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Off-farm employment, gender, and nutrition in rural Africa

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Abstract

How do rural households in Africa diversify their income sources, and what are the implications of off-farm employment for welfare? This dissertation attempts to answer these questions by presenting four essays focusing on the roles of farm and off-farm income, women's participation in off-farm employment, and agricultural technologies. Using data from five different African countries and various econometric modeling approaches, the essays provide evidence on the composition of household income, how women's off-farm employment influences household and individual dietary quality, and how agricultural technologies influence gendered off-farm employment in rural Africa.

The first essay investigates the role of various income sources for households using survey data from four African countries—Kenya, Namibia, Tanzania and Zambia. We find that off-farm sources, including wage employment, self-employment, remittances, and transfers, account for 60% of total household income. The second essay examines how women's participation in off-farm employment influences household consumption patterns, with a particular focus on calorie and micronutrient intake. Using detailed panel data from Malawi, we find that women's participation in off-farm work, especially in self-employment and wage employment, is positively associated with household consumption of calories and key micronutrients, including vitamin A, iron, and zinc. The third essay uses cross-section survey data from Tanzania and Zambia and reveals that women's participation in off-farm work is associated with an improvement in their dietary quality in terms of food groups consumed.

The fourth essay analyzes the association between the adoption of complementary agricultural technologies and gendered participation in off-farm employment. Using nationally representative household survey panel data from Tanzania, the essay provides new evidence that adopting improved seeds, inorganic fertilizers, and mechanized land preparation is associated with an increase in household self-employment, especially among women, while men tend to shift toward wage employment, suggesting gender-specific off-farm labor responses.

The evidence from this dissertation underscores the important role of off-farm jobs for rural development in Africa. We conclude that there is need for design of policies that are gender-sensitive promoting access to profitable businesses and expanding rural job opportunities that are lucrative and formal. Such policies are key for achieving various development goals, including poverty reduction, nutrition improvements, and women's empowerment.

Zusammenfassung

Wie diversifizieren ländliche Haushalte in Afrika ihre Einkommensquellen, und welche Auswirkungen hat die Tätigkeit in nicht-landwirtschaftliche Bereichen auf das Wohlergehen für den gesamten Haushalt? Diese Dissertation versucht, diese Fragen anhand von vier Essays zu beantworten, die sich auf die Rolle von landwirtschaftlichem und nichtlandwirtschaftlichem Einkommen, der Beteiligung von Frauen an nicht-landwirtschaftlicher Beschäftigung sowie landwirtschaftliche Technologien konzentrieren. Unter Verwendung von Daten aus fünf verschiedenen afrikanischen Ländern und ökonometrischen Modellschätzungen liefern die Essays empirische Evidenz über die Zusammensetzung des Haushaltseinkommens, darüber, wie die nichtlandwirtschaftliche Erwerbstätigkeit von Frauen die Ernährungsqualität von Haushalten und Individuen beeinflusst, und wie landwirtschaftliche Technologien geschlechterspezifische Muster der nicht-landwirtschaftlichen Beschäftigung im ländlichen Afrika prägen.

Das erste Essay untersucht anhand von Umfragedaten aus vier afrikanischen Ländern – Kenia, Namibia, Tansania und Sambia – die Rolle verschiedener Einkommensquellen für Haushalte. Wir stellen fest, dass außerlandwirtschaftliche Einkommensquellen, darunter Lohnarbeit, Selbstständigkeit, Rücküberweisungen und Transfers, 60% des gesamten Haushaltseinkommens ausmachen. Das zweite Essay analysiert, wie die Beteiligung von Frauen an außerlandwirtschaftlicher Erwerbstätigkeit die Konsummuster der Haushalte beeinflusst, mit einem besonderen Fokus auf die Aufnahme von Kalorien und Mikronährstoffen. Unter Verwendung detaillierter Paneldaten aus Malawi zeigen wir, dass die Beteiligung von Frauen an außerlandwirtschaftlicher Arbeit – insbesondere in der Selbstständigkeit und der Lohnarbeit – positiv mit dem Haushaltskonsum von Kalorien und wichtigen Mikronährstoffen, darunter Vitamin A, Eisen und Zink, zusammenhängt. Das dritte Essay nutzt Querschnittsdaten aus Tansania und Sambia und zeigt, dass die Beteiligung von Frauen an außerlandwirtschaftlicher Erwerbstätigkeit mit einer Verbesserung der Ernährungsqualität im Hinblick auf die konsumierten Lebensmittelgruppen verbunden ist.

Das vierte Essay verwendet national repräsentative Paneldaten von Haushaltsbefragungen aus Tansania, um den Zusammenhang zwischen der Einführung komplementärer landwirtschaftlicher Technologien und der geschlechter-spezifischen Beteiligung an nicht-landwirtschaftlicher Beschäftigung zu analysieren. Unsere Ergebnisse zeigen, dass die Einführung von verbessertem Saatgut und Düngemitteln sowie mechanisierter

Bodenbearbeitung die Zahl der selbstständigen Erwerbstätigen im Haushalt erhöht, insbesondere bei Frauen, während Männer eher in Richtung Lohnarbeit tendieren, was auf geschlechtsspezifische Reaktionen auf die außerlandwirtschaftliche Erwerbstätigkeit hindeutet.

Die Ergebnisse dieser Dissertation unterstreichen die wichtige Rolle nicht-landwirtschaftlicher Tätikeit für die Entwicklung im ländlichen Afrika. Wir schließen daraus, dass es notwendig ist, politische Maßnahmen zu entwickeln, die geschlechter-sensibel sind, den Zugang zu profitablen Unternehmen fördern und attraktive sowie formelle Beschäftigungsmöglichkeiten im ländlichen Raum ausweiten. Solche Politikmaßnahmen sind entscheidend, um verschiedene Entwicklungsziele, wie Armutsbekämpfung, Verbesserung der Ernährung und Stärkung der Rolle von Frauen, zu erreichen.

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CHAPTER 1

1. Introduction

1.1. Background and problem statement

Rural livelihoods in Africa are undergoing significant transformation. While farming remains a key component of household livelihoods, rural off-farm employment has substantially gained in importance over the last 25 years (Barrett et al., 2001; Davis et al., 2017; De la O Campos et al. 2025; Hazell et al., 2024; Van Hoyweghen et al. 2020; Winters et al., 2009). These shifts are taking place in a context of rapidly rising populations which increases the problem of land scarcity, and growing exposure to climate risks that undermine the stability of agricultural incomes (Amare et al., 2023; Christiaensen & Maertens 2022; Musungu et al., 2024). Between 1960 and 2024, Africa's population has increased more than fivefold, and it is projected to grow by a further 63% by 2050 (United Nations, 2024). This rapid population growth intensifies pressure on arable land, increases land fragmentation, and heightens competition for agricultural resources, making farming increasingly unable to provide sufficient income and employment for rural households. The uncertainties of rainfall-dependent agriculture, together with soil degradation, declining productivity, and climate change effects such as extreme temperatures, unreliable rainfall, and recurrent floods, have further reduced the reliability of farming as the only source of livelihood (Hazell et al., 2024). These challenges are compounded by limited access to irrigation, modern inputs, and extension services, which constrain the ability of smallholders to adapt (Suri & Udry, 2022). As a result, many rural households turn to off-farm activities as additional sources of income.

Importantly, the high risk and seasonality of farming, combined with the absence of well-functioning insurance and credit markets, have pushed many rural households into off-farm employment (Breza et al., 2025; McCullough, 2017). When crop failures or price shocks occur, off-farm income provides a critical safety net, allowing households to smooth consumption and avoid distress sales of assets (Jayachandran, 2006). Seasonal gaps in agricultural labor also create incentives for households to seek temporary wage employment, non-farm self-employment, or migration-based work during the off-season (De Janvry et al., 2022; Fink et al., 2020). For poorer households with limited assets, off-season work serves as a survival strategy, while for better-off households it may represent an opportunity to diversify and accumulate assets (Ricker-Gilbert, 2014). Over time, these seasonal dynamics have contributed to the normalization of off-farm activities as an integral part of rural livelihood systems rather than a marginal or exceptional choice.

At the same time, structural and economic changes have created new opportunities outside farming. Improvements in rural infrastructure, better market integration, and the growth of the service and informal sectors have widened the scope for income diversification (Evans & Mendez-Acosta, 2021; Hazell et al., 2024). In many regions, small towns and secondary cities are emerging as hubs of economic activities, stimulating demand for labor (Ingelaere et al., 2018; Tacoli, 2022). Improved road networks and transport services linking villages and towns reduce transaction costs and connect rural people to urban markets, creating new opportunities for trade and wage labor (Agergaard et al., 2019; Chen et al., 2025). The expansion of electricity connections in Africa and other developing regions has opened new avenues for off-farm employment by facilitating the growth of rural enterprises, agro-processing, and service-sector activities (Pieper et al., 2025). In addition, the spread of mobile phones and digital technologies has facilitated access to information, financial services, and employment opportunities beyond farming (Bahia et al., 2024; Rajkhowa & Qaim, 2022). Rural individuals, especially youth faced with limited prospects in agriculture, increasingly seek wage work, migration opportunities, and engagement in small-scale enterprises (Chamberlin et al., 2020; Christiaensen & Maertens, 2022; de Brauw et al., 2014; Hazell et al., 2024; Hirvonen, 2016). These trends suggest that off-farm employment is not only a coping strategy but also an integral part of rural economic transformation, reshaping patterns of labor allocation, income distribution, and household welfare across the continent.

Income diversification in rural areas in Africa has been widely studied (Corral and Reardon 2001; de Janvry & Sadoulet 2001; Lanjouw & Lanjouw 2001; Ruben & Van den Berg 2001; Pfeiffer et al. 2009; Babatunde & Qaim 2010; Winters et al. 2010; Mishra et al. 2015; Van Den Broeck & Kilic 2019; Rahman & Mishra 2020; D'Souza et al. 2020). This literature consistently shows that off-farm income has become increasingly important, but that agriculture remains the dominant source of income for most rural households. Yet, in light of ongoing structural transformation processes across African economies, it is not entirely clear whether farming continues to constitute the primary source of household income today. The existing literature also take an aggregate household perspective, ignoring possible differences between individual household members (Davis et al. 2017; Yeboah and Jayne 2018; Bouchakour and Saad 2020; Van Hoyweghen et al. 2020; De la O Campos et al. 2025). Given that job opportunities and preferences may vary by gender, age or education levels, intra-household perspectives are important. In addition, previous research often looks at farm and off-farm income as broad aggregates, without further distinguishing between employment types and activities. Studies on off-farm employment typically differentiate between off-farm wage employment and self-employment (McCullough 2017; Nagler and Naudé 2017; Van Den Broeck and Kilic 2019; Abay et al. 2021) but do not further examine the sectors and subsectors within these broad categories. The first essay of this dissertation, therefore, contributes to the literature by examining whether own-farm agricultural activities remain the dominant source of rural income, while also assessing the sectors and subsectors in which rural households and individuals are engaged.

Within this evolving context, gender dynamics are critical. Women, in particular, face both opportunities and constraints in accessing off-farm employment (Egger et al., 2022; Quisumbing & Pandolfelli, 2010; Van Den Broeck & Kilic, 2017). In Africa, gains in women's education and the increase in gender-awareness initiatives have expanded possibilities for their involvement in off-farm jobs (Olivetti et al., 2024). Yet, many of them remain constrained by persistent barriers such as restrictive cultural norms, heavy household unpaid responsibilities, and unequal access to productive assets (Jayachandran et al., 2021). Women's participation in off-farm employment not only contributes to household income but also has important implications for food security and nutritional well-being of household members. By generating additional income, women's involvement in off-farm work can strengthen households' capacity to purchase a wider range of quality foods, including vegetables, fruits, and animal-source products that are key sources of essential micronutrients (Melaku et al., 2024; Sangwan & Kumar, 2021). Importantly, when women earn and control income, their increased bargaining power within the household can further shape food purchasing and allocation decisions in favor of more nutritious diets (Debela et al., 2021; Gupta et al., 2019; Masters et al., 2022; Meenakshi & Quisumbing, 2025; Ogutu et al., 2020; Quisumbing & Doss, 2021). Despite this potential, relatively few studies have assessed the broader nutritional implications of women's employment in Africa. We contribute to this strand of literature in the second essay by analyzing how women's off-farm employment influence household consumption of calories and three key micronutrients—vitamin A, iron and zinc in Malawi. We analyze off-farm employment broadly, while also distinguishing between different types of off-farm employment activities, including casual agricultural labor on small or large farms (commonly referred to as *ganyu* in Malawi), non-farm wage employment, and self-employment. We also differentiate between calories and micronutrients consumed from own-produced and purchased foods. This differentiation enables us to better understand the mechanisms through which women's employment influences dietary quality.

In addition, it remains unclear how women's off-farm employment is associated with individual-level dietary quality. A few studies on the role of maternal employment for child diets and nutrition in different countries of Africa and Asia exist, with varying results depending on the context (Debela et al., 2021; Hosen et al., 2023; Melaku et al., 2024; Rashad & Sharaf, 2019). However, far less is known about how women's off-farm employment affects their own diets and nutrition, a gap that this dissertation addresses. The third essay analyzes how women's participation in off-farm work relates to their overall dietary diversity, and also investigate which food groups are most affected to better understand the implications for the intake of key nutrients. In this essay, we also explore potential mechanisms driving these outcomes, focusing on changes in income, bargaining power, and time allocation. A better understanding of potential mechanisms can help design targeted interventions that improve women's dietary quality by addressing relevant barriers. The focus on women's diets is important because women in developing countries are disproportionately affected by undernutrition and micronutrient deficiencies (UNICEF, 2023). Additionally, women of reproductive age face a particularly high nutritional vulnerability due to the physiological demands of pregnancy and lactation, which can affect both their health and the development of their infants (Cusick & Georgieff, 2016; UNICEF, 2023).

Off-farm employment matters for household welfare, yet the ways in which agricultural technologies reshape men's and women's labor choices remain less understood. Despite growing policy emphasis on technology adoption as a driver of rural transformation (De Janvry & Sadoulet, 2020; Reardon et al., 2019), evidence on how different technology bundles influence household participation in off-farm employment, especially along gender lines in Africa, remains limited. Much of the existing empirical literature on the labor implications of agricultural technology adoption in developing countries has focused primarily on its effects on farm labor use (Afridi et al., 2023; Aihounton & Christiaensen, 2024; Bustos et al., 2016; Tamru et al., 2017). While many of these studies show that labor-saving technologies free up family labor, they fail to systematically examine where that labor goes. A few existing studies examining the effects of farm technologies on off-farm employment present mixed findings. While some suggest that technological change frees household labor for engagement in non-farm activities (Belton et al., 2025; Ma et al., 2024; Takeshima, 2024), others indicate that it may increase labor demands on the farm, thereby limiting opportunities for off-farm work (Ricker-Gilbert, 2014). Such studies primarily focus on individual technologies and overlook a broader understanding of how bundled technologies collectively influence household off-farm labor allocation. Bundling of agricultural technologies is promoted as one of the ways to increase land and labor productivity (Suri & Udry, 2022; Tabe-Ojong & Geffersa, 2024; Vemireddy & Choudhary, 2021), yet little is known about the effect of such bundled technologies on off-farm labor outcomes. We address this research gap in the fourth essay and therefore contribute to the broader literature on structural transformation by exploring how the use of different combinations of farm technologies by households influence gender-differentiated participation in off-farm employment, specifically wage and self-employment.

1.2. Research objectives

This dissertation addresses the overarching research questions concerning the roles of different income sources, the influence of women's participation in off-farm employment on nutrition, and the relationship between agricultural technologies and gendered off-farm labor allocation. The specific objectives are as follows:

1. To analyse the role of various income sources for households and individuals.

2. To investigate the link between women's off-farm employment and household consumption of calories and micronutrients.

3. To examine how women's off-farm employment influences their individual-level dietary quality.

4. To understand how agricultural technologies influence gendered off-farm labor allocation.

1.3. Data sources and estimation approaches

This dissertation employs different datasets and econometric approaches to address the above objectives. In the first essay (Chapter 2), we use a rural cross-sectional survey with 2,663 household-level and 6,321 individual-level observations from Kenya, Namibia, Tanzania, and Zambia. Households were sampled using multi-stage sampling approach. The selected households were visited and interviewed with a structured questionnaire, which was almost identical in all four countries, with only small local adjustments. I, Chrispinus Mutsami, was personally involved in both the preparation and implementation of the survey across the participating countries. We present descriptive statistics of farm and off-farm sources of household income and individual participation in various economic activities and sectors. We estimated a multivariate probit (MVP) model to examine the socio-economic factors that facilitate or prevent participation in specific types of jobs.

The second essay (Chapter 3) uses nationally representative panel data collected in four waves (between 2010 and 2019) from Malawi's Integrated Household Panel Survey (IHPS) conducted by the National Statistical Office in collaboration with the World Bank. Our analysis is restricted to households engaged in farming activities. The dataset includes four survey rounds—2010/2011, 2013, 2016/2017, and 2019/2020—providing a comprehensive overview of individual and household dynamics over a ten-year period. After extensive data cleaning and the removal of incomplete observations, the final total sample used was 7,034 households. To examine the relationship between women's off-farm employment and household consumption of calories and micronutrients, we employed fixed effects (FE) model to control for time-invariant heterogeneity.

In the third essay (Chapter 4), we use the same datasets employed in the first essay (Chapter 2); however, our analysis focused exclusively on two countries, Tanzania and Zambia. The sample consists of 1,151 households in which at least one adult woman was available for interview. Within this sample, 773 observations are from Tanzania and 378 from Zambia. This focused approach allows for a more detailed analysis of women's off-farm employment and its relationship with individual outcomes within these two country contexts. We utilized an instrumental variable (IV) regression approach which helps to address endogeneity challenges.

For the fourth essay (Chapter 5), we use nationally representative panel data from the Tanzanian Living Standards Measurement Study (LSMS), specifically the National Panel Survey (NPS), covering two waves in which households were surveyed in 2014/2015 and 2019/2020. Our analysis focuses on crop farming households, yielding a sample of 1,055 households in 2014/2015 and 1,477 households in 2019/2020, for a total of 2,532 household observations across the two survey rounds. To assess the relationship between adoption of agricultural technologies and gendered labor allocation, we employed a multinomial endogenous treatment effects (METE) model with IV and Mundlak's regression approaches, addressing endogeneity challenges.

