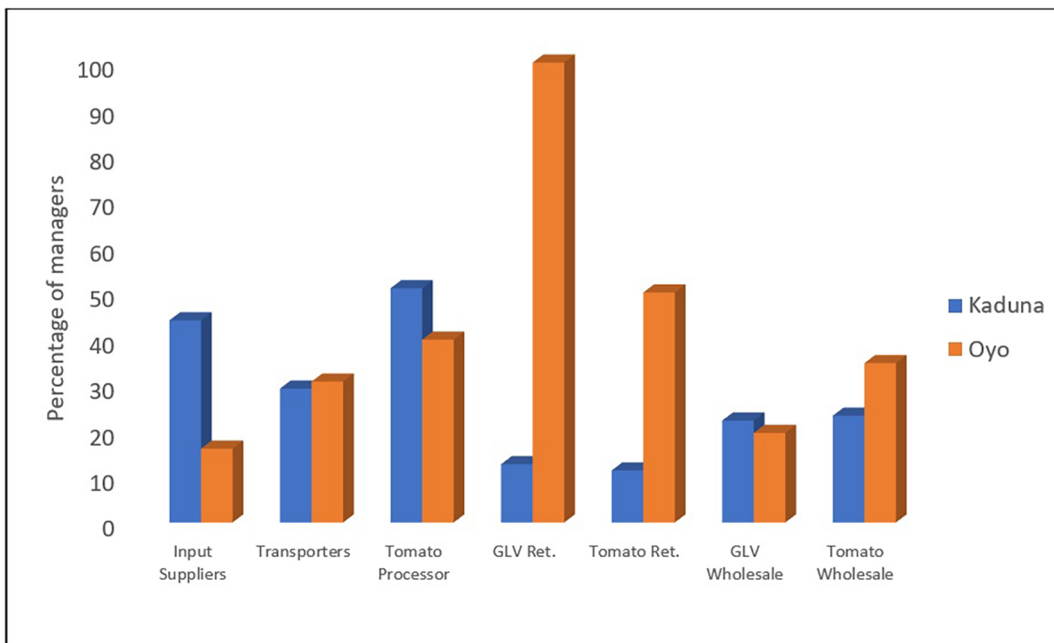


Figure 4. Extent of hiring casual labor by enterprises that hire any labor.

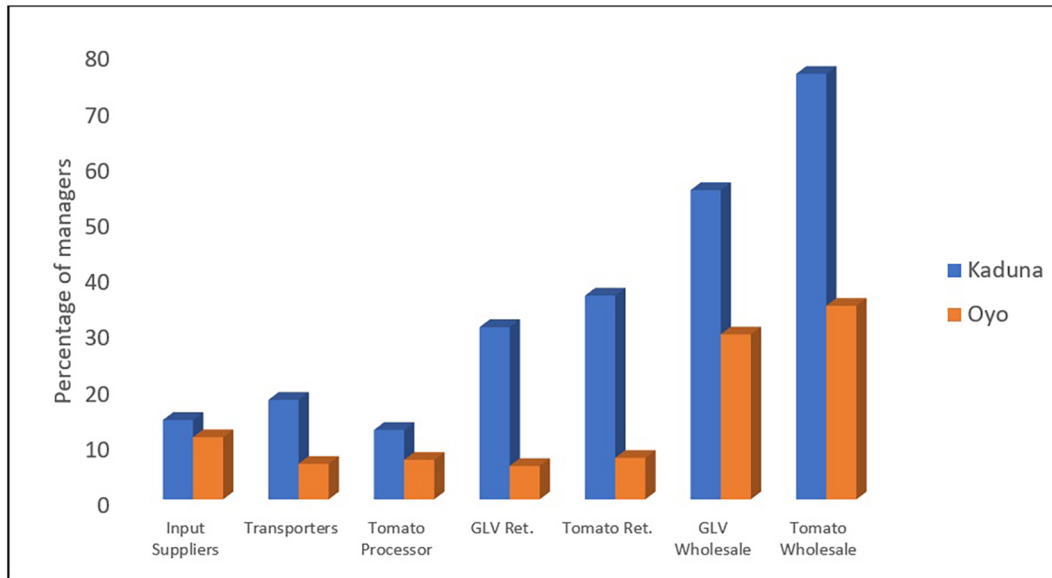


Figure 5. Extent of hiring permanent labor by enterprises that hire any labor.

segments where female engagement (as an entrepreneur) is significant is at the retail segment where females account for between 25% and 35% of enterprise owners. In contrast, females are highly engaged at all segments of the value chain in Oyo state and dominate as enterprise owners in tomato processing, wholesale and retail (Figure 3). In Oyo, even for the male dominated segments (input supply and production), >30% of enterprise owners are female. One exception is transportation with 100% of enterprise owners being men. Our results are similar to⁵² who found that 92% of the vegetables retailers in their study in Papua New Guinea were women but with no women participating in the transportation business and⁵³ who found that tomato production in Kenya is male dominated.

Our second key finding from the descriptive analysis is that the tomato (GLV) value chains do not only provide employment for enterprise managers but provide employment for others they hire. This finding cuts across the two study states and value chains. On the farm, 70% of GLV producers hire some non-family labor (85% for Tomatoes). Off-farm, this varies from 70-90% in Oyo compared to 70-80% in Kaduna for GLV and Tomatoes, respectively. Off the farm, apart from retailers in Oyo, there is non-trivial level of hiring across all nodes (25% -90%) (Table 2). A higher share of enterprises in Kaduna hire compared to Oyo (except at the transporter and the GLV farm nodes). Most hiring is done at production and tomato wholesale nodes. Conditional on hiring we see that enterprises that hire casual workers hire about 5 casual workers a month while those who hire permanent workers tend to employ 3 permanent employees on average.

Third, hiring off the farm varies significantly across study states and nodes. Conditional on hiring, GLV plot managers hire 114 person days per ha compared to 144 person days per ha for tomatoes. Our results are consistent with,³ who recorded an average of 121 labor days of hired labor for tomato farms in Oyo State in Nigeria. GLV plot managers in Kaduna state hire significantly more person days per ha compared to those in Oyo state. However, there is no significant difference in the number of person days hired by tomato plot managers between states. Off the farm, a larger share of enterprises in Oyo hire casual labor, while a larger share of enterprises in Kaduna hire permanent labor (Figures 4 and 5). However, conditional on hiring, the average number of permanent employees are higher in Oyo compared to Kaduna. (Table 2). Higher numbers of permanent employees in Oyo is noted among input suppliers, transporters, and GLV retailers. On average, retailers who hire any labor tend to hire casual labor, while wholesalers who hire any labor mostly hire permanent labor. While the average number of casual employees is similar across most nodes (5 per month), the number of permanent employees varies significantly across states with Oyo hiring more permanent employees (3 in Oyo Vs. 2 in Kaduna at the input supply node, 2 in Oyo Vs. 1 in Kaduna at the transport node and 4 in Oyo Vs. 2 in Kaduna at the GLV retail node).

In terms of quality of the jobs (remuneration), we find that permanent jobs generally offer remuneration comparable to rates paid for semi-skilled labor in more formal employment in the study states. However, remuneration for casual workers is quite low. It is important to note that the wages for casual workers are the reported amounts paid by enterprise managers in our sample but do not mean they are the only source of wages for the hired employee. Casual workers may

Table 2. Employee hiring.