1.4. Dissertation outline

The remainder of this dissertation is organized as follows. Chapter 2 contains the first essay which analyzes the role of farm and off-farm income sources and jobs, while also assessing the sectors and subsectors in which rural individuals are engaged. Chapter 3 presents the second essay where we examine how women's off-farm employment influences household consumption of calories and key micronutrients, specifically vitamin A, iron, and zinc, in Malawi. We also differentiate between calories and micronutrients consumed from own-produced and purchased foods. Other mechanisms such as changes in household income, farm production diversity, and women's decision-making are also explored. Chapter 4 presents the third essay, which uses survey data collected in Tanzania and Zambia to examine how women's off-farm employment influences their individual-level dietary quality. This chapter also analyzes effects of women's off-farm employment on the consumption of different food groups to better understand the nutritional implications. Chapter 5 presents the fourth essay, which discusses how the use of different combinations of farm technologies by households influence gender-differentiated participation in off-farm employment, specifically wage and self-employment. Chapter 6 presents the overall conclusion, discusses policy implications, and provides study limitations.

CHAPTER 2

2. Evolving farm and off-farm income sources and jobs in rural Africa[1]

Abstract

Livelihood sources in rural Africa are diverse and dynamic. Using recent primary survey data from four African countries — Kenya, Namibia, Tanzania, and Zambia — we consider regions with different conditions related to climate, agroecology, infrastructure, and nature conservation to analyze the role of various income sources for households and individuals. While most rural households are involved in small-scale farming, we challenge the conventional notion that own agricultural activities still constitute the main source of income. On average, off-farm sources – including wage-employment, self-employment, remittances, and transfers – account for 60% of total household income. The off-farm income share increases with total income, meaning that the poorest households are the ones most dependent on agriculture. These patterns are similar across all four countries. Most off-farm employment involves self-employed activities in small informal businesses. More lucrative formal employment opportunities are rare and mostly pursued by individuals with post-secondary education and training. Men are more likely to be involved in wage-employment than women. Furthermore, individual social networks and access to road and market infrastructure are positively associated with off-farm employment. The important role of off-farm jobs for rural development should receive more policy attention. Larger investments into generating inclusive non-agricultural employment opportunities are needed.

Keywords: Rural employment; Off-farm employment; Rural poverty; Gender; Rural transformation; Sub-Saharan Africa

[1] This chapter is published as Mutsami, C., Parlasca, M. C., & Qaim, M. (2025). Evolving farm and off-farm income sources and jobs in rural Africa. *Journal of International Development*, 37(6), 1367-1380. https://doi.org/10.1002/jid.70010. I, Chrispinus Mutsami, compiled the data, carried out the analysis, interpreted the results, and wrote the paper with support from the coauthors.

2.1. Introduction

The landscape of income generation in rural Africa is undergoing significant change. While subsistence agriculture remains common, commercial farm and off-farm activities have substantially gained in importance over the last 25 years (Barrett et al., 2001; Winters et al., 2009; Davis et al., 2017; Van Den Broeck & Kilic, 2019; Mondal et al., 2021; Christiaensen & Maertens, 2022; Khan & Morrissey, 2023). Changes in household livelihood strategies away from farming are to a large extent driven by push factors, such as land scarcity and climate change (Gunathilaka et al., 2018; Amare et al., 2023; Iqbal et al., 2023; Musungu et al., 2024). At the same time, pull factors, such as improved access to education, information, and economic growth, create new opportunities for households to enter into cash crop farming, non-agricultural employment, and/or migration of household members with associated remittances (Asher & Novosad, 2020; Djoumessi et al., 2020; Essers, 2016; Deininger et al., 2022; Wheeler et al., 2022; Kelley et al., 2024). Such structural transformation from mainly agriculture to a more diversified economy is commonly observed with economic development, even though in Africa this transformation seems to be slower than elsewhere (Timmer et al., 2012; Hazell et al., 2024). One reason is that productivity gaps between agriculture and other sectors are often smaller than expected in sub-Saharan Africa (McCullough, 2017).

The diversification of income sources in rural Africa has garnered considerable attention in the research literature (Reardon, 1997; Corral & Reardon, 2001; de Janvry & Sadoulet, 2001; Lanjouw & Lanjouw, 2001; Ruben & Van den Berg, 2001; Pfeiffer et al., 2009; Babatunde & Qaim, 2010; Mishra et al., 2015; Van Den Broeck & Kilic, 2019; Rahman & Mishra, 2020; D'Souza et al., 2020; Ba et al., 2021; Hazell et al., 2024). This body of research suggests that off-farm income is gaining in importance but that agriculture remains the dominant source for most rural households.

However, important knowledge gaps remain (Otsuka & Fan, 2021; Christiaensen & Maertens, 2022). First, given ongoing structural transformation, it is not clear whether agriculture is really still the main income source today for most households in rural Africa.

Second, most existing studies take an aggregate household perspective, ignoring possible differences between individual household members (Davis et al., 2017; Yeboah & Jayne, 2018; Bouchakour & Saad, 2020; Van Hoyweghen et al., 2020; De la O Campos et al., 2025). Given that job opportunities and preferences may vary by gender, age, or education levels, intra-household perspectives are important. While a few studies examine gendered and age-related aspects of off-farm employment (Yeboah & Jayne, 2018; Van Den Broeck & Kilic, 2019; Abay et al., 2021; Dolislager et al., 2021), they mostly rely on data collected 10-15 years ago and may therefore not fully capture the current situation.

Third, previous research often looks at farm and off-farm income as broad aggregates, without further distinguishing between employment types and activities. Studies on off-farm employment typically differentiate between off-farm wage-employment and self-employment (McCullough, 2017; Nagler & Naudé, 2017; Van Den Broeck & Kilic, 2019; Abay et al., 2021), but do not further examine the sectors and subsectors within these broad categories. A more disaggregated analysis of different sectors ─ such as services, construction, and manufacturing, etc. ─ can help identify possible employment constraints and develop policies for more inclusive rural job markets (Hazell et al. 2024).

Here, we address these research gaps, using primary cross-sectional survey data that we collected ourselves in 2023 across various rural regions in four African countries, namely Kenya, Namibia, Tanzania, and Zambia. We pursue two main research objectives: First, we explore the role of different farm and off-farm income sources at the household level and for individual men and women. Second, we use regression models to investigate various socioeconomic factors that facilitate or prevent individual participation in the different types of income generation.

Our main data source is a survey of 2,685 households from the four countries and 6,722 adult individuals living in these households. These data are supplemented with data from surveys of community leaders (N=164) and rural employers (N=610) also carried out in 2023 in the same study regions. Our data cover more details on individual employment and jobs in various sectors and subsectors than existing living standard monitoring surveys (LSMS).[2] Our primary data are not representative at the country level but cover a broad range of typical conditions in rural sub-Saharan Africa. Our intention is not to provide country-level studies but to analyze the role of different income and employment sources in rural Africa under various typical climatic, agroecological, and infrastructure conditions.

The rest of this article is organized as follows. In Section 2.2, we present materials and methods, starting with a brief overview of the study regions in the four countries, and then explaining

[2] Our surveys permit detailed multi-job reporting, capturing all income-generating activities an individual is involved in, whereas LSMS surveys typically record only one primary and one secondary job. This is a limitation given that individuals often engage in more than two types of work. Additionally, our data include surveys of rural employers—an important perspective that is not commonly available in LSMS datasets.

the data collection approaches and statistical methods used for data analysis. The empirical results are presented in Section 2.3, while Section 2.4 concludes with some broader discussion.

2.2. Materials and methods

2.2.1. Study regions

We use data collected in different rural regions of Kenya, Namibia, Tanzania, and Zambia. The study regions offer considerable climatic, agroecological, economic, and institutional heterogeneity and, together, represent a wide range of conditions typical for rural sub-Saharan Africa. The regions chosen are somewhat poorer than the rural averages in the four countries, which should be kept in mind for the interpretation of the findings.

Kenya. In Kenya, our study focuses on Baringo County located in the Rift Valley. Baringo is among the poorest counties in Kenya (Kenya National Bureau of Statistics, 2024). Many households in the region are involved in livestock keeping, especially cattle and goats. Some are also engaged in crop farming, including maize, beans, vegetables, and fruits. However, Baringo is prone to droughts, which presents a major challenge for crop farming.

Baringo has several projects related to thermal energy development, which also create jobs in the region. However, given limited educational levels, local residents find employment in these projects primarily as unskilled laborers in jobs related to manual work and security services. In addition, Baringo has a few nature conservancies with wildlife, including elephants and various bird species, attracting mainly local tourists. The local tourism industry is not yet well developed and suffers from infrastructure constraints.

Namibia. In Namibia, we focus on the Zambezi Region in the northeastern part of the country. The Zambezi Region is at the core of the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA), which serves as a vital wildlife corridor in southern Africa. Common agricultural activities include cattle and goat keeping and the cultivation of maize and a few other crops. The region has several nature conservancies and national parks, attracting both domestic and international tourists. The tourism sector provides some employment for hotel and restaurant staff, tour guides, or administrative personnel.

The Zambezi Region is susceptible to floods and droughts. The local economy is therefore characterized by high unemployment rates (Hulke et al., 2022). To cushion people against poverty and food insecurity, the Namibian government is running a safety net program, including cash transfers for old people, parents with children, and families severely affected by weather extremes.

Tanzania. In Tanzania, we focus on Morogoro and Iringa, two neighboring regions in the mid-eastern part of the country, located within the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). SAGCOT is a program aiming to enhance agricultural productivity, food security, and environmental sustainability. Local households engage in crop and livestock farming. Furthermore, some households are involved in different food processing activities. Both regions, Morogoro and Iringa, have private and public forest reserves, yielding products like timber, firewood, and charcoal (Jha et al., 2021).

Zambia. In Zambia, our study focuses on the Western Province, which is also located within the KAZA TFCA with private and communal nature conservancies. Western Province is among the poorest regions in Zambia (Zambia Statistics Agency, 2022). Many households are involved in small-scale farming, growing food crops such as maize, cassava, and groundnuts, and rearing cattle. Conflicts with wildlife, resulting in crop and livestock losses, are common. Some of these losses for local farm households are compensated by the conservancies and national parks. Other economic activities for locals include jobs in the tourism sector, artisanal fishing, and the collection and marketing of various forest products.

2.2.2. Surveys

Our analysis builds on cross-sectional data from a rural household survey conducted between April and August 2023.[3] For each study region in the four countries, we followed a two-stage sampling procedure. First, within each region we randomly selected villages using a probability proportional to size approach. Thus, we selected 47 villages in Kenya (Baringo County), 45 in Namibia (Zambezi Region), 60 in Tanzania (Morogoro and Iringa), and 30 in Zambia (Western Province). Second, in each of these villages we created full household lists from which we randomly sampled 15 to 16 households. Our overall sample comprises 2,685 households: 703 in Kenya, 652 in Namibia, 870 in Tanzania, and 437 in Zambia. We also asked questions about the income sources and employment activities of all adults living in these households (18 years

[3] Data collection in Kenya was done from July 14 - August 14, 2023, in Namibia from May 15, 2023 - June 17, 2023, in Tanzania from June 24 - August 3, 2023, and in Zambia from June 5 - June 25, 2023.

and older), resulting in a total sample of 6,722 adult individuals:[4] 1,717 in Kenya, 1,765 in Namibia, 2,086 in Tanzania, and 1,154 in Zambia. Due to missing data for some relevant variables, a few observations had to be dropped. The analysis is based on 2,663 household- and 6,321 individual-level observations with complete data.

The selected households were visited and interviewed with a structured questionnaire, which was almost identical in all four countries, with only small local adjustments. The interviews were conducted in local languages by a team of research assistants (about 10 in each country), who were trained and supervised by the researchers. The questionnaire captured various farm, household, and contextual characteristics with a particular focus on economic activities and income sources. For individual household members, we asked various socioeconomic characteristics, such as age, gender, marital status, educational attainment, and participation in different types of social groups. Given our focus on individual employment patterns, we also asked for the involvement in different types of farming and off-farm activities.[5]

The household survey is complemented by a survey of village leaders in each of the sampled villages to better understand the different local livelihood strategies and employment opportunities. Out of the 182 sampled villages, we successfully interviewed 164 community leaders. The remaining leaders were unavailable for interviews during our survey period. In addition, we conducted a survey of the main employers in the sampled villages and relevant surrounding areas (including nearby towns). The employers were not selected randomly, as complete lists of all local employers in formal and informal sectors were not available. Instead, using information gathered from the household interviews and discussions with village leaders, we purposively selected employers to ensure coverage of all relevant sectors and subsectors. In total, we sampled 610 employers: 136 in Kenya, 140 in Namibia, 220 in Tanzania, and 114 in Zambia. For the village leader and employer surveys, we also used structured questionnaires.

2.2.3. Definition of farm and off-farm income sources

We are particularly interested in the different income sources of households and individuals. The two main aggregate income sources are own farming (including food crop, cash crop, and

[4] The household-level and individual-level questions were answered by one main respondent, typically the household head. This approach allowed us to collect data on employment and income sources of all household members, including those who were absent at the time of the interview.

[5] Further details of the household survey questionnaire and data can be accessed at https://doi.org/10.5880/trr228db.24 (Kenya); https://doi.org/10.5880/trr228db.25 (Namibia); https://doi.org/10.5880/trr228db.26 (Tanzania); https://doi.org/10.5880/trr228db.27 (Zambia).

livestock production) and off-farm sources (including wage-employment, self-employment, and remittances and transfers). At the household level, we consider a household to be involved in a certain activity if at least one household member participated in this activity during the last twelve months.[6] At the individual level, we define participation in own farming as contributing to the family labor in any of the three farming activities – food crop, cash crop, or livestock production. In our study regions, traditional cash crops such as coffee, tea, sugarcane, or cocoa are not widely cultivated. However, several fruits, vegetables, and other crops are grown by households with the main intention to sell. Therefore, in our study we define cash crops as crops where more than 50% of the harvest was sold, whereas food crops are crops where more than 50% was kept for home consumption.

In terms of off-farm activities, individual wage-employment is defined as having been employed at any time during the past 12 months in exchange for remuneration (either in cash or in kind) paid by somebody from outside the own household (Van den Broeck & Kilic, 2019; Christiaensen & Maertens, 2022). Wage-employment can be in any sector, including agriculture (i.e., working on a farm not owned by the household), construction, manufacturing, services, etc., regardless of whether the employment contract or the business is formal or informal. A detailed classification of the sectors and subsectors considered in our study is found in Table A2.1 in the Appendix. Households are considered to be involved in off-farm wage-employment when at least one member participated in wage-employment.

Self-employment at the individual level is defined as spending work time in a household-owned non-agricultural enterprise. This can either be the person owning and managing the enterprise or also another household member who had spent time on this enterprise during the past 12 months. We classify household members not owning the enterprise as self-employed too, as they actively contribute to the business and either receive payment or share the earnings or benefits with other household members. As for wage-employment, we also break down self-employment into different sectors. Households involved in self-employment are those with at least one member participating in a self-employed activity.

Non-employment-related off-farm income includes remittances and transfers, either in-cash or in-kind. Remittances are defined as income received during the last 12 months from relatives or friends not permanently living in the household. Transfers are defined as income received

[6] We acknowledge that a long recall period of 12 months may be associated with some measurement error. However, we believe that any resulting bias will be small, as respondents were only required to recall whether they themselves or other adult household members participated in a certain activity or not.

during the last 12 months from government or non-governmental organizations. In our study, remittances and transfers are captured at the household level, as these are sources of income but not activities, and our analysis at the individual level is confined to activities.

To analyze the contribution of each income source to total household income, we use 12 months of income data from both farm and off-farm economic activities. Farm income is calculated as the value of output from crops (both food and cash crops) and livestock, minus production costs. Off-farm income includes earnings from wage-employment, self-employment, remittances, and transfers. Self-employment income is determined by subtracting costs from total revenue. Per capita income for each source is then calculated by dividing total income by household size. Finally, per capita income in local currencies is converted to international dollars using purchasing power parity (PPP) exchange rates.[7]

2.2.4. Statistical approaches

We explore patterns of rural income generation and involvement in different activities through descriptive analyses. At first, we analyze proportions of households involved in different types of own-farming and off-farm activities and income sources. Then, we examine the contribution of each income source to overall household income for the sample as a whole, and also for three income terciles (lowest, middle, and highest) to better understand associations between different income sources and socioeconomic status. Note that we calculate income terciles within each country. At the individual level, we analyze proportions of individuals participating in different activities, again for all individuals and also by income tercile.

Beyond the descriptive analyses, we explore key socioeconomic factors associated with individual participation in different activities using regression models. In particular, we use multivariate probit (MVP) models to account for potential correlation between the different activities (Cappellari & Jenkins, 2003). In a first model, we focus on five activities, including food crop, cash crop, and livestock production, self-employment, and wage-employment, using the following MVP specification:

$$Y_{ijD} = \alpha_D + \beta_D' \boldsymbol{X}_{ijD} + \tau_j + \varepsilon_{ijD} \qquad D = 1, \ldots 5 \tag{2.1}$$

[7] The PPP rates for 2023 are 42.91 for Kenya, 7.14 for Namibia, 886.12 for Tanzania, and 6.61 for Zambia (https://data.worldbank.org/indicator/PA.NUS.PPP).

where Y_{ijD} is a binary variable showing whether or not individual i in country j participates in activity *D*. Individual and household characteristics are captured by the vector $\boldsymbol{X}_{ijD}$, β'_D is a vector of parameters to be estimated, τ_j are country fixed effects, and ε_{ijD} is a normally distributed random error term. The vector $\boldsymbol{X}_{ijD}$ includes socioeconomic variables such as age, gender, education levels, marital status, group membership, household size, a household-level asset index,[8] land size, access to electricity, and recent shocks experienced, including serious illness or death of a household member. A detailed description of these variables is provided in Table A2.2 in the Appendix.

In a second model, we use a similar MVP specification to analyze determinants of participating in various off-farm wage-employment sectors, such as agriculture, retail business, education, public organizations, other services (tourism, hospitality, and transport), and construction (see Table A2.1 in the Appendix).

2.3. Results

2.3.1. Socioeconomic characteristics of households

Table 2.1 presents summary statistics of socioeconomic characteristics of the sampled households in the four study countries (individual-level characteristics are shown in Table A2.3 in the Appendix). The average age of household heads is 51 years. Around two-thirds of the household heads are men, 57% have completed secondary education, but only 3% have post-secondary education or training.

Table 2.1 shows that, on average, 77% of the sample households in the four countries are poor in terms of income poverty, meaning that they have less than 2.15 US dollars per capita and day in PPP terms. In addition, the average income poverty gap stands at 57%, suggesting that poor households have an income that is 57% below the poverty line. These poverty rates are higher than the national averages from official statistics,[9] which is due to two reasons. First, we only focus on rural areas of sub-Saharan Africa, where poverty rates are higher than in urban areas. Second, some of the rural regions we selected are among the poorer ones, as

[8] We use principal components analysis on the assets owned by the household to construct the asset index. Assets considered include ownership of television, radio, mobile phone, motorbike, car, cooking gas appliance, and electricity connection, among others.

[9] The national poverty rate is 31.7% in Kenya (Kenya National Bureau of Statistics, 2024), 28.7% in Namibia (Namibia National Planning Commission, 2023), 43.5% in Tanzania (World Bank, 2024), and 64.3% in Zambia (World Bank, 2025).

explained above. This means our country-level data should not be misinterpreted as nationally representative.

Table 2.1: Socioeconomic characteristics of sample households

Variables	All	Kenya	Namibia	Tanzania	Zambia
Age of household head (years)	51.50	48.45	53.22	52.15	52.51
	(16.06)	(15.74)	(15.97)	(15.13)	(17.79)
Household head is male (dummy)	0.67	0.72	0.56	0.72	0.68
Household head is married (dummy)	0.56	0.46	0.55	0.63	0.61
Primary education of household head (dummy)	0.23	0.12	0.24	0.25	0.38
Secondary education of household head (dummy)	0.57	0.38	0.56	0.73	0.57
Post-secondary training of household head (dummy)	0.03	0.02	0.06	0.01	0.03
Household size (number)	5.20	5.89	5.06	4.51	5.67
	(2.49)	(2.63)	(2.38)	(2.12)	(2.70)
Farm size (ha)	1.81	0.55	3.02	1.47	2.69
	(2.92)	(0.71)	(4.76)	(1.36)	(2.84)
Income poverty (dummy)	0.77	0.75	0.70	0.76	0.92
Income poverty gap (0-1)	0.57	0.51	0.48	0.58	0.78
	(0.39)	(0.39)	(0.40)	(0.40)	(0.30)
Observations	2,663	703	652	870	437

Notes: Mean values are shown with standard deviations in parentheses. Income poverty is defined as a per capita income of less than 2.15 PPP US dollars per day. The poverty gap is calculated as the difference between the poverty line and the per capita income of the poor, divided by the poverty line.

2.3.2. Household income sources

Table 2.2 provides an overview of the different income sources of households. As can be seen, farming is still very common in rural Africa: 72% of the sampled households have at least one household member involved in own farming activities. Most households are involved in food crop production (64% of all households, 92% in Tanzania). Cash crop farming is observed in one-third of all households. Almost half of the households are involved in livestock production. Comparing the countries, farming activities are less important in Namibia than in the other study regions, which may be due to frequent droughts and wildlife conflicts in the Namibian Zambezi Region.

Table 2.2 shows that off-farm income sources are also crucial for rural households. Around 63% of the households derive income from at least one off-farm source; and in none of the countries is this proportion below 50%. Looking at the different employment types, self-employment is more important than wage-employment. Many rural areas have limited wage-employment opportunities, meaning that people have to open up their own small businesses if they want to diversify their income sources. These small businesses include retail trade, artisanal crafts, and selling of forest products such as charcoal and timber.

The large number of small businesses and their importance for the local economies is also reflected in the data from our community leader and employer surveys. More than half of the community leaders interviewed ranked small businesses as the second most important economic activities in their village after agriculture (Figure A2.1 in Appendix). In the employer survey, the largest proportion of employers (around 40%) is running small businesses (Figures A2.2 and A2.3 in Appendix). These small businesses are mostly run by household members with only occasional employment of non-household members.

Table 2.2: Socioeconomic characteristics of sample households

	All	Kenya	Namibia	Tanzania	Zambia
Panel A: Own farm income sources					
Food crop activities	0.64	0.49	0.28	0.92	0.88
Cash crop activities	0.33	0.21	0.22	0.43	0.48
Livestock activities	0.48	0.63	0.15	0.57	0.55
Total own farm activities	0.72	0.69	0.29	0.96	0.91
Panel B: Off-farm income sources					
Self-employment	0.23	0.23	0.15	0.32	0.17
Wage-employment	0.14	0.22	0.15	0.10	0.10
Total off-farm employment	0.35	0.41	0.29	0.39	0.24
Remittances	0.28	0.15	0.31	0.38	0.28
Transfers	0.16	0.10	0.38	0.05	0.18
Total off-farm sources	0.63	0.53	0.76	0.64	0.59
Observations	2,663	703	652	871	437

Other important off-farm income sources are transfers and remittances, with more heterogeneity across study regions (Table 2.2). Namibia has the highest proportion of households benefiting from transfers (38%), while in Tanzania only 5% of the households receive any transfers. As explained, in Namibia many households receive government transfers. In addition, transfers from NGOs to compensate households for wildlife-caused losses of crops and livestock are common (Hulke et al., 2022).

On average, 28% of the sample households receive remittances (Table 2.2), with the highest rate in Tanzania and the lowest rate in Kenya. Many rural households send members to other rural areas, towns, cities, or foreign countries in order to work and send back remittances (Raycraft, 2019; Kafle et al., 2020; Mulwa & Visser, 2020; Chamberlin et al., 2021; Christiaensen & Maertens, 2022; Amare et al., 2023). That Kenya has the lowest proportion of households receiving remittances is somewhat surprising, given widely-used mobile money services in the country (Parlasca et al., 2022). However, mobile money services are now also widely used in many other African countries, facilitating the sending and receiving of money at low transaction costs.

2.3.3. The structure of income from different sources

We now analyze the contribution of different income sources to overall household income. The left-hand side of Figure 2.1 pools the data from all four countries. Income from all off-farm sources combined accounts for about 60% of total household income. Each off-farm income source alone accounts for at least 10% of total income. On average, off-farm income has, therefore, overtaken agriculture in terms of income contribution in the study regions.

Figure 2.1 also shows the structure of household income by income tercile. As can be seen, the relative importance of off-farm income increases with total income. This pattern is driven by income from off-farm employment rather than by transfers or remittances. For the poorest households (lowest tercile), off-farm employment only accounts for 7% of overall income, while for the richest households (highest tercile) it accounts for more than 50%. Higher income from off-farm employment is associated with lower income shares from food crop and livestock production, but not from cash crop production.

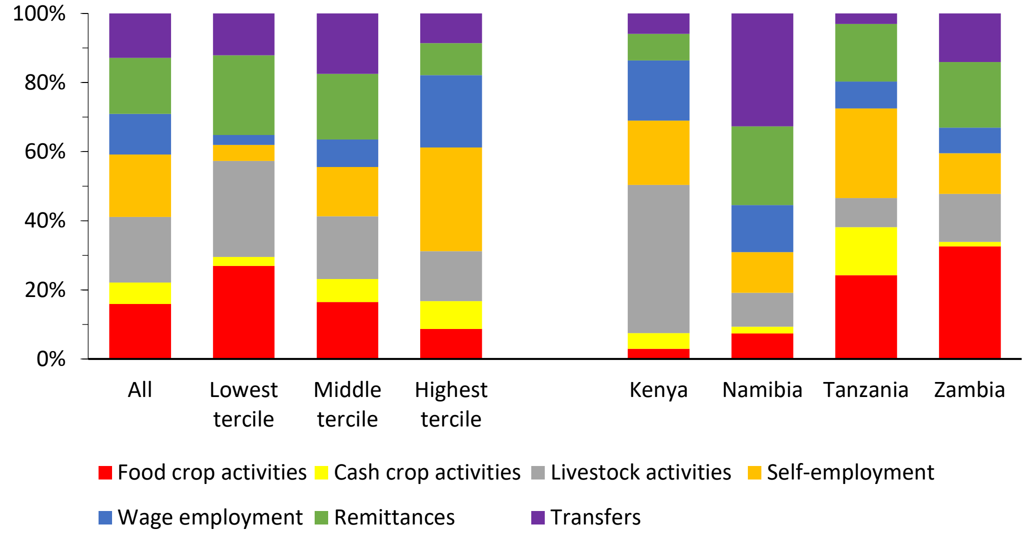

Figure 2.1: Structure of rural household income by income tercile and country

Notes: Farm and self-employment incomes are calculated as the value of all output minus production costs. Terciles are calculated separately for each country. N=2,663. Further details by country are shown in Figure A2.4 in the Appendix.

The right-hand side of Figure 2.1 shows the structure of household income by study country. We find that each study region has its unique major source of income: livestock is the main source in the study region in Kenya, transfers in Namibia, self-employment in Tanzania, and food crop production in Zambia. But in all countries, off-farm income sources account for 50% or more of total household income on average. Contributions of the different income sources by tercile for each study country are shown in Figure A2.4 in the Appendix.

2.3.4. Individual participation in off-farm employment

We now look in more detail at individual-level involvement in different types of off-farm employment. Given the important role of self-employment, we start with self-employed activities. Figure 2.2 shows the proportion of individuals involved in different sectors of self-employment for the whole sample from all four countries (a breakdown by country is shown in Figure A2.5 in the Appendix). We only look at those individuals involved in self-employed activities. Figure 2.2 reveals that retail businesses are by far the most common type of self-employment. These retail businesses are often informal in nature and include small shops, market stalls, and roadside vendors selling food, household items, clothing, and sometimes also farm inputs such as fertilizers, seeds, or pesticides. Retail businesses are common among individuals in all income terciles, but they are most widely observed among individuals in the highest income tercile.

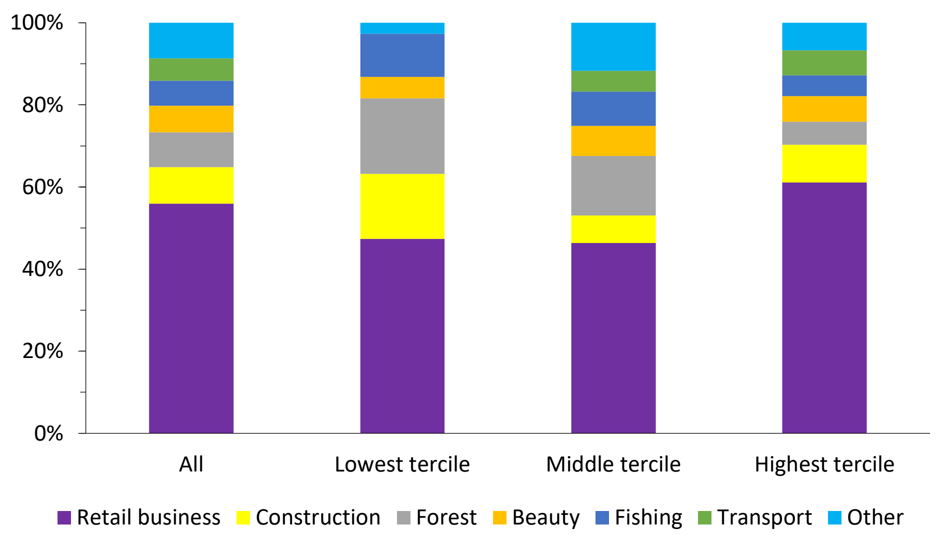

Figure 2.2: Proportion of individuals involved in self-employment sectors by income tercile

Notes: The sample only includes household members participating in off-farm self-employed activities (N= 694). Terciles are calculated separately for each country.

Other self-employment sectors widely observed in the study regions, especially among individuals in the lowest and middle income terciles, are fishing, forest, and construction. These are mostly informal small-scale and not very lucrative activities not much preferred by individuals from better-off households. Typical forest activities involve tree cutting, burning charcoal, or collecting firewood for sales to other local households or nearby restaurants. Forest activities are particularly relevant in the study region in Kenya (Figure A2.5), where acacia trees and other wooden species are used to burn charcoal or as firewood and sometimes timber (Alvarez et al., 2019; Tabe-Ojong et al., 2022). Small-scale fishing activities are more common in Namibia and Zambia due to the Zambezi River and other water bodies in the study regions. Typical self-employed activities in the construction sector are the preparation of structures for buildings in the community or the manufacturing and sale of bricks to other local households and businesses.

Self-employed activities in transport and other sectors (including beauty, health, hospitality, and tourism) exist in the study regions, but their importance is context-specific. For instance, the transport sector is a relevant source of self-employed income in the study regions in Kenya and Tanzania, especially for the youths who offer informal transport via motorbikes. These activities are less common in Namibia and Zambia. In Tanzania, almost 10% of the self-employed work is in the beauty sector, making it the third largest sector after retail business (66%) and construction (also around 10%). Tourism accounts for a maximum of 1% of self-employed activities, even in the regions close to national parks. While social media and online booking platforms now enable direct marketing of tourism services, it appears that rural households in the study regions have not yet been able to tap into this growing and potentially profitable sector.

Turning to wage-employment, Figure 2.3 shows that rural wage-employment occurs in a wide range of different sectors (a breakdown by country is shown in Figure A2.6). Agriculture is the most common wage-employment activity and is relevant especially in the lowest and middle income terciles. Individuals with wage-employment in agriculture work on farms owned by someone else and conduct tasks such as plowing, planting, weeding, harvesting, or managing livestock. Many of these workers lack formal contracts, and due to the seasonal nature of agriculture, their employment is typically short-term (Fabry et al., 2022; Meemken et al., 2025; Nzira et al., 2025). Seasonal contracts, which are agreements that last for a specific agricultural season and do not guarantee year-round employment, are common in this sector. This trend is evident in Figure A2.7 in the Appendix, showing that more than 80% of individuals working in agriculture have seasonal contracts with their employers.

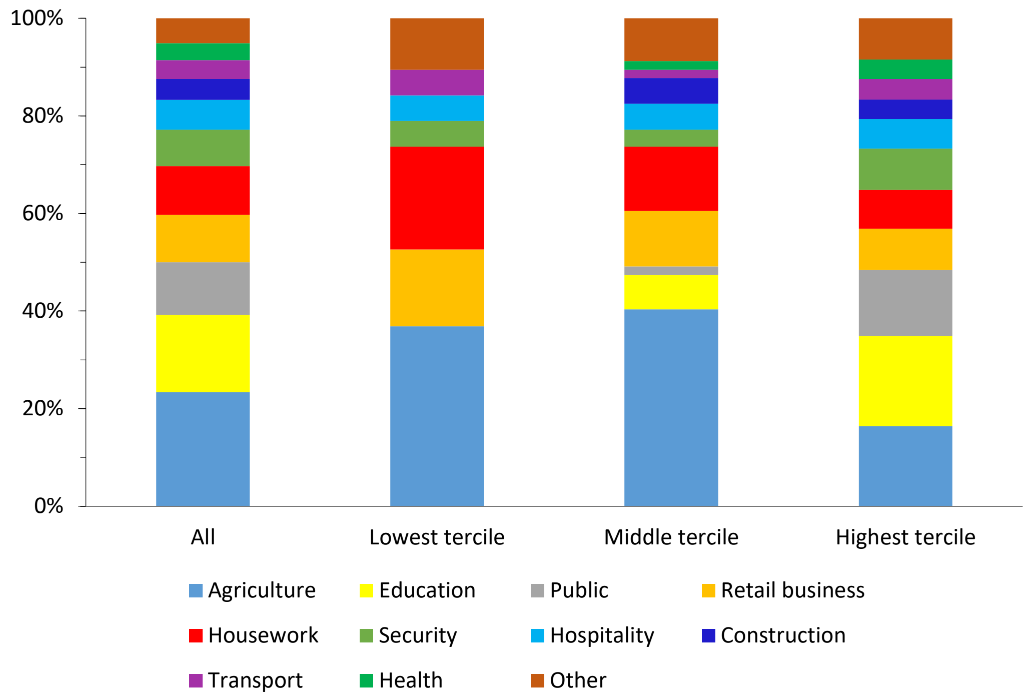

Figure 2.3: Proportion of individuals involved in wage-employment sectors by income tercile

Notes: The sample only includes household members participating in off-farm employment activities (N=499). Terciles are calculated separately for each country.

Figure 2.3 also shows that education and the public sector are relevant for wage-employment in the study regions. The education sector mainly refers to teachers working in public or private schools, while the public sector refers to work in other public organizations, such as local or national governments, administration, social institutions, public infrastructure, law enforcement, and agricultural extension. Employment in these two sectors often involves formal and longer-term contracts and more favorable wages than in informal sectors. Education and the public sector are most relevant for individuals in the highest income tercile. Strikingly, none of the individuals in the lowest tercile is employed in either of these two formal sectors.

Furthermore, Figure 2.3 shows that around 10% of the individuals are employed in the retail business sector, mostly as shop attendants. A similar proportion is employed as house workers, involving jobs in other households as maids, cleaners, or cooks. Evidence from the employer survey suggests that wages in retailing (commerce) and informal service sectors are low (Nzira et al., 2025), which may explain why we see more participation in these sectors in the lower income terciles. There are also some differences across the study regions. For example, tourism is a relevant sector for wage-employment in Namibia, while the housework sector is more relevant in Zambia (Figure A2.6).

2.3.5. Determinants of individual participation in different activities

We now analyze the socioeconomic factors associated with individual participation in different activities, using the MVP models explained above. The first model looks at the three own farm activities – food crops, cash crops, and livestock – and the two aggregates of off-farm employment – self-employment and wage-employment. Table A2.5 in the Appendix confirms that the error terms of the individual equations are correlated, so the MVP approach is appropriate. The estimation results are shown in Table 2.3.

The sex of the individual seems to be an important factor determining participation in various activities. Men are significantly more likely to be involved in cash crop and livestock production than women. Men are also significantly more likely to be involved in wage-employment. The estimates in Table 2.3 can be interpreted as marginal effects, meaning that men are almost 16 percentage points more likely to be involved in wage-employed activities than women. These gendered effects are likely due to women's larger involvement in household chores, including childcare and meal preparation, and possibly also other cultural restrictions for women to be involved in labor markets (Jayachandran, 2015).