	Input supplier	Tomato processor	Transporter	GLV wholesale	Tomato wholesale	GLV Retailer	Tomato Retailer	GLV producer	Tomato producer
Hired (%) (All)	0.4 (0.5)	0.5 (0.5)	0.4 (0.5)	0.4 (0.5)	0.6 (0.5)	0.4 (0.5)	0.4 (0.5)	0.7 (0.5)	0.8 (0.4)
Oyo	0.3 (0.4)	0.5 (0.5)	0.4 (0.5)	0.3 (0.4)	0.4 (0.8)	0.1 (0.3)	0.1 (0.3)	0.7 (0.5)	0.9 (0.34)
Kaduna	0.5 (0.5)	0.6 (0.5)	0.4 (0.5)	0.6 (0.5)	0.6 (0.5)	0.5 (0.5)	0.4 (0.5)	0.7 (0.5)	0.8 (0.4)
t-test	***	*		***	***	***	***		***
Casual workers (#) (All)	3 (4)	3 (4)	2 (1)	5 (2)	5 (2)	5 (3)	5 (2)		
Oyo	2 (1)	3 (2)	1 (1)	5 (2)	5 (5)	3 (2)	5 (3)		
Kaduna	4 (4)	4 (4)	2 (1)	5 (2)	5 (1)	6 (3)	5 (2)		
t-test	*				***				
Permanent workers (#) (all)	2 (2)	3 (3)	1 (1)	2 (1.01)	3 (1)	2 (1)	2 (1)		
Oyo	3 (3)	2 (1)	2 (2)	2 (1)	2 (2)	4 (3)	2 (1)		
Kaduna	2(2)	3 (3)	1 (1)	2 (1)	3 (1)	2 (1)	2 (1)		
t-test	*		**		***	***			
Man days per ha								114(202)	144 (968)
Oyo								70 (91)	139 (931)
Kaduna								123 (217)	151 (968)
t-test								*	

Note: Authors calculations. Standard deviations in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

work for multiple employers concurrently. Remuneration varies significantly across the two value chains and between states, as shown in Table 3. Casual labor wages differ by state at nearly every node, except for input suppliers and wholesalers (for both tomato and GLV). In off-farm roles, Kaduna pays more than Oyo, whereas on-farm jobs in Oyo offer higher wages than those in Kaduna. This disparity may explain why more off-farm enterprise owners in Oyo hire casual labor.

Farm level jobs offer wages to casual workers that appear somewhat higher than those for casual workers at the wholesale and retail nodes—2,070 Naira/day for GLV plots and 2,680 Naira/day for tomato plots (slightly more than one US dollar). This might be because of the difference in the nature of tasks and the fact that daily workers in markets might be able to engage in multiple jobs each day while this might be less likely for the farm workers. In contrast, more skilled casual roles, such as those at tomato processors, transporters, and input suppliers, offer relatively better wages on average. Permanent labor wages also show significant differences between states across most nodes, except for the GLV wholesaler and retailer. Overall, Oyo state offers higher wages than Kaduna, which may explain the greater reliance on permanent labor in Kaduna. Monthly wages for permanent employees range from 38,000 to 115,000 Naira, comparable to monthly earnings of teachers and shop attendants in Nigeria at the time of the survey^[1].

Table 4 and 5 present the descriptive statistics about our study sample. Overall, for all our control variables, there are significant differences between states. Enterprise managers in Oyo are significantly older and more experienced than those in Kaduna. Except for tomato wholesalers, enterprise managers in Kaduna are significantly more diversified than those in Oyo while the enterprise managers in Oyo are more educated than those in Kaduna. Plot sizes in Oyo are bigger than those in Kaduna overall. Except the transport node, enterprise managers in Kaduna handle larger volumes per month compared to those in Oyo. As expected, product prices are lower at the farm node and increase relatively as you move higher in the value chain to reflect costs associated with value addition and transaction costs. Output Prices are also consistently higher in Oyo compared to Kaduna, likely in part due to Kaduna being a dominant supplier of horticultural products compared to Oyo.

Table 5 summarizes additional control variables that are more specific to the farm. There is a significant level of engagement of family members in farm level business. GLV producers in Oyo use more family members (10 Vs. 7 in Kaduna), in contrast, tomato producers in Kaduna use more family members than Oyo. Plot managers in Oyo are more involved in associations and use some level of mechanization more than those in Kaduna. However, plot managers in both value chains are highly commercialized-over 80%. In Kaduna, tomato plot managers are more commercialized while in Oyo, GLV plot managers are more commercialized.

4.2 Drivers of employment on the farm

Table 6 presents the results for the double hurdle estimations on farm. Four key findings emerge.

First, we do not find strong evidence that female plot managers are unable or unwilling to hire labor. On the contrary, we find that where significant, female plot managers are more likely to hire labor compared to their male counterparts. More specifically, gender has no significant effect on hiring decisions on the extensive margin among GLV farmers. However, for tomato plots, being a female is associated with a 12 Percentage point higher probability of hiring labor, all else equal and these results are statistically significant at 1% (Table 6). Interestingly, conditional on hiring, female plot managers tend to hire significantly less (by 22 man-days). On one hand, these results might reflect that women's decisions to hire labor are still influenced by socio-cultural dynamics, where the household head (in most cases the men) has more decision-making power in terms of resource use.^{54,55} On the other hand, this might also reflect women's higher engagement in their farms and less need for labor. We find that female plot managers in our sample managers are more engaged on their plots spending up to 11 months on tomato plots and 10 months on GLV plots per year compared to their male counterparts who spend an average of 9 and 8 months on their tomato and GLV plots, respectively. Together, our results imply that female farmers in the tomato and GLV value chain in Nigeria are not unable or unwilling to hire in labor, but might face constraints or different labor needs compared to their male counterparts and this is worthy of further consideration. Our finding of lower hiring on the intensive margin is consistent with the literature that notes that female entrepreneurs hire less than male entrepreneurs and that female entrepreneurs prefer working from home or close to home.^{49,50}

[1]These comparisons are based on anecdotal evidence from a post field work survey carried out in the study states by teams of enumerators in the study states who were deliberately asked to visit 5 primary schools and 5 small food retail shops in the capital cities of Ibadan (Oyo) and Kaduna City (Kaduna) between June and July 2025.

Table 3. Employee remuneration.

	Input supplier	Tomato processor	Transporter	GLV wholesale	Tomato wholesale	GLV Retailer	Tomato Retailer	GLV producer	Tomato producer
Wages per day ('000 Naira) (casual)*	2.71 (1.12)	3.15 (2.45)	7.20 (4.07)	1.25 (0.18)	1.23 (0.12)	1.29 (0.15)	1.25 (0.21)	2.07 (0.62)	2.68 (0.80)
Oyo	2.89 (1.69)	2.35 (1.74)	5.37 (2.59)	1.24 (0.19)	1.3 (0.3)	1.20 (0.60)	1.09 (0.37)	3.42 (0.07)	3.39 (0.06)
Kaduna	2.67 (0.95)	3.75 (5.31)	9.74 (4.40)	1.25 (0.17)	1.22 (0.1)	1.29 (0.10)	1.30 (0.10)	1.79 (0.12)	1.79 (0.11)
t-test		**	***			*	***	***	***
Wages per month ('000 Naira) (permanent)	38.88 (19.12)	41.19 (11.70)	60.33 (54.32)	92.23 (35.75)	118.57 (36.18)	46.90 (13.53)	54.46 (16.22)		
Oyo	50.48 (26.63)	51.50 (13.78)	79.68 (84.37)	89.88 (43.20)	87.56 (68.993)	45.54 (9.01)	46.13 (5.10)		
Kaduna	33.48 (11.04)	35.52 (4.58)	52.76 (35.13)	93.32 (31.90)	126.04 (23.36)	46.94 (13.67)	56.15 (17.86)		
t-test	***	***	*		***				

Note: Authors calculations. Standard deviations in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

Table 4. Control variables used in the estimation.

	Input supplier	Tomato processor	Transporter	GLV wholesale	Tomato wholesale	GLV Retailer	Tomato Retailer	GLV producer	Tomato producer
Age: Oyo	42.2(12.0)	46.4(11.51)	43.4(8.0)	44.5(11.3)	45.1(18.2)	45.9 (13.1)	42.6(13.9)	48.8(13.5)	48.6(15.7)
Age: Kaduna	38.8 (10.2)	39.1 (9.8)	40.2 (8.2)	41.8 (10.6)	40.2 (7.6)	39.4 (11.4)	39.1 (9.8)	40.8(12.7)	38.4(11.4)
t-test	***	***	***	***	***	***		***	***
Business exp: Oyo	7.5 (5.0)	10.5 (8.4)	15.67(10.03)	14.2 (9.8)	18.2 (17.4)	14.5 (10.0)	16.0(11.4)	10.5(9.56)	14.0 (7.9)
Business exp: Kaduna	14.8(10.5)	11.4 (7.6)	13.4 (8.6)	14.4 (8.8)	14.4 (6.2)	13.1 (9.0)	14.5 (8.5)	7.8 (6.3)	10.6(9.8)
t-test			***		***			***	***
Output Price/kg (000N): Oyo	3.7 (8.1)	2.1 (0.3)	1.5 (0.9)	1.9 (0.2)	2.3 (0.1)	2.3 (0.2)	2.5 (0.3)	1.5 (0.0)	0.3 (0.1)
Output Price/kg (000N): Kaduna	1.2 (1.1)	1.6 (0.7)	5.0 (10.4)	1.9 (0.2)	2.3 (0.1)	2.4 (0.3)	2.4 (0.3)	0.4 (0.1)	0.3 (0.2)
t-test	***	***	***	*	***	***		***	***
Diversification: Oyo	0.6 (0.5)	0.6 (0.5)	0.6 (0.5)	0.6 (0.5)	0.7 (0.8)	0.7 (0.5)	0.6 (0.5)	0.4 (0.5)	0.5 (0.5)
Diversification: Kad	0.8 (0.4)	0.8 (0.4)	0.7 (0.5)	0.6 (0.5)	0.3 (0.4)	0.7 (0.5)	0.6 (0.5)	0.6 (0.5)	0.6 (0.5)
t-test	***	***	*		***			***	***
Education: Oyo	0.9(0.3)	0.7 (0.5)	0.6 (0.5)	0.5 (0.5)	0.6 (0.8)	0.5 (0.5)	0.4 (0.5)	0.5 (0.5)	0.5 (0.5)
Education: Kaduna	0.7 (0.5)	0.7 (0.5)	0.5 (0.5)	0.4 (0.5)	0.5 (0.4)	0.6 (0.5)	0.5 (0.5)	0.4 (0.5)	0.5 (0.5)
t-test	***		***	**	***	*	*	*	**
Biz size (tons/season)/Plot size (ha)	44.4 (47.5)	208.9 (219.7)	35.5 (65.7)	5.6 (35.4)	241.5(152.7)	1.3 (5.8)	23.2 (13.7)	0.9 (1.3)	1.2 (1.8)
Oyo	57.2(49.2)	138.2 (204.0)	42.8 (71.2)	5.1 (20.8)	176.9(266.7)	1.5 (4.4)	17.8(13.4)	1.7 (2.2)	1.5 (2.3)
Kaduna	31.9(42.3)	251.0 (218.2)	27.3 (58.0)	8.6 (47.2)	257.1(113.1)	1.3 (5.8)	25.0(13.3)	0.7 (0.9)	0.9 (1.1)
t-test	***	***	***	*	***		***		***

Note: Authors calculations. Standard deviations in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

Table 5. Other control variables for the farm node.

	GLV producer	Tomato producer
Number of household members engaged: Oyo	10 (11)	6 (7)
Number of household members engaged: Kaduna	7 (7)	7 (8)
t-test	***	**
Membership in an association: Oyo	0.5 (0.5)	0.5 (0.5)
Membership in association: Kaduna	0.2 (0.4)	0.2 (0.4)
t-test	***	***
Commercialization rate (%): Oyo	86.9 (24.2)	89.0 (23.7)
Commercialization rate (%): Kaduna	85.4 (28.2)	92.5 (16.0)
t-test	***	
Farmer used mechanization (Yes): Oyo	0.1 (0.3)	0.1 (0.4)
Farmer used mechanization (Yes): Kaduna	0.0 (0.1)	0.0 (0.0)
t-test	***	***

Note: Authors calculations. Standard deviations in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

Table 6. Double-Hurdle estimates for the factors associated with hiring on the farm.

	Stage 1 (Decision to hire)		Stage 2 (Person days hired)	
	Tomatoes	GLVs	Tomato	GLV
Female	0.120*** (0.0217)	-0.055 (0.101)	-22.21*** (6.308)	-3.627 (10.42)
Age	0.003*** (0.001)	-0.003* (0.002)	-0.239 (0.178)	-0.567* (0.339)
Education	0.026 (0.021)	-0.036 (0.043)	6.540 (5.842)	-9.301* (5.574)
Diversification	-0.018 (0.021)	0.026 (0.042)	-10.67* (5.756)	-1.109 (5.461)
Farming experience	0.002 (0.001)	0.004 (0.003)	0.849*** (0.302)	1.996** (0.777)
Farm size	0.027*** (0.009)	0.042* (0.024)	27.28*** (3.894)	31.27*** (6.467)
Family engagement	-0.006*** (0.002)	-0.015*** (0.002)	-0.909** (0.444)	-4.354*** (1.409)
Oyo state	0.159 (0.225)	-0.357 (0.627)	-21.04 (55.49)	-11.42 (114.9)
Wage	-0.105 (0.134)	0.218 (0.256)	26.48 (34.60)	16.00 (51.59)
ROSCA member	0.096*** (0.020)	0.037 (0.047)	-	-
Output price	-0.071 (0.089)	0.0367 (0.263)	15.45 (22.56)	-11.99 (33.71)

Table 6. *Continued*

	Stage 1 (Decision to hire)		Stage 2 (Person days hired)	
	Tomatoes	GLVs	Tomato	GLV
Distance to market	-0.0001 (0.0002)	-5.32e-05 (0.0001)	-0.001 (0.004)	-0.011*** (0.002)
Use mechanization	0.129*** (0.023)	0.226*** (0.070)	7.322 (11.46)	27.97** (13.90)
Commercialization	0.0005 (0.0005)	0.001 (0.001)	-0.163 (0.142)	0.318*** (0.098)
Production cycles	-0.0204 (0.019)	-0.022 (0.027)	0.214 (6.204)	-2.985 (3.057)
IMR	-	-	-	95.98** (47.45)
Constant	-	-	-0.179 (70.83)	-32.88 (113.9)
Observations	1,279	507	1,061	352
R-squared			0.342	0.308

Note: Robust standard errors in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.

With regards to our second hypothesis (i.e. the state where farms are located), we find that the location of the plot manager does not matter for the decision to hire labor and the amount of labor hired by tomato and GLV plot managers. Our third hypothesis relates to market conditions. We find that wages and output prices have no significant effect on the decision to hire labor or the amount of labor hired. The limited impact of location and market factors on labor hiring decisions reflects the high labor demand for tomato and GLV production (hiring rates in our sample are high ranging between 70% and 90%) and contrasts with views that African farmers tend to depend on family labor and do not hire.