Another significant determinant is the dependency ratio.[10] A larger ratio means that working-age adults have to care for more children or old family members. As can be seen from Table 2.3, a larger dependency ratio is associated with a higher likelihood of being involved in food crop and livestock production as well as self-employed activities. This is a plausible result, as activities in own farming and self-employment at home are often better compatible with family care work than wage-employment in rural Africa (Debela et al., 2021). Individual age is positively associated with all economic activities, but in a decreasing way at older ages, as indicated by the negative estimates for the square term of age.

[10] The dependency ratio is calculated as $\left(\frac{Number\ of\ members\ aged\ 0\text{–}15\ and\ above\ 65\ years}{Number\ of\ members\ aged\ 15\text{–}64\ years}\right) \times 100$.

Table 2.3: Factors influencing individual participation in income-generating activities

	Food crop (1)	Livestock (2)	Cash crop (3)	Self-employment (4)	Wage-employment (5)
Age (years)	0.032***	0.025***	0.021***	0.046***	0.030***
	(0.004)	(0.002)	(0.002)	(0.006)	(0.001)
Age squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male (dummy)	0.018	0.065***	0.034**	-0.003	0.156***
	(0.002)	(0.006)	(0.003)	(0.000)	(0.006)
Married (dummy)	0.185***	0.163***	0.120***	-0.008	0.028
	(0.020)	(0.015)	(0.009)	(0.001)	(0.001)
Primary education (dummy)	0.107***	0.018	0.073***	0.089***	0.186***
	(0.012)	(0.002)	(0.006)	(0.011)	(0.008)
Secondary education (dummy)	0.039	-0.015	0.058**	0.136***	0.216***
	(0.004)	(0.001)	(0.005)	(0.017)	(0.009)
Post-secondary training (dummy)	-0.011	-0.143***	-0.076*	0.007	0.473***
	(0.001)	(0.013)	(0.006)	(0.001)	(0.019)
Dependency ratio	0.037***	0.024***	0.004	0.041***	0.007
	(0.009)	(0.002)	(0.024)	(0.023)	(0.014)
Asset ownership (index)	0.005*	0.029***	0.039***	0.018***	0.006
	(0.001)	(0.003)	(0.003)	(0.002)	(0.010)
Farm size (ha)	0.018***	0.011***	0.017***	-0.012**	-0.024***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Illness/death (dummy)	-0.008	-0.019	-0.028*	-0.046**	0.023
	(0.001)	(0.002)	(0.002)	(0.006)	(0.001)
Group membership (dummy)	0.069***	0.118***	0.133***	0.077***	0.096***
	(0.008)	(0.011)	(0.010)	(0.010)	(0.004)
Time to nearest road (minutes)	-0.012	-0.002	0.009	-0.026***	-0.011
	(0.001)	(0.000)	(0.001)	(0.003)	(0.000)
Time to nearest market (minutes)	0.034**	0.026*	0.010	0.007	-0.069***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.003)
Country dummies	Yes	Yes	Yes	Yes	Yes
Observations	6,321	6,321	6,321	6,321	6,321

Notes: Average marginal effects from MVP model are shown with standard errors in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Log pseudo likelihood = -11491, Wald χ^2 (85) = 3586.

Education is also an important factor. It is positively associated with the involvement in most activities, but especially in off-farm activities. In comparison to not having completed primary education, which is the reference category in our model, secondary education increases the likelihood of being involved in off-farm self-employment and wage-employment by 13.6 and 21.6 percentage points, respectively. Individuals with post-secondary education are more likely to be in wage-employment than those without education, with an increased likelihood of nearly 50 percentage points. This is plausible because individuals with more education tend to have access to higher-paying jobs. This raises the gap in earning potentials between agriculture and other sectors and shifts employment decisions more towards off-farm work.

In terms of infrastructure, closer proximity to roads and markets significantly increases the likelihood of self-employment and wage-employment (distance decreases the likelihood). Farm size is positively associated with the likelihood of being involved in farming activities, which is not surprising. However, the magnitude of the farm-size effects is not very large. Each additional hectare of land increases the likelihood of being involved in crop and livestock farming by less than 2 percentage points (Table 2.3). Mean farm sizes vary by country, but most farms in our study regions are significantly smaller than 3 hectares. Furthermore, the results suggest that asset ownership is relevant for farming, especially cash cropping, and for self-employed off-farm activities, but not for wage-employment.

Finally, being member of a group – such as farmer groups, church groups, self-help groups, etc. – tends to increase the likelihood of being involved in all economic activities, with the largest marginal effects observed for cash crop and livestock production. Group membership is typically associated with having larger social networks and better access to information, which is useful for pursuing various economic activities.

2.3.6. Determinants of individual participation in different wage-employment sectors

We now look at socioeconomic factors associated with individual participation in different wage-employment sectors, using our second specification of the MVP model and only including wage-employed individuals. Table A2.6 in the Appendix confirms error term correlation between the different sectoral equations. The MVP estimation results are shown in Table 2.4. Some interesting gender patterns are observed. Women are more likely to be wage-employed in the retail sector and as teachers in education, whereas men are more likely to be wage-employed in other services and construction.[11]

Table 2.4 also suggests that education is an important factor determining access to different types of wage jobs. Education does not seem to matter much for employment in agriculture and retailing. However, having completed primary and secondary education is significantly associated with the likelihood of having jobs in education and construction. The sectoral differences are even more pronounced for post-secondary education, which increases the likelihood of being employed in education, public organizations, and construction significantly

[11] The service sector, as defined here, refers to jobs in tourism, hospitality, transportation, and personal services (including hairdressing and beauty services, tailoring, cleaning and housekeeping services), excluding jobs in retailing and education, which are captured separately.

and with large average marginal effects. For education and the public sector, these results are unsurprising, as jobs in these sectors often require specialized knowledge and training. For construction, the result is perhaps more surprising, as construction may be associated with simple manual tasks. Yet, the small-scale construction sector in rural areas often involves jobs in masonry, carpentry, electrical wiring, plumbing, roofing, and welding, which do require at least some post-secondary level training. Our results also suggest that individuals with post-secondary education are significantly less likely to be wage-employed in agriculture, retailing, and other services sectors.

Table 2.4: Factors influencing individual participation in different wage-employment sectors

	Agriculture	Retail	Service	Public	Construction	Education
	(1)	(2)	(3)	(4)	(5)	(6)
Age (years)	-0.001	-0.002	0.003	0.002**	0.001	0.003***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Male (dummy)	0.020	-0.093***	0.121***	0.027	0.120***	-0.10***
	(0.031)	(0.025)	(0.042)	(0.025)	(0.034)	(0.025)
Married (dummy)	-0.026	-0.035	0.037	-0.004	-0.044	-0.007
	(0.043)	(0.028)	(0.049)	(0.033)	(0.038)	(0.031)
Primary education (dummy)	0.017	-0.109**	0.026	-0.069	0.034***	0.50***
	(0.069)	(0.046)	(0.085)	(0.071)	(0.093)	(0.069)
Secondary education (dummy)	-0.009	-0.069	-0.068	-0.003	0.052***	0.636***
	(0.077)	(0.050)	(0.091)	(0.068)	(0.098)	(0.083)
Post-secondary training (dummy)	-0.274***	-0.296***	-0.383***	0.172***	0.270***	0.858***
	(0.097)	(0.081)	(0.101)	(0.066)	(0.097)	(0.082)
Dependency ratio	0.003	-0.012	0.003	0.027**	0.011	0.015
	(0.020)	(0.016)	(0.023)	(0.013)	(0.018)	(0.015)
Asset ownership (index)	-0.024***	0.008	-0.009	0.013***	0.014**	0.019***
	(0.009)	(0.006)	(0.009)	(0.005)	(0.006)	(0.006)
Farm size (ha)	-0.023	0.005	0.009	-0.004	0.003	-0.003*
	(0.017)	(0.008)	(0.011)	(0.005)	(0.007)	(0.005)
Illness/death (dummy)	-0.008	0.050	-0.045	-0.056*	-0.019	-0.004
	(0.044)	(0.029)	(0.047)	(0.029)	(0.037)	(0.030)
Group membership (dummy)	0.127***	-0.059	-0.041	-0.055	-0.083	-0.003
	(0.045)	(0.042)	(0.059)	(0.034)	(0.090)	(0.038)
Time to nearest road (minutes)	-0.031	0.020	-0.027	0.005	-0.009	0.013
	(0.021)	(0.014)	(0.021)	(0.012)	(0.016)	(0.013)
Time to nearest market (minutes)	0.049	0.041	-0.075	0.027	-0.047	0.061**
	(0.039)	(0.029)	(0.048)	(0.023)	(0.031)	(0.026)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	450	450	450	450	450	450

Notes: Average marginal effects from MVP model are shown with standard errors in parenthesis * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Only wage-employed individuals are included (N=450), Log pseudo likelihood = -1444, Wald χ 2 (97) = 355.

The results in Table 2.4 also show that asset ownership is positively associated with higher-paying jobs in education, public organizations, and construction, and negatively associated with wage-employment in agriculture. These findings align with the patterns observed in Figure 2.3, where individuals from the highest-income tercile were found to be more involved in jobs in education and the public sector, whereas individuals from the lower and middle income terciles were more likely employed in agriculture.

2.4. Discussion and conclusion

Households in rural sub-Saharan Africa derive income from multiple sources. While most previous research suggests that agriculture is still the dominant source of rural incomes, our findings challenge this conventional view. Using recent data from different rural areas in four African countries – Kenya, Namibia, Tanzania, and Zambia – we have analyzed farm and off-farm sources of household income and individual participation in various economic activities and sectors. Estimating multivariate probit regression models, we have further examined socioeconomic factors that facilitate or prevent the involvement in specific types of jobs.

Our results show that off-farm income sources, including wage-employment, self-employment, transfers, and remittances, make up around 60% of total household income across the four study countries. This share of off-farm income is higher than what is reported in many previous studies (e.g., Reardon et al., 2007; Winters et al., 2009; Haggblade et al., 2010). For instance, Reardon et al. (2007) and Haggblade et al. (2010), using rural survey data from the 1990s and 2000s, report that non-farm earnings accounted for an average of 34% of rural household income in Africa, with the remaining share coming from agriculture. These findings align with those of Winters et al. (2009), who estimate that non-farm activities contributed between 30% and 35% of total income in selected sub-Saharan African countries. Drawing on data from various African countries—collected between 1990 and 2011—Davis et al. (2017) report that non-farm sources accounted for 37% of household income on average. We therefore argue that the share of agricultural farm income is declining over time, due to continued population growth, land scarcity, and ongoing structural transformation in rural Africa, an observation that is consistent with other recent studies in Africa (Hazell et al., 2024; De la O Campos et al., 2025). Furthermore, worsening climatic conditions and more frequent weather shocks are particular threats for agricultural income stability in the African small-farm sector (Musungu et al., 2024).

The specific income-generating activities on-farm and off-farm can vary considerably from one region to the other, as our results also underline. However, the finding that the off-farm income share of rural households is large, and on average also larger than the income share derived from own farming, holds across all study regions. Our results also show that the off-farm income share increases with total household income, meaning that the poorest households remain most dependent on agriculture. Even the off-farm jobs of the poorest households are often in the agricultural sector, leaving them vulnerable to aggravating climatic conditions. Access to off-farm employment can be an important mechanism for smallholder farming households to cope with weather shocks (Musungu et al., 2024), but the poorest households often have very limited access to lucrative types of off-farm employment.

We have also looked at different types of off-farm employment and find that self-employment is the most common type for the majority of rural households. This is most likely due to limited wage-employment opportunities in rural areas of sub-Saharan Africa. In contrast, the entry barriers for starting and operating small own businesses are relatively low (Nagler & Naudé, 2017). Moreover, given that most rural households remain in agriculture to some extent, and agricultural activities are seasonal in nature, self-employed activities in small own businesses are a useful complement, as these can typically be timed more flexibly than most wage-employment relations.

Our results also show that most off-farm activities of rural households are informal in nature. Self-employed activities are mostly in small-scale retailing, fishing, collection of firewood, or burning of charcoal. Wage-employment is often in agriculture, small-scale retailing, housework (domestic workers), security (mostly private security companies), and construction. Employment in higher-paying formal jobs is rare. These findings are in line with the existing literature, indicating that infrastructure conditions in most rural parts of Africa are underdeveloped, entailing unfavorable conditions for the establishment of larger industries and service businesses (Dercon & Gollin, 2014; Christiaensen & Maertens, 2022; Nzira et al., 2025). Constraints in terms of access to roads, markets, and electricity discourage private-sector business investments, which are crucial for generating more formal employment opportunities.

Our findings also indicate that income from remittances constitutes a sizable share of overall household income. Local markets can often not provide sufficient jobs to absorb the labor supply, meaning that short-term seasonal migration or longer-term migration of individual household members is widely observed. Migrating household members send back remittances, contributing to an inflow of capital to rural areas. Migration is particularly relevant for the rural youths, who often have less access to land, better education, and a longer time horizon than older people to benefit from migration.

Our regression analyses reveal that primary and secondary education are important for harnessing opportunities in off-farm self-employment and wage-employment, whereas post-secondary education and training are key for accessing higher-paying wage jobs. Post-secondary training is especially important for wage-employment in education, public organizations, and the construction sector. Previous studies also highlight the importance of education for off-farm employment, yet without a detailed breakdown by sector (Winters et al., 2009; Van Den Broeck & Kilic, 2019).

We would like to highlight a few limitations of our study. First, we rely on cross-sectional data, meaning that we are not able to analyze income dynamics. Our argument that the share of farm income in total income is decreasing, while the role of off-farm sources is increasing, is based on comparison of our data with previous results from the literature. This also aligns with conclusions in other recent work (Van den Broeck & Kilic, 2019; Christiaensen & Maertens, 2022), but further analysis of the role of various types of off-farm jobs and sources with longitudinal data would be useful. Second, and related to the cross-sectional nature of our data, our regression models identify associations, which should not be misunderstood as causally identified effects.

A third limitation is that our study regions are not fully representative of the four study countries. For instance, the study regions are somewhat poorer than the national rural averages. However, given our finding that the poorest households are typically those depending most on agriculture and have the lowest shares of off-farm income, we expect that in better-off regions the role of off-farm activities is equally high or even higher. Our goal was not to portray representative country-level data, but to analyze the role of various income sources under heterogenous conditions that are typical for many parts of rural sub-Saharan Africa. The concrete numbers should not be generalized, but we argue that the broader findings can still provide insights that are useful and relevant also beyond the specific regions studied. Exceptions may possibly be high-potential agricultural regions with significant export cash crop production.

It is evident that off-farm income sources are important for rural households and should be considered more explicitly in the formulation of rural development policies. One key policy recommendation is that more rural job opportunities need to be created, as most employment types currently observed are small-scale, informal, and not very lucrative. This will require larger public and private investments in rural infrastructure, including roads, electricity, water, and network connections. Better off-farm employment opportunities can reduce households' vulnerability to climate change and can also help to reduce poverty, as households with larger off-farm income shares are typically less poor. Another important policy implication is to improve rural education and vocational training to facilitate people's access to higher-paying jobs. While agriculture remains important, fair employment in various other sectors needs to increase for sustainable rural development.

CHAPTER 3

3. Women's off-farm employment improves household nutrition in Malawi[12]

Abstract

Improving rural nutrition remains a pressing development challenge across sub-Saharan Africa, where agriculture dominates livelihoods but diets often lack diversity and essential nutrients. In this context, women's participation in off-farm employment may play a critical role in shaping household food consumption patterns. By generating additional income, women's off-farm work can enhance households' ability to purchase diverse and nutrient-rich foods, reduce reliance on subsistence farming, and strengthen women's decision-making power over food choices. Despite these potential pathways, the extent to which women's off-farm employment actually improves household consumption of calories and key micronutrients remains poorly understood. Here we investigate the link between women's off-farm employment and household dietary quality in Malawi, using a ten-year panel dataset. Employing panel regression approaches, we find that women's participation in off-farm work—especially in self-employment and wage employment—is positively associated with household consumption of calories and key micronutrients, including vitamin A, iron, and zinc. In contrast, casual labor (commonly known as *ganyu* in Malawi) shows no significant dietary effects. Our pathway analyses indicate that increased income from off-farm employment enhances consumption of calories and micronutrients from purchased foods, while reliance on own-produced food declines. These results highlight the potential of well-paying off-farm opportunities to improve nutrition, underscoring the need for policies that improve non-farm enterprise and wage employment for women in sub-Saharan Africa.

Keywords: Labor; Dietary quality; Micronutrients; Gender; sub-Saharan Africa

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3.1. Introduction

Despite global advances in food production, the double burden of malnutrition remains a critical challenge. Over 700 million people are undernourished (FAO et al., 2023), while approximately 2.5 billion are overweight, with 800 million classified as obese (WHO, 2024). In addition, recent studies depict high micronutrient deficiencies among vulnerable groups such as women and children (Meenakshi & Quisumbing, 2025; Stevens et al., 2022). These burdens are disproportionately concentrated in developing regions, particularly South Asia and sub-Saharan Africa, where limited access to nutritious food increases health problems (FAO et al., 2024; IFPRI, 2024). In these contexts, increasing women's access to economic opportunities, particularly off-farm employment, offers a promising pathway to improving household dietary quality and addressing nutrition challenges.

Traditionally viewed as the main breadwinners, men are no longer the sole financial providers in households. Economic challenges have increasingly driven many women in developing countries to take on key income-generating roles, particularly through off-farm work (Chen & Ebadi, 2026; Van Den Broeck & Kilic, 2017). This growing participation of women in off-farm employment holds significant potential for improving household nutrition through multiple pathways. By contributing additional income, women expand their households' capacity to a more diverse range of foods, including vegetables, fruits, and animal-source products—key sources of essential micronutrients critical for health and well-being (Melaku et al., 2024). Off-farm income may also reduce reliance on own-farm production, allowing households to diversify their diets beyond seasonal and staple-based consumption patterns (Davis et al., 2017; De Janvry et al., 2021). Importantly, when women earn and control income, their increased bargaining power within the household can further influence food purchasing and allocation decisions in favor of more nutritious diets (Debela et al., 2021; Gupta et al., 2019; Masters et al., 2022; Meenakshi & Quisumbing, 2025; Mutsami et al., 2025b; Ogutu et al., 2020a; Quisumbing & Doss, 2021). These mechanisms suggest that women's engagement in off-farm work could contribute to addressing both undernutrition and emerging challenges of overnutrition in low-income settings.

Despite this potential, relatively a few studies have assessed the broader welfare implications of women's employment in developing countries. Existing research has primarily examined the influence of women's employment on nutrition through two main lenses: anthropometric outcomes (Debela et al., 2021; Hosen et al., 2023; Melaku et al., 2024; Oddo et al., 2018; Rashad & Sharaf, 2019; Tsiboe et al., 2024) and household dietary diversity (Maity, 2020;

Sangwan & Kumar, 2021; Zhu et al., 2024). While anthropometric indicators reflect nutritional status, and dietary diversity scores serve as proxies for food security, both approaches offer limited insight into actual dietary quality, particularly the intake of specific micronutrients.

Seasonality and data limitations present important methodological challenges in understanding the relationship between women's employment and household nutrition in sub-Saharan Africa. Many of the off-farm jobs undertaken by women, as well as household food consumption patterns, are highly seasonal—closely tied to the agricultural calendar and fluctuations in informal labor opportunities—yet seasonality remains insufficiently accounted for in much of the existing research (De Janvry et al., 2021; Frink et al., 2020; Van Cappellen & De Weerdt, 2025). In addition, much of the existing evidence is based on cross-sectional surveys that are not representative, which constrain causal inference and fail to capture the dynamic nature of household welfare (Melaku et al., 2024, Mutsami et al., 2025b; Oddo et al., 2018). Using a four-wave nationally representative panel data (collected between 2010 and 2020) from Malawi's Integrated Household Panel Survey (IHPS), while accounting for seasonality, we seek to fill these research gaps by investigating the relationship between women's off-farm employment and household consumption of calories as well as three micronutrients: vitamin A, iron, and zinc.

This study contributes to the existing literature in three key ways. First, we examine how women's off-farm employment influences household consumption of calories and key micronutrients—specifically vitamin A, iron, and zinc—in Malawi. We analyze off-farm employment broadly, while also distinguishing between different types of off-farm employment activities, including casual agricultural labor on small or large farms (commonly referred to as *ganyu* in Malawi), non-farm wage employment, and self-employment. Much of the existing literature has either treated off-farm employment as a single, undifferentiated category or focused narrowly on one type, such as wage employment (Debela et al., 2021; Sangwan & Kumar, 2021; Tsiboe et al., 2024). By exploring this heterogeneity, we identify which forms of off-farm work are most strongly associated with improved household dietary outcomes.

Second, we differentiate between calories and micronutrients consumed from own-produced and purchased foods. This differentiation enables us to better understand the mechanisms through which women's employment influences dietary quality. Women's employment may increase household income, allowing greater access to market-purchased, diverse, and nutrientdense foods, particularly those not easily produced at home, such as animal-source products and fortified staples (Masters et al., 2022). However, increased employment may also reduce the time available for subsistence farming, potentially reducing food diversity in the household (Sangwan & Kumar, 2021). By differentiating between own-produced and purchased food consumption, we can assess whether women's off-farm employment leads to a substitution effect—where households shift reliance from own-produced to purchased foods. In addition, we examine intermediary pathways, including changes in household income, farm production diversity, and women's decision-making, to further unpack how women's employment translates into dietary improvements.

Third, our contribution is methodological. First, we use nationally representative panel dataset from four waves of the Malawi IHPS, covering 2010 to 2020. The panel structure allows us to control for time-invariant unobserved heterogeneity, thereby reducing potential endogeneity bias that often undermines causal inference in cross-sectional analyses. Second, the IHPS survey is temporally randomized, with data collected in both dry and wet seasons. This design feature allows us to account for seasonal variation—crucial in Malawi, where labor availability, income, and food consumption are highly sensitive to agricultural cycles (De Janvry et al., 2021). By explicitly incorporating seasonality, our analysis offers more robust and accurate estimates of the relationship between women's employment and household nutrition. To our knowledge, only one previous study—Van den Broeck et al. (2021)—has used panel data to examine the effects of men's and women's employment on calories and micronutrient consumption in sub-Saharan Africa. While this study makes an important contribution, it does not account for seasonal dynamics in employment and food consumption, which is explicitly addressed in our analysis. Moreover, the authors do not explore the potential mechanisms—such as income effects, changes in food sourcing, or women's bargaining power—through which employment may influence dietary outcomes.

Our focus on Malawi is relevant since it is among the poorest countries globally (ranked as fourth poorest in the world), with high rates of malnutrition, particularly in rural areas (World Bank, 2023; IFPRI, 2024). While employment by both men and women can affect household nutrition, we focus on women due to their broader role within the household. In addition to income generation, women are often responsible for unpaid household activities such as family farm work, cooking, childcare, and other domestic chores (Sangwan & Kumar, 2021; Schneider et al., 2024; Blackden & Wodon, 2006). These tasks position women to influence dietary quality not only through their income but also through their time use and caregiving decisions.

The remainder of this paper is organized as follows. Section 3.2 explains the conceptual framework that underpins the analysis. Section 3.3 outlines the data used in the study, including details of the household survey and measurement of key variables. Section 3.4 outlines the empirical strategy employed to identify the relationships between women's off-farm employment and household nutrition. Section 3.5 discusses the main findings and offers an interpretation of the results. Finally, Section 3.6 concludes the paper and provides policy recommendations based on the evidence presented.

3.2. Conceptual framework

Women's labor force participation is directly related to household nutritional outcomes (Bhandari & Burroway, 2018; Zhu et al., 2024). Figure 3.1 illustrates a simple conceptual framework of how women's participation in off-farm employment can affect household nutritional outcomes through three key mechanisms: increased income, shifts in time allocation, and enhanced agency or bargaining power. Each of these pathways influences both the quantity of food consumed and the overall quality of household diets. However, the direction and magnitude of the effects along these pathways are shaped by baseline conditions, household labor dynamics, and the underlying motivations for employment, whether driven by opportunity or necessity, and the nature of employment (e.g., formal or informal).

Women's off-farm employment motivations influence the extent to which off-farm work contributes to nutrition. Off-farm employment, viewed as an opportunity (e.g., skilled or formal sector jobs), tends to be more empowering and beneficial for nutrition (Van den Broeck et al., 2021). In contrast, survival-driven employment—such as casual or temporary labor—typically entails minimal welfare gains: workers often earn barely subsistence-level incomes, lack labor protections or benefits, and face unstable hours (Zizzamia, 2020). This distinction provides a conceptual rationale for analyzing sector-specific effects of women's employment on nutrition outcomes.

In Malawi and other rural areas in sub-Saharan Africa, women not engaged in off-farm employment are typically involved in farming and unpaid care work (Doss et al., 2018). These women often contribute to household food security through own-farm production of crops like maize, tobacco and legumes (De Janvry et al., 2021). However, farming (particularly subsistence farming) is typically low in productivity and offers limited dietary diversity due to resource constraints and market barriers (Doss et al., 2018; Hülsen et al., 2024; Nguyen et al., 2025; Sibhatu et al., 2018).

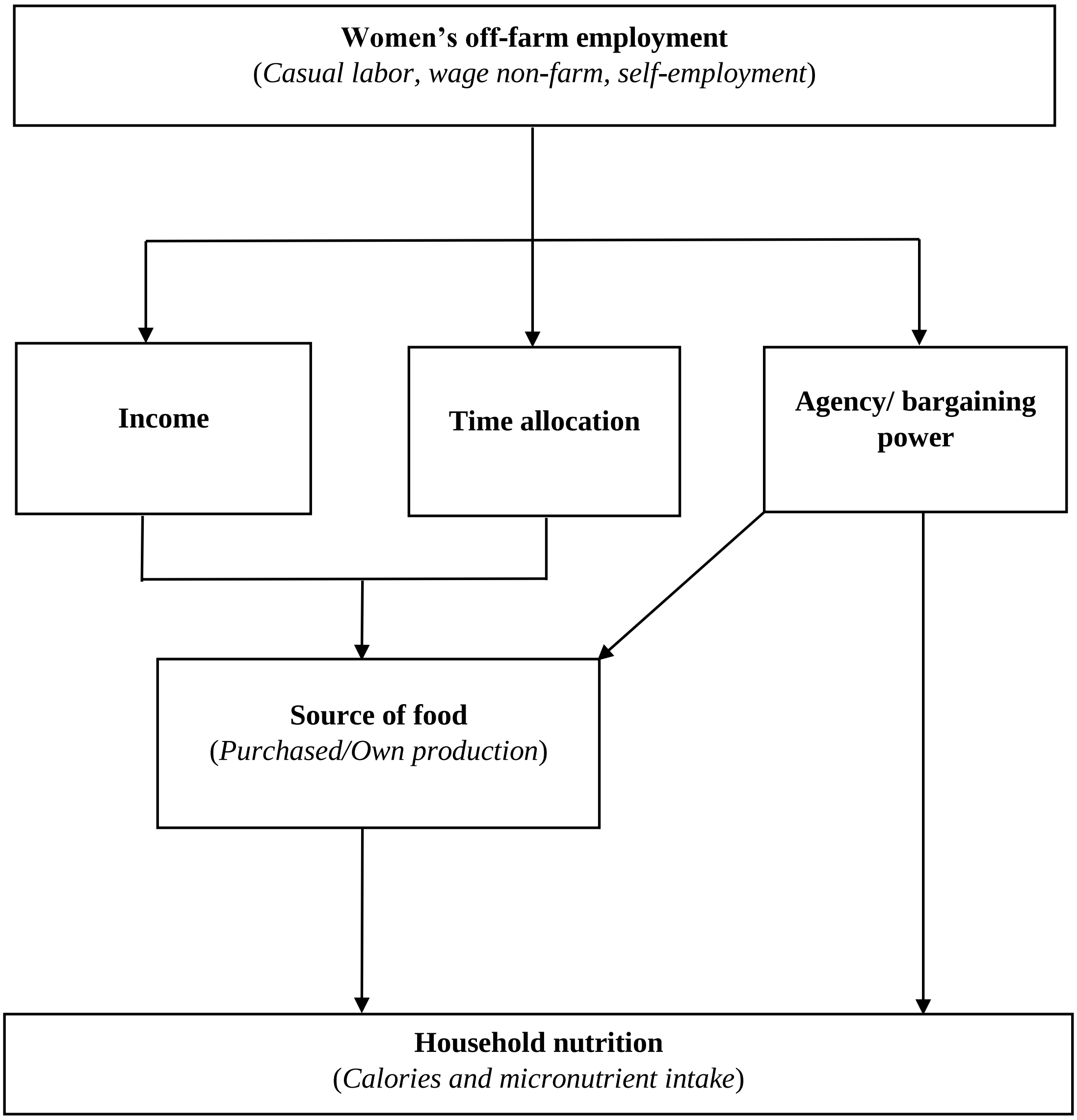

Figure 3.1: Conceptual framework

Source: Own presentation

In some cases, men in the household may also engage in off-farm employment, including in sectors similar to those available to women, such as casual labor (*ganyu*) and non-farm wage jobs, or non-farm enterprises (De Janvry et al., 2021; Van den Broeck et al., 2021). These overlapping roles can influence how household income is pooled and how decisions about food purchases and consumption are made, affecting the nutritional impact of women's employment (Van den Broeck et al., 2021).

It is also important to understand why women engage in off-farm employment. Some women may be pulled into off-farm work by attractive opportunities—such as better pay, stable hours, or entrepreneurial potential—which can translate into greater income, empowerment, and positive nutritional effects (Hazell et al., 2024). Others may be pushed into work out of necessity due to poverty, food insecurity, or limited options—often accepting irregular, low-paying, or physically demanding jobs (Ricker-Gilbert, 2014). These so-called "last resort" forms of employment, such as casual agricultural labor, are widespread in sub-Saharan Africa and often linked to distress-driven participation (De Janvry et al., 2021; Fink et al., 2020; Mutsami et al., 2025a; Van Cappellen & De Weerdt, 2025). In such cases, the benefits of employment may be limited, and trade-offs, such as time loss or labor exhaustion, may outweigh nutritional gains.

We now turn to the three main potential mechanisms as shown in Figure 3.1. First, women's employment affects household food consumption through increased income (Masters et al., 2022; Melaku et al., 2024; Sangwan & Kumar, 2021). Off-farm employment provides women with earnings, which can be used to purchase various food items such as fruits, vegetables, and animal-sourced foods, hence improving dietary quality and overall nutrition. Past studies show that women tend to allocate additional income towards household food expenditure, thereby improving food quality and quantity through markets (Masters et al., 2022; Melaku et al., 2024; Sraboni & Quisumbing, 2018). Furthermore, women's income can be reinvested in own farm production through inputs, such as improved seeds, fertilizers, and hired labor, which in turn improves agricultural productivity[13] (Doss et al., 2018; Sangwan & Kumar, 2021). Higher agricultural output can be used as both a direct food source for the household and a means of generating additional income through output commercialization, further improving nutrition (Mondal et al., 2021; Ogutu et al., 2020a).

Second, women's off-farm employment has implications for time allocation, which can affect own-farm food production and household consumption patterns. When women participate in off-farm employment, they often have less time spent on own farming activities, reducing the quantity and diversity of food produced (Johnston et al., 2018). Therefore, households may rely on food markets, which can be beneficial if the income earned is sufficient but problematic if the available jobs are unstable or low-paying. In addition, women engaged in off-farm

[13] Increased agricultural productivity can lead to lower food prices in local markets, thereby improving affordability and access for a broader population. However, such price effects operate at a macro or community level and are beyond the scope of this household-level analysis.

employment may have less time for food shopping and preparation, which can lead to an increased consumption of processed or convenience foods, some of which may be less nutritious than home-cooked meals (IFPRI, 2024; Komatsu et al., 2018; Quisumbing et al., 2021; Sangwan & Kumar, 2021).

The third mechanism relates to women's financial autonomy and bargaining power. Women with their income often gain greater influence over how household income is spent, and research suggests that they are more likely than men to prioritize income to diverse and nutritious food (Melaku et al., 2024; Ogutu et al., 2020a; Sraboni & Quisumbing, 2018). In addition, employment can shift intra-household dynamics, granting women a stronger voice in discussions and decisions regarding food purchases, meal composition, and long-term investments in household nutrition.

In summary, women's off-employment affects household food consumption through increased income effects, shifts in time allocation, and changes in household bargaining power. While off-farm employment can enhance food security by increasing income and empowering women in decision-making, it can also introduce trade-offs in the time available for food production, purchase, and preparation. Understanding these mechanisms is essential for policymakers in developing countries aiming to support women's participation in employment activities while ensuring positive food security and nutrition outcomes.

3.3. Data

3.3.1. Household survey

This study uses nationally representative panel data collected in four waves from Malawi's Integrated Household Panel Survey (IHPS) conducted by the National Statistical Office in collaboration with the World Bank.[14] Our analysis is restricted to households engaged in farming activities. The dataset includes four survey rounds—2010/2011, 2013, 2016/2017, and 2019/2020—providing a comprehensive overview of individual and household dynamics over a ten-year period.

The Malawi IHPS differs from other LSMS-type surveys in other African countries through its unique design that attempts to capture seasonality. Malawi has two seasons i.e., rainy season (November to April) and dry season (from May to October). Each wave of the IHPS is

[14] The raw datasets used in this paper are publicly available at the World Bank Microdata Library: https://microdata.worldbank.org/index.php/catalog/3819.

conducted in two rounds—Visit 1 is done during the post-planting (rainy) season and Visit 2 during the post-harvest (dry) season—enabling the collection of data that reflect intra-annual variation in household behavior since many rural households depend on agriculture. A key methodological novelty of the IHPS lies in the random separation of the sample into two groups: Panel A and Panel B households. The randomization is done at the enumeration area (EA) level. During each visit, different sections of the questionnaire are administered to Panel A and Panel B households. For instance, in Visit 1, in addition to agriculture, other modules—such as those focused on household characteristics, labor, and consumption—are administered only to Panel A households, while Panel B households only provide information on agriculture. During Visit 2, modules on agriculture, household characteristics, labor, and consumption are administered on Panel B households while Panel A households are interviewed on their agricultural activities. This alternating structure allows the survey to collect seasonally balanced data without overburdening individual households, while still ensuring that each module is captured across both seasons. Households in both panels are similar in terms of socioeconomic characteristics as shown in the balance test results presented in Table A3.1 in the Appendix.

As shown in Table A3.2, the baseline survey, conducted during the 2010/2011 agricultural season, collected data from a sample of 1,287 farming households. This was followed by a second wave in 2013, which expanded the sample to 1,595 households. The third wave, carried out in the 2016/2017 production season, further increased the sample to 1,813 households. The fourth and final wave, corresponding to the 2019/2020 production season, surveyed 2,339 households. The increase in sample size over time is largely due to the inclusion of split households—households that formed out of original households interviewed in earlier rounds. After extensive data cleaning and the removal of incomplete observations, the final total sample remains at 7,034 households.[15]

The average attrition rate across the survey waves is about 10.7%. Such attrition—caused by factors such as sub-sample selection, migration, household dissolution, or death—may pose a potential threat to the representativeness of the sample and the validity of longitudinal

[15] It is important to note that after 2010, only a sub-sample of households was selected for follow-up after each wave (including newly formed split households). Consequently, constructing a fully balanced panel is challenging: only 657 households were interviewed in all four survey rounds. This restriction significantly reduces the sample size and statistical power when analyses are limited to consistently observed households.

inference. To reduce potential bias resulting from non-random attrition, we apply attrition weights[16] in all regression analyses.

3.3.2. Measuring women's employment

Our main variable of interest is women's off-farm employment, which refers to the participation of women in income-generating activities outside of their own agricultural farms. Given the rural economic structure of Malawi, we focus on three key types of off-farm employment:[17] Casual labor (*ganyu*), wage off-farm employment, and self-employment. Casual labor arrangement is where individuals, especially those from poorer households, provide labor for other farms (mostly less-poor farmers or estate farms) in exchange for cash or in-kind payments (e.g., food or farm inputs) (De Janvry et al., 2022; Ricker-Gilbert, 2014). It is a common activity used by poor households as a coping mechanism during periods of financial need, with rural women frequently engaging in agricultural weeding, harvesting, or household chores for relatively wealthier families (Ricker-Gilbert, 2014).