Fourth, we find that farm and plot manager characteristics significantly influence labor hiring decisions. All else equal, larger farms are more likely to hire labor, with each additional hectare associated with a 3 and 4-percentage point higher probability of hiring in tomato and GLV farms respectively. Farm size is also positively and significantly associated with the number of man-days hired for both tomatoes and GLVs. Specifically, each additional hectare is associated with 27 and 31 more man-days hired in on tomato and GLV plots, respectively. These findings align with,⁵⁶ who observed higher labor hiring on larger Nigerian farms, though they noted lower productivity due to supervision costs. In contrast,³ reported a negative correlation between farm size and job quantity among tomato farmers in Oyo State.

As expected, more family members engaged on the household tomato and GLV farm reduces the need for hired labor. An additional family member engaged in farming is associated with a 1 and 2-percentage-point lower probability of hiring external labor for tomatoes and GLVs, respectively. For those who do hire, each additional family member is associated with 1 and 4 fewer man-days hired in on tomato and GLV plots, respectively. Despite larger farm sizes, family labor remains a preferred source due to lower supervision costs.⁵⁷

Mechanization and commercialization also influence labor demand. Plot managers using mechanized tools are more likely to hire labor for both crops and conditional on hiring, mechanization is associated with higher labor use on GLV plots. These findings are likely due to the widespread use of hand sprayers in our sample (for the production of horticultural products) which require manual operation. Similarly, highly commercialized GLV plot managers hire more labor, likely reflecting the crop's labor-intensive harvesting process to get the highly perishable product to the market in as fresh a condition as possible in continuous but relatively smaller quantities. The average number of harvests for GLV in our sample is 3.

4.3 Drivers of hiring off-farm along the tomato and GLV value chains

Table 7 presents the marginal effects from the probit estimations of the drivers of the decision to hire off-farm. We present the key results in line with our three key study hypotheses. First, where significant, female enterprise managers are

Table 7. Probit models for determinants of labor hiring across the off-farm nodes (marginal effects).

Decision to hire	Transporter	Input supplier	Tomato processor	GLV retailer	Tomato retailer	GLV WS	Tomato WS
Female (1/0)		-0.242*** (0.048)	-0.280*** (0.076)	-0.082 (0.055)	-0.0722 (0.0507)	-0.231*** (0.052)	-0.132*** (0.051)
Age (in years)	0.004 (0.003)	0.002 (0.002)	0.003 (0.003)	0.002 (0.003)	-0.002 (0.003)	-0.003 (0.003)	-0.0005 (0.002)
Formal education (1/0)	0.007 (0.049)	0.100** (0.049)	0.086 (0.067)	0.024 (0.050)	-0.043 (0.046)	0.086* (0.046)	0.043 (0.040)
Diversification (1/0)	0.034 (0.051)	0.008 (0.047)	0.106 (0.086)	0.006 (0.048)	0.036 (0.044)	0.071 (0.046)	0.061 (0.042)
Oyo state (1/0)	-0.062 (0.065)	-0.177*** (0.054)	0.124 (0.114)	-0.408*** (0.039)	-0.310*** (0.047)	-0.196*** (0.054)	-0.127** (0.051)
Business experience (years)	0.011*** (0.003)	-0.0004 (0.001)	-0.0004 (0.004)	-0.003 (0.003)	-0.002 (0.003)	0.002 (0.003)	-0.002 (0.003)
Scale (tons)	0.002*** (0.0004)	0.0002* (9.89e-05)	-0.004*** (0.001)	0.005 (0.004)	0.006*** (0.002)	0.0004 (0.001)	0.001*** (0.0001)
Permanent wage ('000 N)	-0.002*** (0.001)	-0.001 (0.001)	-0.001 (0.003)	-0.006*** (0.001)	-0.005*** (0.002)	-0.0005 (0.001)	-0.001 (0.001)
Casual wage ('000 N)	0.004 (0.007)	-0.032* (0.019)	0.005 (0.014)	-0.168 (0.134)	-0.029 (0.135)	0.161 (0.114)	0.202* (0.118)
Price (N/Kg)		-0.002 (0.006)	-0.116 (0.072)	0.396*** (0.083)	0.080 (0.087)	0.008 (0.112)	-0.288** (0.131)
Peri urban	0.143** (0.068)	-0.070 (0.054)	-0.310*** (0.096)	0.194*** (0.069)	0.019 (0.069)	0.246*** (0.062)	0.238*** (0.049)
Rural	0.212*** (0.056)	-0.019 (0.059)	-0.272** (0.135)	-0.085* (0.051)	-0.056 (0.058)	-0.001 (0.055)	-0.021 (0.055)
Union member (1/0)				0.049 (0.052)	0.065 (0.050)	0.080* (0.047)	-0.063 (0.041)
Observations	515	625	313	542	500	579	803

Robust standard errors in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.

significantly less likely to hire labor. More specifically, female managers' hiring is significantly less likely at the input supplier, tomato processor, and GLV/tomato wholesaler nodes. This trend is likely due to their greater personal involvement in enterprise activities (as noted on the farm as well), which reduces the need for external labor. Additionally, cultural constraints—such as limited access to financial resources or spousal/family/community support—might also inhibit women's ability to hire. Interestingly, gender does not appear to influence hiring decisions at the retail nodes for tomatoes and GLVs, which we noted earlier was largely for casual workers.

Second, contrary to our expectation, but consistent with the results from the National Bureau of Statistics, off-farm hiring of labor is more common in Kaduna than Oyo. This is the case for all nodes except tomato processors and transporters. Third, output prices influence labor hiring decisions differently across value chain nodes. GLV retailers tend to hire more labor when GLV prices rise, likely due to increased demand and the labor-intensive nature of GLV handling. In contrast,

higher tomato prices are associated with a lower probability of hiring, possibly reflecting trade-offs between different kinds of labor (casual and permanent) masked in an analysis of hiring at the extensive margin. For other nodes in the value chain, output prices do not significantly impact hiring decisions. Prices for both GLVs and tomatoes are seasonal and volatile, with higher prices during the low season but significant fluctuation within the season as well.⁵⁸ Managers may not be able to wait to observe output prices before making labor decisions.

Finally, several enterprise-level factors affect the decision to hire. Higher formal education is positively associated with hiring for input suppliers and GLV wholesalers. Managerial experience enhances hiring likelihood for transporters and has no significant effect at other nodes. Larger business size correlates with increased labor hiring among transporters, input suppliers, tomato retailers and tomato wholesalers, but negatively influences hiring for tomato processors. Enterprises in peri-urban or rural areas are more likely to hire labor at the transporter, GLV retailer and wholesaler nodes, while tomato processors in peri-urban and rural areas are less likely to hire compared to those in urban settings. This might reflect the higher needs for labor among transport and wholesale enterprises who, though located in rural or peri-urban areas require significant engagement with urban markets. For tomato processors who are likely to depend more on infrastructure, being in urban areas is likely to support higher processing capacity and labor need.

4.4 Factors influencing casual vs. permanent labor hiring

Beyond the decision to hire any labor, we also explore the extent to which casual labor and permanent labor are complements or substitutes for enterprises at off-farm segments of the tomato and GLV value chains. As noted in [Table 3](#), the remuneration for permanent workers in our sample was above the minimum wage for the period our data was collected, while casual wages were lower and often quite low. [Tables 8](#) and [9](#) present the results of the bivariate probit models showing the motivation of the decision to hire casual or permanent labor (and the first stage of a double hurdle model), while [Tables 10](#) and [11](#) present the results for the Poisson models showing the drivers of the number of casual or permanent labor, conditional on hiring off the farm (the second stage of the double hurdle model).