Wage off-farm employment refers to more formal or semi-formal jobs away from agriculture, such as working as domestic workers, shop assistants, or employees in small businesses, teachers, health practitioners, and those working in service sectors such as hospitality and tourism. These jobs typically provide more stable income than casual labor but remain scarce, particularly in rural areas (Mutsami et al., 2025a). Self-employment includes small-scale business activities where women operate their income-generating enterprises. Examples include selling vegetables in local markets, tailoring, running food stalls, operating beauty shops, or engaging in handicrafts.

To capture women's employment, we measure participation at both the intensive and extensive margins. The intensive margin captures the number of hours worked by women in off-farm activities over the past seven days. Getting information about the number of hours allocated to different labor activities in the last one week helps to avoid issues associated with recall bias (Arthi et al., 2018; De Janvry et al., 2022). Since a household may have multiple women engaged in off-farm work, we compute the household-level mean hours worked by gender

[16] Attrition weights were calculated using inverse probability weighting (IPW). We estimated the probability of remaining in the sample using logistic regression model. The inverse of the probability of remaining in the sample was then used as the attrition weight, hence adjusting for potential selection bias due to non-random attrition.
[17] The questionnaire also captures information on individuals' participation in unpaid apprenticeships, but we do not consider this category in our analysis since very few individuals engage in it.

following Sangwan & Kumar (2021). This aggregation allows our analysis to correspond to the case of a representative woman within the household, allowing consistency across different household structures.

It is possible that our primary measure of women's employment may underestimate total hours worked, particularly in households with multiple women engaged in off-farm activities who contribute varying amounts of labor. To address this concern, we conduct robustness checks using alternative measures: the total number of hours worked by all women in the household, and the maximum number of hours worked by any individual woman. In addition, averaging hours worked across multiple women within a household may mask important intra-household dynamics, particularly in larger households. For example, we expect the nutritional effects of off-farm employment to differ between women with greater household responsibilities—such as mothers or spouses of the household head—and those with less roles. To address this concern, we conduct a robustness check using hours worked only by women who are either the household head or the spouse of the head, as these individuals are more likely to influence household food consumption decisions. These alternative specifications help ensure that our results are not sensitive to how women's labor input is aggregated within households. To measure the extensive margin, we use a binary indicator that takes a value of 1 if at least one woman in the household engaged in off-farm employment and 0 otherwise.

3.3.3. Measuring dietary quality

To measure dietary quality, we use the information from the food consumption module of the survey. This module records the quantities of various food items consumed by the household over the past seven days. The questionnaire also captures information on the sources of food consumed, differentiating between market purchases, where households report both the quantity and cost of food items bought, and own-food production, which includes food sourced from family farms.[18]

To compute calories and micronutrient intake, we first calculate the edible portions of the reported food quantities. These edible portions are then converted into calories and micronutrient values using the Malawian food composition tables (MAFOODS, 2019). Since households vary in size and composition, we adjust calorie and micronutrient intake using adult

[18] Households in Malawi could also receive food from relatives and friends as gifts; however, our analysis does not focus on these sources due to the limited number of observations.

male equivalents (AE), a standard approach in food economics research (Khonje et al., 2022b; Kilimani et al., 2022; Ogutu et al., 2020a). The key nutrients of interest in this study are: calories, measured in kilocalories per AE per day; vitamin A, measured in micrograms of retinol equivalents (μg RE/day/AE); iron, measured in milligrams per AE per day (mg/day/AE); and zinc, also measured in milligrams per AE per day (mg/day/AE). This approach ensures comparability across households. While we acknowledge that the human body requires a wide range of micronutrients for optimal health, we focus on vitamin A, zinc, and iron. We selected these micronutrients due to evidence linking their deficiencies to significant health challenges experienced globally (Development Initiatives, 2018; IFPRI, 2024; Stevens et al., 2022). We also acknowledge that measure of diet quality is based on food availability at the household level rather than actual intake, which may lead to overestimation due to potential food wastage or leftovers. This is a limitation of the study, as variation between available and consumed food can affect the precision of nutrient intake estimates.

In addition, while our method of measuring nutrition (i.e., calculating calories and micronutrients consumed in a household) is widely used in the food economics literature, it does not account for intra-household food distribution. Since our food consumption data were collected at the household level, we are unable to capture how food and nutrients are allocated among individual household members. This, therefore, means that differences in food consumption between men, women, and children within the same household cannot be captured. However, previous studies have shown significant associations between household-level and individual-level dietary measures (Koppmair et al., 2017; Ogutu et al., 2020a), suggesting that household-level measures still provide meaningful information on overall nutritional adequacy.

3.4. Empirical strategy

3.4.1. Basic model

We assess the influence of women's off-farm employment on household consumption of calories and micronutrients. Since our analysis is based on observational data, where women in households self-select into off-farm employment, there is a potential concern of endogeneity. Such endogeneity may be caused by time-invariant factors such as women's motivation, skills, and preferences, which may influence both their off-farm employment decisions and consumption of calories and micronutrients. Since we have a panel dataset covering four survey waves, we account for time-invariant unobserved heterogeneity by using household fixed effects (FE) (Wooldridge, 2010). We estimate the following panel data econometric model:

$$N_{it} = \alpha + \beta E_{it} + \rho W_{it} + \delta X_{it} + \tau_i + \varepsilon_{it} \quad (3.1)$$

N_{it} represents the main outcomes—calorie, vitamin A, zinc, and iron consumption. Our main explanatory variable of interest is E_{it}, whose parameter estimate β indicates the relationship between women's off-farm employment and household consumption of calories and micronutrients. As mentioned above, we first run a regression using women's participation in off-farm employment in general, then also run specifications where we have the different employment activities—self-employment, wage employment, and casual labor. We expect the effect of women's time spent in self-employment, wage employment, and casual labor to be different because casual jobs attract lower earnings than wage and self-employment. W_{it} indicates a vector of women's characteristics such as education (years), age (years) and household head status (dummy) while X_{it} shows a vector of household characteristics, including household size (number), household credit access (dummy), asset value (Malawian Kwacha), farm size (ha), and average annual rainfall (mm). Since we want to focus on women, we control for the participation of men in off-farm activities. Although the survey was designed to account for seasonality through temporal randomization of data collection, as explained in Section 3.3.1, we further control for the month in which each interview was conducted. This additional control helps to capture any residual seasonal effects that may influence household food consumption or labor patterns during specific months of the year. τ_i represents time-invariant household-specific unobserved heterogeneity, and ε_{it} captures idiosyncratic shocks.

In sub-Saharan Africa, women's participation in employment can also be shaped by regional dynamics, such as changes in infrastructure (e.g., roads, markets, and urban expansion), demographic shifts, and evolving institutional conditions (Hazell et al., 2024). These regional factors can influence both the availability and type of employment opportunities over time. However, because regional dummy variables are time-invariant, they are dropped in FE models and therefore cannot capture temporal changes (Ogutu et al., 2020b). To address this limitation, we include interaction terms between region[19] and year dummies as covariates in our regressions. This approach of incorporating interaction terms between region and year dummies in the fixed effects models also enables us to control for time-varying unobserved heterogeneity, particularly those occurring at the regional level. Such heterogeneity, if left

[19] Malawi has three regions: North, South and Central.

unaccounted for, could bias the estimated effects of women's employment on household nutritional outcomes.

To address concerns about multiple hypothesis testing, we apply the two-stage False Discovery Rate Control (FDRC) procedure outlined by Benjamini et al. (2006) to adjust p-values across our key nutrition outcomes. This approach helps reduce the likelihood of false positives that may arise from estimating multiple models across different employment categories and food sources.

As a robustness check, we also employ the pseudo-fixed effects (pseudo-FE) estimator proposed by Mundlak (1978). This approach can yield more efficient estimates than standard fixed effects models, particularly when within-group variation is limited relative to between-group variation (Mundlak, 1978; Wooldridge, 2019). Mundlak model includes time averages of all time-varying covariates ($\widetilde{W}_{it}$ and $\tilde{X}_{it}$), as shown in Equation (3.2).

$$N_{it} = \alpha + \beta E_{it} + \rho W_{it} + \delta X_{it} + \pi \widetilde{W}_{it} + \gamma \tilde{X}_{it} + \varepsilon_{it} \quad (3.2)$$

3.4.2. Exploring mechanisms

Based on our conceptual framework above, we discuss how we test the four potential channels through which women's employment may influence the consumption of calories and micronutrients: food source (market vs. own production), changes in income, farm production diversity, and bargaining power. We start by investigating how women's employment leads to the substitution of market-purchased food for home-produced food. We do this by re-estimating Equation (3.1), this time distinguishing between calories and micronutrients obtained from market sources versus those from the family farm.

Additionally, we explore other potential mechanisms, such as how women's employment affects household income, farm production diversity, and decision-making. To examine the role of income, we first run a regression to see how women's off-farm employment influences household income. We calculate income as the sum of the net income from all economic activities, including farming and off-farm employment, as well as any transfers. Household income is measured per capita[20], by dividing the total income by the number of household

[20] We adjust for inflation by calculating the real value of household income using the Consumer Price Index (CPI) for each survey year, with 2017 as the base year, as shown: $Real\ value = \frac{Nominal\ value}{CPI\ in\ survey\ year} X\ CPI\ in\ 2017$ (https://data.worldbank.org/indicator/PA.NUS.PPP)

members. We then estimate a regression of how household income influences the consumption of calories and micronutrients. Based on our discussion above, we expect household income to be positively associated with the consumption of calories and micronutrients.

Considering that women's participation in off-farm activities may reduce the time available for own-farm activities, we analyze the farm production diversity pathway to determine whether women's employment leads to a reduction in the crop or livestock raised by the household using Equation (3.1). Farm production diversity is measured by counting the number of distinct food groups produced by a household. In addition, we calculate crop and livestock diversity separately by counting the number of different crop species and livestock types produced or raised by the household. This analysis enables us to assess whether women's off-farm employment influences household agricultural production decisions.

We also examine the association between women's off-farm employment and their decision-making regarding the use of income from different sources. We use income decision-making as a proxy for women's autonomy and their bargaining power in the household. The decision-making variables are measured as binary variables, where a value of 1 indicates that a woman was involved in making decisions on how the income from different sources is used—either jointly with a male member or independently—while a value of 0 signifies that she was not involved in such decisions. The main sources of income considered include business, salary, and other non-farm sources such as remittances, as well as cash and in-kind transfers.

3.5. Results and discussion

3.5.1. Descriptive statistics

Table 3.1 presents the descriptive summary statistics for selected socioeconomic characteristics, as well as women's employment and consumption variables, for both the pooled sample and disaggregated by survey year. Panel A of Table 3.1 shows that the average woman in the sample is approximately 35 years old and has just over five years of formal education. Households tend to be small, with about five members, and operate farms averaging 1.8 hectares in size. Only a minority of households reports access to credit (18%) and less than one-third are female-headed.

We observe in Panel B of Table 3.1 that about half of the women are involved in farming on family farms while one-third are employed in off-farm work. The most common type of off-farm employment among sampled women is casual labor, followed by self-employment, and wage employment. Panel C of Table 3.1 indicates that across all women in the sample, the average number of hours worked during the seven days prior to the survey is 7.27 in off-farm employment and 8.95 in on-farm agricultural activities. The number of hours worked remained relatively stable across the four survey waves. Similarly, most women did not experience much changes in their off-farm employment status over the survey rounds. Only about 20–23% of women switched their off-farm employment status across the four waves, indicating limited fluctuation in participation (Table A3.3 in the Appendix). Panel D of Table 3.1 shows that nearly half of men in the sample participate in off-farm employment, with self-employment and casual labor being the most common forms.

Panel E of Table 3.1 shows that, on average, a household consumes 2969 kcal/day/AE of calories, 928 µg RE/day/AE of vitamin A, and 18 and 19 mg/day/AE of iron and zinc, respectively. We observe that the dietary quality indicators fluctuated over time. For example, average calorie consumption was approximately 2,855 in 2010, increased to 3,204 in 2013, declined to 2,392 in 2016, and then rose again to 2,977 in 2019. The average nutrient intake levels observed in our sample are broadly consistent with previous studies conducted in Malawi. For example, Khonje et al. (2022a), using nationally representative data, report average household consumption of 2,817 kcal/day/AE, 945 µg RE/day/AE of vitamin A, 18 mg/day/AE of iron, and 16 mg/day/AE of zinc. In contrast, Trijsburg et al. (2021), also using nationally representative data from 2019, report slightly higher estimates for calorie intake (3,659 kcal/day/AE) and zinc (21 mg/day/AE). These slight variations may reflect differences in survey design, seasonal timing, and methods used to estimate nutrient intake.

Table 3.1: Descriptive results for key variables by survey year

	Full sample	2010	2013	2016	2019
Panel A: Socioeconomic characteristics					
Female-headed household (1/0)	0.26	0.23	0.24	0.26	0.29
Women age (years)	34.61	34.35	34.50	34.57	34.86
	(28.20)	(29.13)	(28.72)	(30.51)	(25.59)
Women education (years)	5.34	4.77	5.17	5.33	5.78
	(4.78)	(6.23)	(4.55)	(5.28)	(4.61)
Household size (number)	4.98	4.96	5.23	5.01	4.80
	(4.24)	(5.33)	(5.82)	(3.69)	(4.11)
Credit access (1/0)	0.18	0.02	0.18	0.13	0.31
Farm size (ha)	1.80	2.02	1.80	1.77	1.69
	(1.88)	(1.72)	(1.77)	(1.79)	(1.24)
Value of assets (MK)	129.99	29.71	90.26	122.29	218.23
	(138.20)	(57.22)	(101.75)	(145.93)	(224.16)
Annual rainfall (mm)	926.15	743.86	1558.20	687.63	780.32
	(636.10)	(400.71)	(752.56)	(341.18)	(564.27)
Distance to market (km)	16.31	7.34	18.0	18.59	18.31
	(14.35)	(4.02)	(13.55)	(15.98)	(12.18)
Panel B: Women employment participation rates					
Off-farm employment (1/0)	0.34	0.23	0.25	0.40	0.42
Self-employment (1/0)	0.14	0.12	0.13	0.15	0.16
Off-farm wage employment (1/0)	0.05	0.04	0.05	0.05	0.05
Casual labor (1/0)	0.18	0.09	0.09	0.25	0.25
Own farm labor (1/0)	0.53	0.53	0.52	0.49	0.56
Panel C: Hours worked by women					
Off-farm wage employment (hours)	7.27	5.18	6.52	7.25	8.93
	(15.43)	(13.37)	(16.0)	(14.42)	(16.64)
Self-employment (hours)	3.23	2.57	3.30	3.08	3.65
	(10.52)	(9.38)	(10.98)	(10.06)	(11.11)
Off-farm wage employment (hours)	1.42	1.07	1.61	1.28	1.60
	(7.73)	(6.33)	(7.82)	(6.87)	(7.82)
Casual labor (hours)	2.30	1.30	1.28	2.70	3.25
	(6.67)	(5.30)	(5.54)	(6.75)	(7.73)
Own farm labor (hours)	8.95	9.70	10.30	7.49	8.75
	(14.17)	(15.34)	(15.03)	(12.45)	(14.04)
Panel D: Men employment participation rates					
Off-farm employment (1/0)	0.48	0.39	0.39	0.50	0.57
Self-employment (1/0)	0.16	0.12	0.15	0.17	0.18
Off-farm wage employment (1/0)	0.14	0.16	0.15	0.14	0.14
Casual labor (1/0)	0.23	0.14	0.13	0.26	0.32
Own farm labor (1/0)	0.46	0.49	0.46	0.45	0.46
Panel E: Total calories and micronutrient consumed					
Calories consumption (Kcal/day/AE)	2855.28	2855.22	3203.96	2391.87	2976.75
	(1541.65)	(1554.92)	(1719.91)	(1303.21)	(1490.71)
Vitamin A consumption (μg RE/day/AE)	933.22	703.52	1111.80	757.05	1074.40
	(563.23)	(558.46)	(538.12)	(536.7)	(516.96)
Iron consumption (mg/day/AE)	18.06	15.18	21.74	13.39	20.76
	(9.73)	(9.95)	(9.02)	(8.38)	(9.08)
Zinc consumption (mg/day/AE)	16.35	11.98	20.94	11.68	19.23
	(10.05)	(9.13)	(9.90)	(7.99)	(9.56)
Observations	7034	1287	1595	1813	2339

Notes: Standard deviations are shown in parentheses. AE and RE denote adult equivalent and retinol equivalent, respectively. MK refers to Malawi Kwacha. All reported labor hours refer to hours worked per week.

The descriptive statistics in Table 3.2 indicate that households with women participating in off-farm employment have significantly higher nutrient intake compared to those without such participation. Specifically, they consume on average 155 more kilocalories, 63 µg more vitamin A, 1.53 mg more iron, and 1.21 mg more zinc per adult equivalent per day—all statistically significant at the 1% level. These results suggest a positive association between women's off-farm employment and both the quantity and quality of household diets.

Table 3.2: Descriptive statistics for food consumption by women's employment

	Participated in off-farm employment		Mean difference
	Yes	No	
	(1)	(2)	(3) = (1)–(2)
Calories consumption (Kcal/day/AE)	2929.11	2774.15	154.95***
	(1489.40)	(1584.30)	
Vitamin A consumption (µg RE/day/AE)	963.27	900.20	63.07***
	(599.26)	(518.85)	
Iron consumption (mg/day/AE)	18.79	17.26	1.53***
	(10.33)	(8.96)	
Zinc consumption (mg/day/AE)	16.92	15.71	1.21***
	(10.81)	(9.10)	
Observations	2,401	4,633	7,034

Notes: AE and RE denote adult equivalent and retinol equivalent, respectively. Mean values are shown with standard deviations or (standard errors for column 3) in parentheses. Statistical differences between participants and non-participants in off-farm employment are performed using t-tests. *** denotes significant at 1% level.