With regards to gender, we find that female enterprise managers along the tomato value chain are generally less likely to hire both casual and permanent labor compared to their male counterparts ([Tables 8](#) and [9](#)). This disparity is likely due in part to women's higher levels of time investment in their enterprises (as noted earlier) but is also probably influenced by cultural norms that limit women's access to resources. However, we find that this gender-based difference is not observed at the GLV retail nodes, where hiring decisions appear unaffected by the manager's gender and for which we have much larger female representation. At the intensive margin, we find that conditional on hiring, the numbers hired do not significantly differ between men and women across most nodes off-farm ([Tables 10](#) and [11](#)) and where significant, women are expected to hire more labor than men. The two exceptions are among tomato wholesalers and input suppliers. For tomato wholesalers, a female manager is associated with a 30% lower rate of hiring permanent labor compared to her male counterparts. Similarly, female input suppliers are associated with 60% fewer permanent employees compared to male input suppliers.

We find significant variation in hiring across the two study states. Managers in Oyo State are less likely to hire both casual and permanent labor at the tomato and GLV wholesale and retail nodes compared to those in Kaduna State. Additionally, transporters and input suppliers in Oyo are less inclined to hire permanent employees and casual labor, respectively, compared to their counterparts in Kaduna. However, conditional on hiring permanent and casual employees, managers in Oyo State tend to hire more employees than those in Kaduna State. For being a tomato wholesaler in Oyo is associated with hiring 27% more casual staff compared to Kaduna. The disparity is even more pronounced among GLV wholesalers and transporters who are associated with 8 times and 48% more permanent employees compared to those in Kaduna. The only exception is for casual labor hired by input suppliers that is lower in Oyo. These regional differences are similar to our findings on the farm (where farmers in Oyo hired more man-days on their tomato plots) and confirm that local economic conditions, labor availability, and possibly cultural or policy factors influence hiring decisions.

Related to market conditions, we find that labor hiring decisions are sensitive to changes in market prices, particularly wages and product prices. An increase in permanent labor wages leads to a decreased likelihood of hiring both permanent and casual labor among tomato and GLV retailers, indicating that these labor types may be complementary at these nodes. However, in terms of numbers hired, for example, [Table 10](#) indicates that wages do not affect the numbers hired at tomato and GLV retail nodes, while a 1,000 Naira increase in casual wages prompts GLV wholesalers to hire 43% less permanent employees, suggesting that permanent and casual labor are complements at the wholesale node. Therefore, the relationship between permanent and casual labor is complementary at the retail and wholesale nodes. [Table 9](#) further indicates that higher permanent wages reduce the likelihood of casual labor hiring among transporters, suggesting a complementary relationship between permanent and casual labor. Conditional on hiring, when the permanent wage increases by 1,000 Naira, transporters are expected to reduce both the number of permanent and casual workers hired by

Table 8. Bivariate models for the determinants of hiring casual or permanent labor at trader nodes (marginal effects).

Decision to hire permanent/ casual labor	GLV Ret permanent	GLV Ret casual	Tomato Ret permanent	Tomato Ret casual	GLV WS permanent	GLV WS casual	Tomato WS permanent	Tomato WS casual
Female (1/0)	-0.164*** (0.024)	-0.062 (0.041)	-0.125*** (0.030)	-0.087** (0.040)	-0.211*** (0.042)	-0.217*** (0.051)	-0.100** (0.046)	-0.116*** (0.044)
Formal education (1/0)	0.019 (0.026)	0.011 (0.038)	0.015 (0.029)	-0.034 (0.035)	0.011 (0.036)	0.070* (0.037)	0.068** (0.028)	0.056* (0.030)
Diversification (1/0)	0.065** (0.028)	0.007 (0.038)	-0.008 (0.026)	0.036 (0.032)	0.012 (0.040)	0.065* (0.039)	-0.021 (0.035)	0.057 (0.037)
Oyo state (1/0)	-0.148*** (0.019)	-0.386*** (0.046)	-0.163*** (0.031)	-0.288*** (0.047)	-0.091** (0.045)	-0.173*** (0.052)	-0.214*** (0.051)	-0.122** (0.048)
Business experience (years)	0.005*** (0.001)	-0.001 (0.002)	0.004*** (0.001)	-0.003* (0.002)	0.002 (0.002)	0.0004 (0.002)	0.002 (0.002)	-0.002 (0.002)
Scale (tons)	0.005** (0.002)	0.004 (0.003)	0.002*** (0.001)	0.005*** (0.001)	0.001 (0.0004)	0.0003 (0.001)	0.001*** (0.0001)	0.001*** (0.0001)
Permanent wage (000 N)	-0.004*** (0.001)	-0.005*** (0.001)	-0.002*** (0.001)	-0.004*** (0.001)	-0.0002 (0.0005)	-0.001 (0.001)	-0.0001 (0.0005)	-0.0004 (0.0005)
Casual wage (000 N)	-0.099 (0.066)	-0.125 (0.142)	0.072 (0.128)	-0.035 (0.121)	0.067 (0.096)	0.115 (0.086)	-0.006 (0.119)	0.149 (0.097)
Union member (1/0)	0.015 (0.029)	0.044 (0.037)		0.026 (0.029)	0.059 (0.038)	0.057 (0.040)	0.035 (0.035)	-0.048 (0.035)
Price (N/Kg)	0.151*** (0.048)	0.325*** (0.064)	0.019 (0.054)	0.069 (0.073)	0.051 (0.091)	0.012 (0.093)	-0.101 (0.111)	-0.22* (0.115)
Peri urban	-0.005 (0.038)	0.143** (0.056)	0.007 (0.033)	0.022 (0.042)	0.086* (0.050)	0.210*** (0.055)	0.029 (0.040)	0.189*** (0.045)
Rural	-0.097*** (0.026)	-0.067* (0.038)	-0.014 (0.036)	-0.035 (0.049)	-0.027 (0.049)	-0.011 (0.049)	-0.057 (0.051)	-0.027 (0.053)
Observations	542	542	500	500	579	579	803	803

Note: Robust standard errors in parentheses.
 ***p < 0.01,
 **p < 0.05,
 *p < 0.

Table 9. Bivariate models for the determinants of hiring casual or permanent labor at transporter, input supplier and tomato processor nodes (marginal effects).

Decision to hired permanent/casual labor	Transporter permanent	Transporter casual	Input Supplier permanent	Input Supplier casual	Tomato Processor permanent	Tomato processor casual
Female (1/0)			-0.095*** (0.027)	-0.205*** (0.044)	-0.101*** (0.033)	-0.179** (0.074)
Age (in years)	0.003 (0.002)	0.003 (0.003)	-0.0003 (0.001)	0.002 (0.002)	-0.0003 (0.002)	0.002 (0.003)
Formal education (1/0)	0.036 (0.029)	-0.010 (0.040)	0.047 (0.030)	0.077* (0.040)	0.028 (0.034)	0.051 (0.060)
Diversification (1/0)	0.006 (0.030)	0.037 (0.043)	0.024 (0.028)	-0.006 (0.041)	0.043 (0.046)	0.042 (0.076)
Oyo state (1/0)	-0.163*** (0.040)	0.062 (0.056)	0.004 (0.039)	-0.230*** (0.044)	0.028 (0.061)	0.098 (0.093)
Business experience (years)	0.003* (0.002)	0.008*** (0.002)	-0.003 (0.002)	-0.0004*** (0.0001)	-0.002 (0.002)	0.003 (0.004)
Scale (tons)	0.0004** (0.0002)	0.001*** (0.0003)	0.0001 (0.0001)	0.0001* (0.0001)	0.0002 (0.0005)	-0.003*** (0.001)
Permanent wage ('000 N)	-0.0002 (0.0004)	-0.002*** (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.002 (0.002)	-0.001 (0.003)
Casual wage ('000 N)	-0.002 (0.004)	0.002 (0.007)	-0.007 (0.013)	-0.019 (0.018)	0.016** (0.007)	0.007 (0.008)
Price (N/Kg)			-0.002 (0.002)	-0.0002 (0.002)	0.054 (0.035)	-0.135** (0.063)
Peri urban	-0.049 (0.032)	0.145*** (0.056)	-0.041 (0.035)	-0.053 (0.045)	-0.064 (0.042)	-0.170** (0.070)
Rural	0.020 (0.033)	0.158*** (0.044)	0.036 (0.041)	0.009 (0.053)	-0.050 (0.082)	-0.182* (0.108)
Observations	515	515	625	625	313	313

Note: Robust standard errors in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.