Figure 3.2 displays the kernel density distribution of the consumption of calories and three micronutrients and women's employment in different activities, where the vertical line indicates the mean of calories and micronutrients for each employment type. The means of calories and micronutrients for those in casual labor are lower than those in wage and self-employment. This finding suggests that wage and self-employment are associated with higher calorie and micronutrient consumption than casual agricultural jobs. The findings from Table 3.2 and Figure 3.2 provide early insights into the potential of off-farm employment on dietary quality. However, we do not control for confounding factors here. The next section presents regression results after controlling for confounding factors.

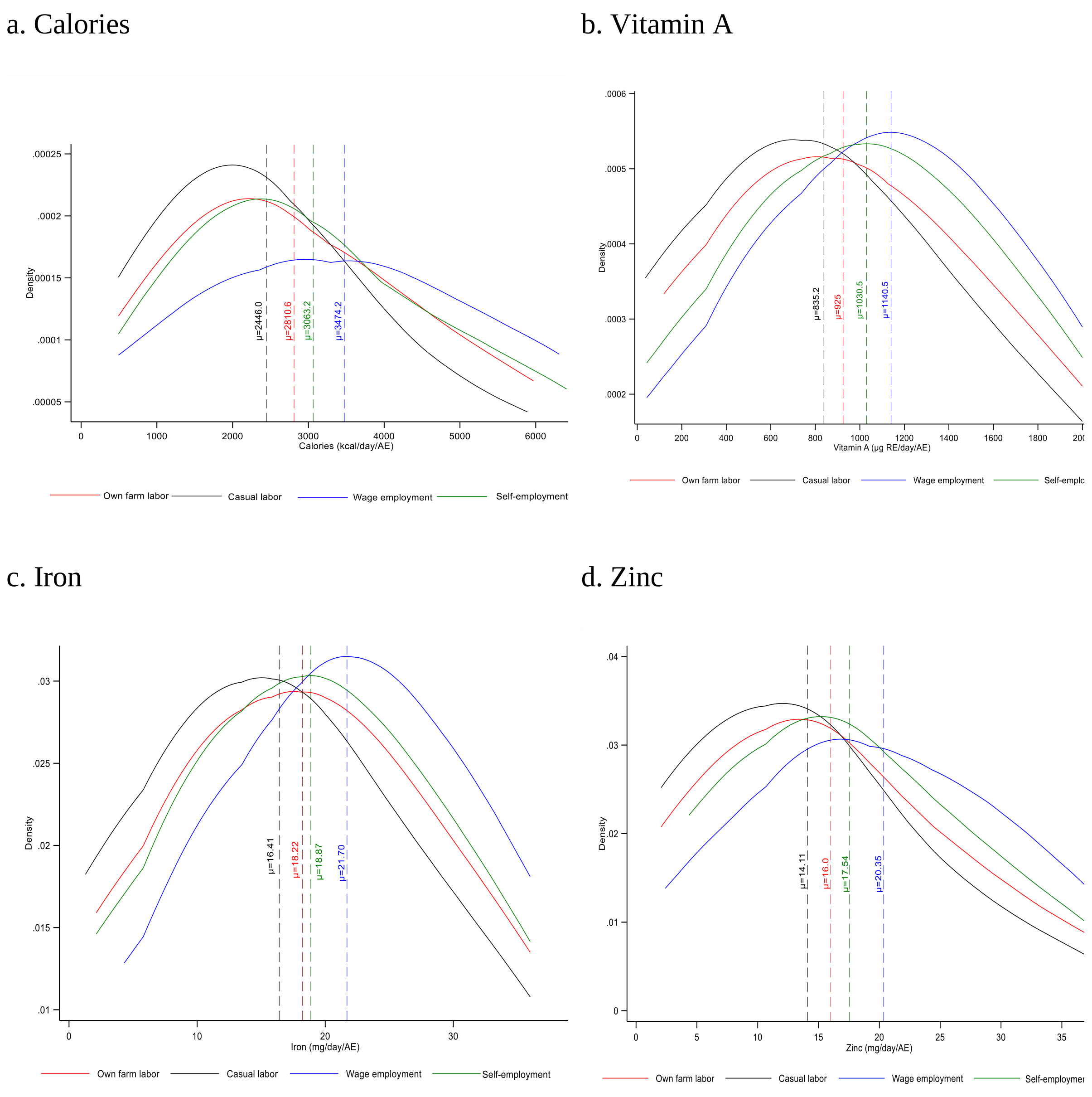

Figure 3.2: Kernel density distribution of consumption and women's employment

Notes: These figures show household consumption of calories and micronutrients for different employment activities by women. AE and RE denote adult equivalent and retinol equivalent, respectively.

3.5.2. Regression results

i. Basic model results

We begin by presenting the results (Equation 3.1) on the relationship between women's participation in off-farm employment and households' total consumption of calories and micronutrients. Panel A in Table 3.3 shows that women's off-farm employment has a positive and significant association with the consumption of calories and the three micronutrients: iron, zinc, and vitamin A. Participation in an additional hour per week in off-farm employment by an average woman in a household is associated with an increase in the consumption of calories by 6.22 kcal, vitamin A by 1.81 µg, iron by 0.021 mg, and zinc by 0.024 mg per AE and day. While the effect sizes are small in magnitude, the coefficients are somewhat precisely estimated. A likely explanation for the small magnitudes is that a large proportion of women in the sample do not engage in off-farm employment (see Table 3.1), resulting in a high number of zeros and thus diluting the average effects across the full distribution. However, when we use a binary indicator for off-farm employment (extensive margin), the estimates suggest that participation is associated with higher daily intake per adult equivalent—121 kcal, 66 µg of vitamin A, 1 mg of iron, and 1.2 mg of zinc (see Table A3.4 in the Appendix). Nevertheless, these results suggest that women's involvement in off-farm employment improves household consumption of calories and micronutrients. This observation is consistent with earlier research showing that women's participation in income-generating activities away from their farms improves household nutrition and food security (Mutsami et al., 2025b; Sangwan & Kumar, 2021).

Next, we present results for the different types of off-farm employment—casual labor, wage employment, and self-employment—assessing the heterogeneities in consumption patterns across these job categories in Panel B of Table 3.3. We observe a positive association between women's self-employment and consumption of calories and the three micronutrients. Wage employment by women also shows a positive and significant association with calorie intake, as well as vitamin A, and zinc. In contrast, participation in casual labor shows no significant relationship with any of the nutrient outcomes. This finding aligns with previous work suggesting that casual labor in Malawi tends to be low-paying and unstable income, which limits the ability of such households to consistently access sufficient, diverse, and nutritious food (Ravallion & Lokshin, 2010; Ricker-Gilbert, 2014).

Table 3.3: Relationship between women's off-farm employment and household calorie and micronutrient consumption

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Panel A: Off-farm employment				
Off-farm employment (hours)	6.222***	1.805***	0.021*	0.024**
	(2.010)	(0.685)	(0.011)	(0.011)
	[0.024]	[0.027]	[0.072]	[0.06]
Panel B: Specific off-farm activity				
Self-employment (hours)	5.468**	2.332***	0.027*	0.030**
	(2.730)	(0.894)	(0.015)	(0.014)
	[0.067]	[0.027]	[0.072]	[0.066]
Wage employment (hours)	12.027***	3.155***	0.027	0.039**
	(4.025)	(1.191)	(0.021)	(0.021)
	[0.024]	[0.027]	[0.11]	[0.073]
Casual labor (hours)	1.433	0.203	0.006	0.001
	(3.775)	(1.403)	(0.025)	(0.023)
	[0.36]	[0.36]	[0.36]	[0.36]
Household controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes	Yes
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. Adjusted p-values (q-values) are shown in square brackets, following the two-stage procedure for multiple hypotheses testing by Benjamini et al. (2006) and calculated following Anderson (2008). Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, rainfall and men off-farm employment. Full results are presented in Table A3.6-A3.9. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

ii. Purchased and own-produced foods

Food from purchases: Table 3.4 shows how women's off-farm employment affects the consumption of calories and micronutrients from purchased foods. The findings indicate that women's off-farm employment is positively and significantly associated with household consumption of calories and all three micronutrients from purchased foods. The results suggest that women's participation in off-farm employment enhances household economic access to higher-quality diets, likely through increased income. These findings are consistent with previous literature indicating that women's involvement in off-farm work increases their share of household income, which is often directed toward the purchase of more diverse and nutritious foods (Hoddinott & Haddad, 1995; Melaku et al., 2024; Mutsami et al., 2025b).

Table 3.4: Relationship between women's off-farm employment and household calorie and micronutrient consumption from purchases

	Calories	Vitamin A	Iron	Zinc
	(1)	(2)	(3)	(4)
Panel A: Off-farm employment				
Off-farm employment (hours)	4.409**	1.536**	0.025**	0.024***
	(1.729)	(0.736)	(0.012)	(0.008)
	[0.037]	[0.052]	[0.052]	[0.029]
Panel B: Specific off-farm activity				
Self-employment (hours)	5.423**	2.049**	0.035**	0.034***
	(2.376)	(0.91)	(0.016)	(0.011)
	[0.052]	[0.052]	[0.052]	[0.024]
Wage employment (hours)	10.386***	2.979**	0.037	0.035**
	(3.751)	(1.469)	(0.026)	(0.018)
	[0.03]	[0.055]	[0.078]	[0.057]
Casual labor (hours)	-2.818	-0.975	0.005	-0.005
	(2.818)	(1.385)	(0.023)	(0.014)
	[0.14]	[0.208]	[0.266]	[0.247]
Household controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. Adjusted p-values (q-values) are shown in square brackets, following the two-stage procedure for multiple hypotheses testing by Benjamini et al. (2006) and calculated following Anderson (2008). Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, rainfall and men off-farm employment. The full results are in Tables A3.10 – A3.13 in the Appendix. ** denotes significant at 5% level, and *** denotes significant at 1% level.

The next question is whether this observation is consistent across the three off-farm employment activities. We observe a positive relationship between off-farm employment and consumption of calories and micronutrients from purchased foods among women involved in wage non-farm jobs and self-employment. However, Table 3.4 shows that women's participation in casual labor is insignificantly associated with the consumption of calories and micronutrients from purchased foods. This interpretation is supported by descriptive statistics showing that households with women engaged in wage or self-employment earn significantly higher incomes than those relying solely on farming, whereas income from casual labor tends to be even lower than that from farming alone (Table A3.5 in the Appendix).

Food from own production: Table 3.5 presents results on the relationship between women's employment and the consumption of calories and micronutrients from own-produced foods. We observe that women's off-farm employment is associated with a reduction in the consumption of calories, vitamin A, iron, and zinc from own-produced foods. These results indicate that as women engage more in off-farm activities, households may rely less on substance food production.

The findings in Tables 3.4 and 3.5 suggest that women's employment is associated with a substitution of purchased foods for own-produced foods among the sampled households. However, it is plausible that some households use income from off-farm activities to invest in agricultural production, implying a potential non-linear relationship between women's off-farm employment and household dietary quality. To explore this possibility, we generated a predictive curve (Figure A3.1 in the Appendix), which reveals that nutrient consumption from own-produced foods initially declines as women's off-farm work hours increase. However, after approximately 30 minutes of off-farm work per week, the trend reverses, and nutrient intake from own production begins to rise. This finding suggests that an increase in hours worked in off-farm employment may reduce the consumption of food produced on family farms. However, up to a certain point, increased hours worked—which are likely to lead to higher income—can enable households to invest in farm production, potentially resulting in a rise in the consumption of foods produced from their own farms.[21]

[21] Employment hours exceeding 30 per week may not be practically relevant in the Malawian context, as only 2.1% of off-farm employed women in the sample report working 30 hours or more per week.

Table 3.5: Relationship between women's off-farm employment and household calorie and micronutrient consumption from own production

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Panel A: Off-farm employment				
Off-farm employment (hours)	-3.772**	-1.007***	-0.035***	-0.015***
	(1.51)	(0.315)	(0.011)	(0.005)
	[0.019]	[0.008]	[0.008]	[0.011]
Panel B: Specific off-farm activity				
Self-employment (hours)	-4.149**	-1.23***	-0.047***	-0.015***
	(1.896)	(0.408)	(0.014)	(0.007)
	[0.03]	[0.009]	[0.008]	[0.009]
Wage employment (hours)	-3.395	-1.009	-0.047**	-0.015***
	(2.979)	(0.616)	(0.019)	(0.009)
	[0.159]	[0.07]	[0.019]	[0.07]
Casual labor (hours)	-3.77	0.139	-0.004	-0.01
	(3.049)	(0.622)	(0.022)	(0.011)
	[0.145]	[0.358]	[0.358]	[0.176]
Household controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. Adjusted p-values (q-values) are shown in square brackets, following the two-stage procedure for multiple hypotheses testing by Benjamini et al. (2006) and calculated following Anderson (2008). Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, rainfall and men off-farm employment. The full results are in Tables A3.14 – A3.17 in the Appendix. ** denotes significant at 5% level, and *** denotes significant at 1% level.

3.5.3. Exploring potential mechanisms

One of the mechanisms through which women's off-farm employment may influence calorie and micronutrient intake is income. We examine how women's involvement in off-farm employment influences household income. Table 3.6 shows that off-farm employment is positively and significantly associated with per capita household income. We also run a regression to examine how the additional household income influences food consumption in the household. Table 3.6 confirms that an increase in per capita household income is significantly associated with higher consumption of calories and the three micronutrients. This observation is consistent with Hoddinott and Haddad (1995), who provide evidence that increases in women's share of income are associated with improvements in household food expenditure patterns.

Table 3.6: Women's off-farm employment, income, and consumption of calories and micronutrients

	Household income	Calories	Vitamin A	Iron	Zinc
	(1)	(2)	(3)	(4)	(5)
Off-farm employment (hours)	0.025*** (0.005)				
Household income (log)		59.44*** (15.94)	5.516*** (2.533)	0.930*** (0.104)	1.04*** (0.098)
Household controls	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes	Yes
Observations	7,034	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. Household income is transformed using an inverse hyperbolic sine (IHS) transformation ($\log(x + (x^2 + 1)^{0.5})$ (Bellemare & Wichman, 2020). Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, and rainfall. Full results are in Tables A3.18 and A3.19 in the Appendix. *** denotes significant at 1% level.

We also examine farm production diversity as a potential mechanism through which women's off-farm employment may influence household dietary outcomes. Table 3.7 shows a negative and statistically significant association between women's participation in off-farm work and overall household production diversity. This negative relationship is particularly evident for crop diversity, while the association with livestock diversity is negative but not statistically significant. Descriptive analysis of specific crops further indicates that households with women engaged in off-farm employment are less likely to produce key staples such as maize, tobacco, and groundnuts compared to those primarily engaged in farming (Table A3.21 in the Appendix). This observation aligns with the findings in Table 3.5, which show a negative association between off-farm employment and nutrient intake from own-produced food. A plausible explanation is that women's involvement in off-farm work may reduce the time and labor available for farm activities, thereby limiting the household's ability to maintain a diverse production portfolio.

Table 3.7: Women’s off-farm employment and farm production diversity

	Farm (crop + livestock) production diversity (1)	Crop diversity (2)	Livestock diversity (3)
Off-farm employment (hours)	-0.145*	-0.086***	-0.07
	(0.081)	(0.031)	(0.05)
Household controls	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes
Observations	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Full results are in Table A3.20 in the Appendix. Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, rainfall and men off-farm employment. * denotes significant at 10% level and *** denotes significant at 1% level.

As a third mechanism, we examine how women’s participation in off-farm employment influences their decision-making power over the use of household income from various sources. Table 3.8 shows that off-farm employment is positively and significantly associated with women's involvement in income decisions related to non-farm enterprises, wage employment, and other income sources such as remittances and transfers. This finding suggests that as women participate more in off-farm economic activities, they gain increased bargaining power and greater influence over household financial decisions. These results are consistent with prior research indicating that women’s engagement in labor market activities enhances their decision-making autonomy within the household (Majlesi, 2016; Anand et al., 2025). Furthermore, earlier studies have shown that when women control income, they are more likely to allocate resources toward more diverse and nutritious diets (Malapit et al., 2015; Masters et al., 2022; Ogutu et al., 2020a; Sangwan & Kumar, 2021).

Table 3.8: Women’s off-farm employment and income decision-making

	Women involvement in off-farm income control		
	Business income (1)	Wage income (2)	Other income (3)
Off-farm employment (hours)	0.007***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)
Household controls	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Region dummies × year dummies	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes
Observations	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Other income refers to income from sources such as remittances, cash transfers and rentals. Household controls include household size, female-headed household, age, credit access, education, asset ownership, size of land, rainfall and men off-farm employment. Full results are in Table A3.22 in the Appendix. * denotes significant at 10% level and *** denotes significant at 1% level.

3.5.4. Robustness checks

In this section, we perform several robustness tests to confirm and strengthen our main findings. First, we re-estimate the effects of women's participation in off-farm employment on household consumption of calories and micronutrients using the Mundlak (1978) estimator instead of the FE estimator. As shown in Table A3.23 in the Appendix, the results remain consistent with those discussed earlier, suggesting robustness to the choice of estimator. Second, we re-run the FE model using a restricted sample that includes households observed in at least three survey rounds. This procedure allows us to assess whether the results hold when we drop households without within variation. The findings, presented in Table A3.24 in the Appendix remain stable and in line with our main results using the full sample.

Third, some households may engage in more than one type of off-farm employment simultaneously, which could potentially bias our estimates if not properly addressed. However, descriptive analysis (Figure A3.2 in the Appendix) indicates that such cases are rare, with fewer than 3% of households reporting participation in multiple off-farm activities. To assess the robustness of our results, we re-estimate our main specification after excluding these households from the sample. The results remain consistent with our main findings (Table A3.25 in the Appendix), suggesting that overlapping participation in off-farm activities does not significantly bias the observed associations.

In our fourth robustness checks, we examine the sensitivity of our results to alternative measures of women's employment at the household level. Rather than using the average hours worked by working-age women, we first consider the total number of hours worked by all women in the household. The results, presented in Table A3.26 in the Appendix, are largely consistent with those obtained using average hours worked. Next, we use the maximum number of hours worked by any woman in the household as an alternative proxy. Again, the findings remain qualitatively similar to our main results (Table A3.27 in the Appendix). Lastly, we restrict the employment measure to hours worked by women who are either the household head or the spouse of the head, given their typically greater household responsibilities. The results, shown in Table A3.28 in the Appendix, also align with our main findings. Collectively, these robustness checks suggest that our results are not sensitive to the specific measure of women's employment used, reinforcing the validity of our conclusions.