1% also suggesting a complementary relationship. Therefore, it is evident from our results that permanent and casual labor types are complementary at the transporter node. This is likely because, in addition to permanent labor, casual workers are needed to help in loading and offloading the trucks among other jobs. Conversely, casual labor wages generally do not affect hiring decisions, except among tomato processors, where higher casual wages increase the likelihood of hiring permanent labor—suggesting a substitution effect. Conditional on hiring, the wage paid to casual workers significantly affects the number of employees hired by tomato processors and input suppliers. When the casual wage increases by 1,000 Naira, tomato processors are expected to increase the number of permanent employees hired by 3%, while input suppliers are expected to increase the number of permanent employees hired by 10%. These results confirm that permanent and casual labor are substitutes at the tomato processor and input supplier nodes. As casual labor becomes expensive, input suppliers and tomato processors may prefer to have a few permanent workers who can also do the petty jobs that casual workers would have done. In sum, our results suggest that the relationship between permanent labor and casual varies by node. We observe a complementary relationship at the retailers, GLV wholesalers, and transport node while a substitution effect is observed at the tomato processor and the input supplier nodes.

Table 10. Poisson regression for the intensity of hiring casual or permanent employees by tomato and GLV traders (retailers and wholesalers).

	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)
Number hired	GLV Ret perm	GLV Ret casual	Tomato Ret perm	Tomato Ret casual	GLV WS perm	GLV WS casual	Tomato WS perm	Tomato WS casual
Female (1/0)	0.669	1.186***	0.936	1.013	2.243***	1.155*	0.755***	1.149
	(0.306)	(0.0746)	(0.240)	(0.068)	(0.689)	(0.100)	(0.080)	(0.130)
Formal education (1/0)	0.970	0.943	1.169	0.952	0.957	1.059	1.077	0.869**
	(0.202)	(0.0603)	(0.216)	(0.056)	(0.087)	(0.057)	(0.071)	(0.056)
Diversification (1/0)	1.218	0.897*	1.115	0.920	1.272***	1.003	1.037	0.958
	(0.286)	(0.0529)	(0.216)	(0.0581)	(0.106)	(0.055)	(0.067)	(0.059)
Oyo state (1/0)	8.067***	0.923	0.940	1.014	1.477**	0.950	0.947	1.274***
	(6.286)	(0.107)	(0.540)	(0.134)	(0.274)	(0.070)	(0.071)	(0.116)
Business experience (years)	1.015	0.992**	1.006	0.990***	1.000	0.994*	1.005	1.002
	(0.012)	(0.00303)	(0.010)	(0.004)	(0.006)	(0.003)	(0.003)	(0.003)
Scale (tons)	1.016*	0.992	1.016**	1.003	0.999	1.000	1.000**	0.999
	(0.009)	(0.00556)	(0.008)	(0.003)	(0.001)	(0.0004)	(0.0002)	(0.0004)
Permanent wage ('000 N)	1.011	1.001	1.005	1.000	1.003**	1.001	1.001	1.001
	(0.009)	(0.00216)	(0.00728)	(0.002)	(0.002)	(0.001)	(0.001)	(0.0007)
Casual wage ('000 N)	7.063	0.841	1.454	1.141	0.575**	1.028	1.390	0.795
	(8.457)	(0.124)	(1.098)	(0.381)	(0.125)	(0.150)	(0.288)	(0.197)
Price (N/Kg)	0.694	0.918	0.931	1.382**	0.789	1.118	1.353	1.068
	(0.273)	(0.102)	(0.369)	(0.204)	(0.187)	(0.168)	(0.270)	(0.224)
Peri urban	0.891	1.166**	0.976	0.828**	0.658**	1.041	0.994	0.835
	(0.217)	(0.0833)	(0.235)	(0.073)	(0.108)	(0.081)	(0.069)	(0.102)
Rural	1.269	1.082	0.879	0.957	1.028	1.039	1.001	1.138*
	(0.358)	(0.0757)	(0.257)	(0.091)	(0.148)	(0.102)	(0.133)	(0.087)
Inverse Mills					0.281**			0.471*
					(0.162)			(0.207)
Constant	0.108	8.751***	0.557	2.458	14.53**	3.535***	0.574	10.51***
	(0.188)	(3.113)	(0.633)	(1.377)	(15.67)	(1.350)	(0.231)	(4.604)
Observations	79	202	82	161	145	232	280	427

Note: Robust standard errors in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.

We find that higher GLV prices is associated with a higher likelihood of hiring at retail nodes for both permanent and casual labor. For tomato, higher prices are associated with lower probability of hiring casual workers by wholesalers and processors. While initially surprising, these results are not inconsistent with economic theory since they mean that compared to enterprises that don't hire any labor, these enterprises are less likely to depend only on casual labor which might mean that they tend to hire both casual and permanent. Conditional on hiring, a 1,000 Naira increase in tomato prices is associated with hiring 38% more casual workers among tomato retailers (Table 10).

Tables 8-11 reveal that diversified GLV retailers and wholesalers exhibit higher propensity for hiring permanent and casual labor respectively relative to specialized firms. Conditional on hiring, diversified GLV wholesalers and

Table 11. Poisson regression for the intensity of hiring casual or permanent employees by transporters, input suppliers and tomato processors.

	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)	(IRR)
Number hired	Transporter perm	Transporter casual	Supplier perm	Supplier casual	Processor perm	Processor casual
Female (1/0)			0.357*** (0.108)	0.845 (0.183)	0.830 (0.300)	1.490 (0.500)
Age (in years)	0.992 (0.011)	1.000 (0.007)	0.985* (0.008)	0.992 (0.007)	1.003 (0.017)	1.001 (0.009)
Formal education (1/0)	1.220 (0.190)	1.043 (0.115)	1.873*** (0.383)	1.287 (0.239)	0.871 (0.268)	0.882 (0.139)
Diversification (1/0)	1.349* (0.226)	1.174* (0.108)	1.298 (0.249)	0.957 (0.215)	1.120 (0.329)	0.960 (0.350)
Oyo state (1/0)	1.640** (0.388)	1.031 (0.126)	1.412 (0.449)	0.657** (0.123)	0.800 (0.309)	0.709 (0.239)
Business experience (years)	1.017 (0.012)	1.000 (0.006)	1.031* (0.018)	1.015 (0.011)	0.983 (0.022)	0.991 (0.009)
Scale (tons)	1.002* (0.001)	1.000 (0.001)	1.000 (0.001)	1.001* (0.0003)	0.998 (0.003)	1.002 (0.005)
Permanent wage ('000 N)	0.998 (0.001)	0.997** (0.001)	1.004 (0.005)	1.001 (0.003)	1.012 (0.0121)	1.008 (0.008)
Casual wage ('000 N)	1.014 (0.036)	0.999 (0.013)	1.104*** (0.038)	1.021 (0.060)	1.030*** (0.011)	0.997 (0.018)
Price (N/Kg)			1.113 (0.115)	1.049 (0.050)	0.803 (0.235)	1.039 (0.172)
Inverse Mills						0.228** (0.141)
Constant	0.810 (0.583)	1.722* (0.555)	0.715 (0.374)	2.781*** (0.782)	2.403 (2.656)	8.234** (7.687)
Observations	61	151	85	208	31	143

Note: Robust standard errors in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.

transporters employ 27% and 35% more permanent labor respectively, while diversified transporters and GLV retailers employ 17% and 10% more/less casual labor respectively than specialized counterparts. Managerial experience positively correlates with permanent hiring at transport and retail nodes, but experienced input suppliers and tomato retailers hire fewer casual workers. Each additional year of experience increases the amount of permanent labor hired by 3% for input suppliers, while GLV retailers, tomato retailers and wholesalers reduce hiring of casual labor by 1%. Rural GLV retailers are less likely to hire permanent labor, consistent with smaller scale and activity levels. Rural tomato wholesalers, handling large but sporadic volumes, favor casual labor for peak periods over permanent staff. Firm size amplifies hiring intensity: transporters, GLV retailers, and tomato retailers increase permanent hiring. Overall, these results confirm that enterprise structure, location, and managerial experience influence hiring decisions.

5. Conclusions and policy recommendations

Employment in Africa's agri-food sector remains central to poverty reduction and structural transformation, yet off-farm labor dynamics are underexplored. This study fills that gap by providing new empirical evidence on both on-farm and

off-farm labor dynamics in Nigeria's horticultural value chains, highlighting how gender, enterprise structure, and geographic context jointly influence employment outcomes. We find that participation along the horticulture value chain in Nigeria is substantial across men and women, with significant heterogeneity across regions. Kaduna's value chains are male-dominated across nodes, whereas Oyo exhibits higher female engagement and female dominance at some nodes. Employment along horticulture value chains in Nigeria extends beyond entrepreneurial opportunities for MSME owners to wage opportunities with hiring rates ranging from 25% to 90% across these MSMEs. We find significant variation in hiring strategies with Oyo enterprises favoring casual labor, while Kaduna firms exhibit a stronger preference for permanent staff. We also find that wage levels for permanent employees (₦38,000–₦115,000) align with current wages observed in the study states for semi-skilled and unskilled labor, suggesting non-trivial labor market integration.

This study finds that gendered hiring patterns are nuanced. On-farm, female tomato plot managers hire more frequently but employ fewer workers. However, off-farm, female managers are less likely to hire labor, though conditional hiring volumes are statistically indistinguishable from male counterparts. State context matters—Oyo managers hire less often but in larger numbers when they do. Labor type interactions vary by node with complementarities between casual and permanent labor in transport, retail, wholesale and substitution in input supply and tomato processing.

Taken together, our results confirm substantial employment opportunities along Nigeria's horticulture value chains, spanning both entrepreneurial and wage-based work. However, the findings highlight the need for differentiated labor market interventions that address gendered constraints, enterprise scale, and regional market structures to foster inclusive labor systems. For instance, in Kaduna, reducing entry barriers for women could enhance income generation and hiring capacity; further research on constraints to women's hiring behavior could improve productivity and employment outcomes. Similarly, examining wage standards, skill requirements, and regulatory frameworks can strengthen labor quality and equity. Given that larger firms hire more labor, credit-linked hiring schemes or tax incentives could support employment (quantity and quality) and improve job security. Significant state-level variation underscores the importance of state-specific labor policies rather than uniform national strategies to reflect divergent hiring patterns and gender dynamics.

Ethical approval and consent statement

All studies in this project involving humans were approved by Michigan State University Institutional Review Board and were conducted in accordance with the local legislation and institutional requirements. This project has the Michigan State University IRB Study ID: STUDY00007403 and was determined exempt Category: Exempt 2ii. The participants provided their written informed consent to participate in this study.

Consent

The participants provided their written informed consent to participate in this study.

Data availability

Our data is not yet publicly available due to ethical issues. However, data will be made available upon request.

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References

- Mizik T, Nagy J, Molnár EM, *et al.*: **Challenges of employment in the agrifood sector of developing countries—a systematic literature review**. *Springer Nature*. Dec. 01, 2025. [Publisher Full Text](#)
- Diao X, Hazell P, Thurlow J: **The Role of Agriculture in African Development**. *World Dev*. Oct. 2010; **38**(10): 1375–1383. [Publisher Full Text](#)
- Aremu O, Fabry A, Meemken EM: **Farm size and the quality and quantity of jobs—Insights from Nigeria**. *Food Policy*. Oct. 2024; **128**. [Publisher Full Text](#)
- Ramakgasha MJ, Thaba TK, Rudzani N: **Agricultural Production and Agricultural Employment Rate in South Africa: Time Series Analysis Approach**. *Int. J. Econ. Financ. Issues*. Jul. 2024; **14**(4): 148–153. [Publisher Full Text](#)
- Garrone M, Emmers D, Olper A, *et al.*: **Jobs and agricultural policy: Impact of the common agricultural policy on EU agricultural**

- employment.** *Food Policy.* Aug. 2019; **87**.
[Publisher Full Text](#)
6. Garibaldi LA, Pérez-Méndez N: **Positive outcomes between crop diversity and agricultural employment worldwide.** *Ecol. Econ.* Oct. 2019; **164**.
[Publisher Full Text](#)
 7. Headey D, Bezemer D, Hazell PB: **Agricultural employment trends in Asia and Africa: Too fast or too slow?** *World Bank Res. Obs.* Feb. 2010; **25**(1): 57–89.
[Publisher Full Text](#)
 8. De Blasis F: **Global horticultural value chains, labour and poverty in Tanzania.** *World Dev Perspect.* Jun. 2020; **18**.
[Publisher Full Text](#)
 9. Maertens M, Fabry A: **Creating More and Better Jobs in Global Value Chains.** *Future of Work in Agriculture conference.* Mar. 2019. Washington DC.
 10. Van Keulen R, Rumenera P, Banjara G, et al.: **Horticulture value chain analysis: Opportunities for youth employment in Rwanda SNV.** Rome: 2022.
[Publisher Full Text](#)
 11. Christiaensen L, Rutledge Z, Taylor JE: **Viewpoint: The future of work in agri-food.** Elsevier Ltd.; Feb. 01, 2021; vol. **99**.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 12. Thurlow J, Holtemeyer B, Jiang S, et al.: **IFPRI INTERNATIONAL FOOD POLICY Measuring Agrifood Systems New Indicators and Global Estimates Foresight and Policy Modeling Unit CGIAR POLICY INNOVATIONS.** 2025.
 13. Davis B, et al.: **Food and Agriculture FVO Organization of the VAT PANIS ESTIMATING GLOBAL AND COUNTRY-LEVEL EMPLOYMENT IN AGRIFOOD SYSTEMS.** 2023.
 14. Abdelaziz F, Breisinger C, Khouri N, et al.: **Regional section—middle east and northern Africa.** *International Food Policy Research Institute (IFPRI)—2020 Global Food Policy Report: Building Inclusive Food Systems.* Washington, DC: 2020.
 15. IFPRI: **2020 Global Food Policy Report: Building Inclusive Food Systems.** 2020. Accessed: Dec. 13, 2025.
[Reference Source](#)
 16. IFAD: **Rural Development Report: Creating Opportunities for Rural Youth.** 2019. Accessed: Dec. 13, 2025.
[Reference Source](#)
 17. FAO: **FAO State of Food and Agriculture 2017: Leveraging Food Systems for Inclusive Rural Transformations.** 2017.
 18. Townsend R, Benfica RM, Prasann A, et al.: **Shaping the Food System to Deliver Jobs.** 2017.
 19. Tschirley D, et al.: **Africa's Unfolding Diet Transformation: Implications for Agrifood System Employment.** 2015.
 20. Parkhi CM, Liverpool-Tasie LSO, Reardon T, et al.: **Heterogeneous Consumption Patterns of Fruits and Vegetables in Nigeria: A Panel Data Analysis.** 2023.
 21. Cazzuffi C, Pereira-López M, Soloaga I: **Local poverty reduction in Chile and Mexico: The role of food manufacturing growth.** *Food Policy.* Apr. 2017; **68**: 160–185.
[Publisher Full Text](#)
 22. Sauer C, Dolislager M, Reardon T: **Spatialized Links Between the Agri-Food System and Employment in Tanzania.** *The Future of Work in Agriculture.* Washington, D.C: World Bank; 2019.
 23. Corong E, Gautam M, Martin W, et al.: **CGIAR Initiative on Rethinking Food Markets Measuring CGIAR INITIATIVE ON Rethinking Food Markets Employment and Job Quality in Agrifood Systems: A Comprehensive Approach.** 2024.
 24. Nico G, Christiaensen L: **Jobs, Food and Greening: Exploring Implications of the Green Transition for Jobs in the Agri-food System.** World Bank; 2023.
[Publisher Full Text](#)
 25. Busquet M, Bosma N, Hummels H: **A multidimensional perspective on child labor in the value chain: The case of the cocoa value chain in West Africa.** *World Dev.* Oct. 2021; **146**.
[Publisher Full Text](#)
 26. Alvarez JA: **The agricultural wage gap: Evidence from Brazilian micro-data.** *Am. Econ. J. Macroecon.* Jan. 2020; **12**(1): 153–173.
[Publisher Full Text](#)
 27. Fayer SD: **Agriculture: occupational employment and wages.** *Mon. Labor Rev.* 2014; **137**(7).
[Publisher Full Text](#)
 28. Maertens M, Swinnen JFM: **Gender and Modern Supply Chains in Developing Countries.** *J. Dev. Stud.* Oct. 2012; **48**(10): 1412–1430.
[Publisher Full Text](#)
 29. de Janvry A, Duquennois C, Sadoulet E: **Labor calendars and rural poverty: A case study for Malawi.** *Food Policy.* May 2022; **109**.
[Publisher Full Text](#)
 30. World Bank: **World Bank Open Data.** 2024. Accessed: Dec. 13, 2025.
[Reference Source](#)
 31. FAO: **FAO and Kaduna State Government Partner to Transform Tomato Value Chain in Nigeria.** Nigeria: 2025.
 32. Liverpool-Tasie LSO, et al.: **Domestic vegetable value chains in Nigeria and Tanzania: evidence from a Rapid Food System Assessment.** *VeriXiv.* 2025; **2**(232).
 33. NAERLS: **Wet season agricultural performance in Nigeria, Zaria.** NAERLS (National Agricultural Extension and Research Liaison Services) Press.
 34. Adelodun B, Choi K-S: **A review of the evaluation of irrigation practice in Nigeria: Past, present and future prospects.** *Afr. J. Agric. Res.* Oct. 2018; **13**(40): 2087–2097.
[Publisher Full Text](#)
 35. Otekinrin OA, Otekinrin OA, Momoh S, et al.: **How far has Africa gone in achieving the zero hunger target? Evidence from Nigeria.** Elsevier B.V.; Sep. 01, 2019.
[Publisher Full Text](#)
 36. Cable Index: **Multidimensional poverty rates across Nigeria's geopolitical zones.** Accessed: Dec. 13, 2025.
[Reference Source](#)
 37. Adamu FL: **A double-edged sword: Challenging women's oppression within Muslim society in Northern Nigeria.** *Gend. Dev.* 1999; **7**(1): 56–61.
[PubMed Abstract](#) | [Publisher Full Text](#)
 38. Rahman SA: **Women's involvement in agriculture in northern and southern Kaduna State, Nigeria.** *J. Gend. Stud.* Mar. 2008; **17**(1): 17–26.
[Publisher Full Text](#)
 39. Cook K: **Assessment of the Cowpea Value Chain in Kano, Nigeria.** 2008.
 40. UN Women: **United Nations Entity for Gender Equality and the Empowerment of Women.** UN Women Nigeria – Country Results; Sep. 01, 2019. Accessed: Dec. 13, 2025.
[Reference Source](#)
 41. Cochran WG: **Sampling Technique.** New York: John Wiley & Sons; 3rd ed. 1977.
 42. Lohr SL: **Sampling: Design and Analysis.** Boston, MA: Brooks/Cole; 2nd ed. 2010.
 43. Holthausen DM: **Input Choices and Uncertain Demand.** *Am. Econ. Rev.* 1976; **66**(1): 94–103.
 44. Sadoulet E, De Janvry A: **Quantitative Development Policy Analysis.** BALTIMORE AND LONDON: 1995.
 45. Cragg JG: **Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods.** 1971.
 46. De Luca G, Perotti V: **Estimation of ordered response models with sample selection.** *Stata J.* 2011; **11**(2): 213–239.
[Publisher Full Text](#)
 47. Burke WJ, Myers RJ, Jayne TS: **A triple-hurdle model of production and market participation in Kenya's dairy market.** *Am. J. Agric. Econ.* Jul. 2015; **97**(4): 1227–1246.
[Publisher Full Text](#)
 48. Wooldridge JM: **Quasi-likelihood methods for count data.** *Handbook of applied econometrics.* Blackwell Publishing Ltd.; First Edition. 1999; **2**.
 49. Kepler E, Shane S: **Are Male and Female Entrepreneurs Really That Different?** Washington DC: Office of Advocacy, US Small Business Administration; 2007.
[Reference Source](#)
 50. Oladipo O, Platt K, Shim HS: **Female entrepreneurs managing from home.** *Small Bus. Econ.* Aug. 2023; **61**(2): 1–18.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 51. NESG: **NESG 2024Q1 Unemployment alert.** Nigerian Economic Summit Group; Accessed: Dec. 13, 2025.
[Reference Source](#)
 52. Kosec K, Schmidt E, Carrillo L, et al.: **Improving agricultural value chain coordination and gender inclusiveness in PNG.** Aug. 2022. 004.
 53. Ochilo WN, et al.: **Characteristics and production constraints of smallholder tomato production in Kenya.** *Sci Afr.* 2019; **2**: 14.
[Publisher Full Text](#)
 54. Onubogu OH: **Gender Differences in Agricultural Productivity among Rice Farmers in Anambra State, Nigeria: Drivers and Strategies for A Gender Responsive Agriculture.** *International Journal of Food Science and Agriculture.* Jan. 2023; **7**(1): 21–28.
[Publisher Full Text](#)
 55. Oseni G, Corral P, Goldstein M, et al.: **Explaining gender differentials in agricultural production in Nigeria.** *Agricultural Economics (United Kingdom).* May 2015; **46**(3): 285–310.
[Publisher Full Text](#)
 56. Omotilewa OJ, Jayne TS, Muyanga M, et al.: **A revisit of farm size and productivity: Empirical evidence from a wide range of farm sizes**

- in Nigeria.** *World Dev.* Oct. 2021; **146**.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
57. Eastwood R, Lipton M, Newell A: **Chapter 65 Farm Size.** 2010.
[Publisher Full Text](#)
58. Obetta AE, Achike AI: **Analysis of Price Instability and Determinants of Price Difference of Tomato in Nigeria.** *Nigerian Agricultural Policy Research Journal (NAPReJ).* 2022; **10**: 77-84.