3.6. Conclusion and policy implications

Improving rural nutrition remains a significant development challenge across sub-Saharan Africa, where agriculture is the primary livelihood source, yet diets frequently lack diversity and essential micronutrients. In this context, women's participation in off-farm employment may play an important role in shaping household food consumption patterns. Using a ten-year panel data from Malawi, we have assessed the relationship between women's off-farm employment and household consumption of calories and micronutrients. We have employed fixed effects model to control for time-invariant heterogeneity. Furthermore, we have disaggregated off-farm employment into self-employment, wage employment, and casual labor (commonly referred to as *ganyu* in Malawi) to explore heterogeneous effects. We have also assessed how women's employment influences the consumption of food by source—purchased versus own-produced—given the potential for differing nutritional implications. Finally, we investigate potential underlying mechanisms through which women's employment may affect dietary quality, using panel regression techniques.

Our findings indicate that women's participation in off-farm employment is positively associated with household dietary intake, particularly in terms of calorie and micronutrient consumption. While the estimated coefficients for hours worked are small in magnitude, this is consistent with recent literature that also reports relatively small net effects of women's employment on dietary quality. For instance, Sangwan and Kumar (2021), using high-frequency nationally representative data from India, find that an additional day of women's paid work increases household dietary diversity by just 0.0023%. Nevertheless, even small improvements in dietary intake can be meaningful in contexts where nutritional deficiencies are widespread like Malawi, and incremental gains across large populations can translate into significant public health impacts.

We also observe that both self-employment and non-farm wage employment are significantly associated with food consumption, while casual labor does not show a significant effect, likely due to its low and unstable income. Additionally, our findings show that women's off-farm employment is positively and significantly associated with the consumption of purchased calories and micronutrients and negatively associated with the consumption from own-produced foods. This result suggests that women's participation in off-farm employment shifts food sources from own production to market purchases, reinforcing income as the primary driver of improved food consumption. Additional analysis indicates that this shift also results in reduced farm production diversity, which could be due to less time being allocated to farm activities by women engaged in off-farm activities. We also find positive associations between women's off-farm employment and their decision-making regarding income from different off-farm sources, suggesting that off-farm work improves women's bargaining power. High bargaining power among women in the household allows them to allocate resources towards diverse and nutritious food.

It is important to note a few limitations in this study. First, despite the use of FE models to control for time-invariant unobserved heterogeneity and inclusion of several control variables, we cannot completely rule out endogeneity, mainly due to measurement error associated with employment data since studies show that in the absence of a regular work schedule, responses appear to be extrapolated hence introducing errors (Arthi et al., 2018; Van Cappellen & De Weerdt, 2024). However, this type of bias is reduced in our study since respondents were asked to recall the number of hours for employment activities conducted in the last seven days instead of the past 12 months. Second, reverse causality may also bias our estimates, as households with better dietary quality could enable women to work. While we attempted to address this using IV regressions, our instruments did not satisfy the validity criteria. Nevertheless, we caution that our results should be interpreted as associations rather than causal relationships.

Given these insights, we cautiously suggest the following policy implications. First, since our findings show that women's employment enhances the dietary quality of the household, policy support to expand stable and well-paying off-farm wage employment opportunities in rural areas of Africa could be important. In addition to expanding the quantity of wage jobs, policies could also prioritize enhancing their quality to ensure they are decent, secure, and supportive of rural women's well-being. This includes promoting fair wages, safe working conditions, and opportunities for skill development. Another policy area is to encourage and increase productivity in self-employment by prioritizing inclusion. For example, findings from McKenzie (2021) suggest that gender-responsive business training—covering standard business skills like bookkeeping as well as topics addressing gender-based challenges in business—can significantly enhance the profitability, sustainability, and growth of women-owned enterprises.

Second, as women's off-farm employment positively influences household food consumption, policies could focus on reducing barriers to women's participation in economic activities. Such policies include improving access to childcare services and flexible work arrangements. Third, since income from employment is a key factor in improved dietary outcomes, ensuring the availability and affordability of diverse, nutritious foods in rural markets is important. Investments in infrastructure, market linkages, and value chains for nutrient-rich foods can help households translate income gains into better nutrition.

Our empirical results are specific to households in Malawi; however, the broader finding—that women's off-farm employment is positively associated with household dietary quality—has wider relevance. This relationship is likely applicable in other low-income settings where women's labor force participation can influence household income and food choices, particularly in contexts where agricultural livelihoods dominate and diets often lack diversity.

CHAPTER 4

4. Women's off-farm employment and dietary quality in rural Africa[22]

Abstract

Most households in rural Africa are involved in smallholder farming, but off-farm employment is an important additional income source for many. Previous research has analyzed links between off-farm employment and wellbeing, but mostly at the household level, not considering that household members may be affected differently. In particular, gender gaps in employment, nutrition, and other wellbeing dimensions are widely observed. Here, we use survey data collected in Tanzania and Zambia to examine how women's off-farm employment influences their individual-level dietary quality. Regression estimates with instrumental variables show that women's off-farm employment is associated with improved dietary diversity, including more frequent consumption of nutritious foods such as meat, fish, fruits, and vegetables. We also explore potential mechanisms, including changes in household income, women's decision-making, and time allocation. The main results hold across various robustness checks, suggesting that improving women's access to off-farm employment can help increase household income and reduce widespread gender gaps in rural Africa

Keywords: Off-farm employment; Dietary quality; Gender; Time allocation; Nutrition; Africa

JEL Codes: Q18, J21, I31

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4.1. Introduction

For most households in rural Africa, small-scale farming is the main source of livelihoods. However, given rapid population growth, shrinking farm sizes, climate change, and structural transformation, off-farm income and employment have gained in importance, and these trends will further continue (Hazell et al., 2024; Musungu et al., 2024; Mutsami et al., 2025a). Off-farm employment has been recognized as a key avenue for poverty reduction in rural Africa (Davis et al., 2017; Kijima et al., 2006; Van den Broeck et al., 2017). There is also growing evidence that off-farm employment can help improve diets and nutrition in smallholder farm households, the group most affected by undernutrition worldwide (Dzanku, 2019; Rahman & Mishra, 2020; Sangwan & Kumar, 2021; Van den Broeck et al., 2021). Yet, most existing studies analyze effects at the household level, not considering who in the household is involved in off-farm employment and how the nutrition of individual household members is influenced. This is an important limitation, as gender gaps in employment, nutrition, and other dimensions of individual wellbeing are widely observed (Koppmair et al., 2017; Quisumbing and Doss, 2021; FAO, 2023; UNICEF, 2023). Here, we address this limitation and investigate the effects of women's off-farm employment on their individual-level dietary quality.

A few studies on the role of maternal employment for child diets and nutrition in different countries of Africa and Asia exist, with varying results depending on the context (Debela et al., 2021; Hosen et al., 2023; Melaku et al., 2024; Rashad & Sharaf, 2019). However, very little is known about how women's off-farm employment affects their own diets and nutrition. Previous studies have shown that food consumption and nutrition outcomes can differ across household members, underscoring the importance of examining women's diets (Coates et al., 2018; Gupta et al., 2020; Koppmair et al., 2017; Quisumbing and Doss, 2021). A focus on women's diets is relevant not only because women are disproportionately affected by undernutrition and micronutrient deficiencies, but also because women's nutritional status during pregnancy and lactation is a key determinant of child's physical and cognitive development (Cusick & Georgieff, 2016; UNICEF, 2023). Women typically also bear the primary responsibility for managing household diets and nutrition (Tibesigwa & Visser, 2016). Unlike men, women face stronger trade-offs between labor and household tasks (childcare, food purchase or production and preparation, etc.), which shapes how their work translates into nutrition (Jakaria et al., 2022; Maertens & Verhofstadt, 2013).

Women's participation in off-farm employment can influence their dietary quality through three main mechanisms, namely changes in household income, women's decision-making, and time allocation. Income earned from off-farm work may relax household budget constraints, enabling women to purchase and consume more diverse and nutritious foods (Maity, 2020). Increased financial autonomy achieved through own off-farm employment income may enhance women's decision-making power within the household. Studies suggest that income controlled by women often has larger positive diet and nutrition effects than income controlled by men (Kassie et al., 2020; Ogutu et al., 2020). Finally, involvement in off-farm employment may influence women's time available for farm and household activities, which may also influence diets and nutrition. For instance, a higher time burden through off-farm work could reduce women's time spent on food production or purchase and meal preparation, with possible negative implications for dietary quality. In summary, if women have higher preferences for nutritional quality than men, and if off-farm employment increases their decision-making power, then the effect of increases in women's off-farm employment on their own dietary quality will be the sum of three partial effects, namely a positive income effect, a positive decision-making power effect, and a negative labor substitution effect. Whether the sum of these partial effects is positive or negative is an empirical question that depends on the context.

We analyze such effects with primary survey data collected in rural regions of Tanzania and Zambia. Existing data, such as from the World Bank's Living Standards Measurement Study (LSMS), could not be used here because these do not contain individual-level dietary information.

We estimate the impact of women's off-farm employment – measured in terms of a binary variable and also the time allocated to off-farm activities – on women's dietary diversity scores (WDDS), using regression models with instrumental variables. We consider various types of off-farm activities, including self-employment in own non-agricultural businesses and wage-employment. Furthermore, we analyze effects of women's off-farm employment on the consumption of different food groups to better understand the nutritional implications. Finally, we examine associations between women's off-farm employment, household income, women's decision-making, and women's time allocation. In doing so, we aim to connect the research on welfare effects of off-farm employment with the research on drivers of women's dietary quality (Kassie et al., 2020; Komatsu et al., 2018; Quisumbing et al., 2021; Vemireddy & Pingali, 2021).

The remainder of this article is organized as follows. In section 4.2, we discuss the conceptual framework for our analysis. In section 4.3, we describe the survey in Tanzania and Zambia, the measurement of key variables, and the econometric estimation strategy. The empirical results are presented and discussed in section 4.4, while section 4.5 concludes.

4.2. Conceptual framework

Women's participation in off-farm employment can shape the quality of their diets through multiple interconnected mechanisms. The key mechanisms include changes in household income, shifts in women's decision-making[23], and changes in women's time allocation. The impact of each single mechanism on dietary quality, which can be positive or negative, depends on the specific context and nature of the off-farm work. The three mechanisms are discussed in more detail below.

Changes in household income. Being involved in off-farm employment usually adds to household income in comparison to a situation where all household members are only involved in farming (Baysan et al., 2024). This additional income from off-farm activities can relax household budget constraints, enabling greater consumption of purchased foods (Maity, 2020). Empirical evidence shows that much of the dietary diversity in African rural households is purchased in local markets (Nguyen & Qaim, 2025), so we expect positive effects on women's dietary quality. In addition, some of the off-farm income may be reinvested into agriculture, for instance, in the form of yield-enhancing technologies (Hazell et al., 2024). Higher agricultural yields may further improve women's dietary quality through home consumption or market sales (Ogutu et al., 2020a).

Changes in women's decision-making. Women's involvement in off-farm employment means that women contribute directly to cash income earnings, which can enhance their financial autonomy, likely also increasing their role in household decision-making, for instance, on how the income is spent. Women's priorities in terms of how the limited family income is spent are often different from those of men. Research consistently shows that income controlled by women is more frequently allocated to nutritious foods and family health than income controlled by men (Kassie et al., 2020; Ogutu et al., 2020a). This suggests that enhanced women's decision-making power through off-farm employment can lead to higher dietary quality.

[23] We use women's decision-making on household income as a proxy for agency, while recognizing that agency includes other dimensions such as the ability to define goals, perceived control over one's life, and the capacity to achieve those goals (Donald et al., 2020).

Changes in women's time allocation. Women's involvement in off-farm employment means that they have less time for other activities. Women in rural Africa are often time-constrained, having to shoulder most of the household chores and care work and typically also being heavily involved in the household's own farming activities (FAO, 2023). Additional off-farm employment can heighten women's time constraints, possibly reducing the time allocated to meal preparation.[24] In such situations, women may rely on more convenient but less diversified and nutritious food options, potentially compromising dietary quality and nutritional wellbeing (IFPRI, 2024; Komatsu et al., 2018; Quisumbing et al., 2021; Sangwan & Kumar, 2021).

The impact of time constraints on dietary quality may strongly vary by type of off-farm activity and the degree to which different tasks are taken up by other household members. Recent research shows that maternal off-farm involvement in wage-employment can have negative effects of child nutritional outcomes, largely due to reduced breastfeeding and less time spent on childcare and meal preparation, which is not fully offset by more time spent on these tasks by other household members (Debela et al., 2021; Melaku et al., 2024). In comparison, maternal self-employment in own businesses has no negative impact on child nutrition because this mostly happens at home, is therefore not associated with additional commuting time, and offers greater flexibility in terms of women's time management than wage-employment (Debela et al., 2021). To our knowledge, effects of women's off-farm wage- and self-employment on their own dietary quality have not been examined previously.

Taken together, these mechanisms suggest that the relationship between women's participation in off-farm employment and their dietary quality is complex. The net effect depends on which of the three mechanisms is the most dominant in a particular context. While increases in household income and women's decision-making power will generally contribute to enhanced dietary quality, women's time constraints may counteract these benefits. Given the central role of financial constraints for improving dietary quality in rural Africa, we hypothesize that the positive income effect and the empowerment effect from greater decision-making power will dominate the negative labor-substitution effect due to time constraints, such that women's off-farm employment is expected to improve women's dietary quality in the aggregate. This hypothesis will be tested below.

[24] Although market substitutes for household activities performed by women exist (e.g., hiring domestic help), they are often costly and largely inaccessible to women in rural areas (Jakaria et al., 2022).

4.3. Materials and methods

4.3.1. Study area

We collected data for this study through a survey of rural households in Tanzania and Zambia in May and June 2023.[25] In Tanzania, the survey was conducted in Morogoro and Iringa, two neighboring regions in the mid-eastern part of the country. In Zambia, we focused on the Western Province, bordering Angola to the west and Namibia to the south. In all survey regions, agriculture is the main source of livelihoods for rural households, but self-employment in small businesses – such as food processing, retailing, transport, and other services – and wage-employment in agriculture, construction, manufacturing, and the services sector also exist (Mutsami et al., 2025a). Specifically, many individuals in these rural areas take on informal sector activities like selling goods in markets, making handicrafts, or running small businesses such as tailoring or hairdressing. Others engage in informal wage jobs, working as domestic helpers, casual laborers on commercial farms, or in small local enterprises such as shops and food stalls. These jobs often provide low and unstable incomes, with little to no job security or social protection (Nzira et al., 2025). Nonetheless, they remain an important source of livelihood for rural people, especially where formal employment opportunities are scarce.

It should be noted that most of the off-farm activities in these study regions are individually organized (e.g., casual wage work, trading, and small businesses), rather than group-based employment schemes (Mutsami et al., 2025a). Poverty and undernutrition are widespread, and dietary diversity is low (Tanzania National Bureau of Statistics, 2022; Zambia Statistics Agency, 2022). The study regions are not fully representative[26] of rural areas in Tanzania and Zambia, but together provide a range of characteristics typical for many parts of sub-Saharan Africa.

In both Tanzania and Zambia, prevailing gender norms strongly influence the extent to which women can exercise control over income. However, evidence from these and other comparable rural contexts indicates that, when women begin earning their own income through participation in labor markets, their decision-making power over household activities—particularly in areas such as nutrition—tends to increase (Anderson et al., 2017; Doss, 2013;

[25] The study was reviewed and approved by the Ethics Board of the Center for Development Research (ZEF), University of Bonn, Germany. Additional approvals were obtained from the Tanzania Commission for Science and Technology and the University of Zambia.

[26] The regions are somewhat poorer than the rural averages in the two countries. For example, in Zambia, the 2022 poverty statistics show poverty rate of 79% in Western Province, which is higher than the national average of 60% (Zambia Statistics Agency, 2022).

Iversen et al., 2011). At the same time, the degree of autonomy women gain is often mediated by intra-household dynamics and social expectations, suggesting that improvements in women's control over income may vary considerably across households and communities.

4.3.2. Survey of households and individuals

Households to be included in the survey were selected through a two-stage random sampling procedure. First, we randomly selected 60 villages in Tanzania (Morogoro and Iringa) and 30 villages in Zambia, using a probability proportional to size approach. Second, in each village we randomly sampled around 15 households based on full household lists compiled together with the village leaders. Thus, a total of 1307 households were selected for personal interviews, which were conducted in local languages using a structured questionnaire and tablet computers.

The questionnaire had various sections, some focusing on the household in general, and others focusing on individual household members. The general household sections were answered by the household head, who, in most cases, was a male adult. Individual-level sections were administered separately to the main male adult, usually the household head, and the main female adult, usually the head's wife. In some households, only one adult could be interviewed, because a second adult was not available. Here, we only include the 1151 households in which an adult woman could be interviewed. The sample for our analysis includes 773 individual-level women observations in Tanzania and 378 in Zambia.

The household-level questions referred to household size, demographic composition, assets owned, farm production, other economic activities, and a variety of related socioeconomic characteristics. The individual-level questions referred to education, employment, time use, food consumption, and decision-making, among other aspects. Key variables used in the empirical analysis are described in more detail in the following subsections.[27]

4.3.3. Women's dietary quality

Our main outcome variable of interest is women's dietary quality, which we evaluate using women's dietary diversity score (WDDS). WDDS is a widely-used indicator in the nutrition literature that is positively associated with various desirable nutrition outcomes, including

[27] Further details of the household survey questionnaire and data can be accessed at https://doi.org/10.5880/trr228db.26 (Tanzania); https://doi.org/10.5880/trr228db.27 (Zambia).

micronutrient adequacy (Arimond et al., 2010; Haddad et al., 1994; Kassie et al., 2020; Quisumbing et al., 2021).

We calculate WDDS using nine food groups (Kennedy et al., 2011), namely (i) starchy staples; (ii) pulses (beans, peas, and lentils), nuts, and seeds; (iii) milk and milk products; (iv) meat, poultry, and fish; (v) eggs; (vi) dark green leafy vegetables; (vii) other vitamin A-rich fruits and vegetables; (viii) other fruits and vegetables; and (ix) organ meat. Thus, WDDS represents the number of food groups consumed by the adult women during the past 24 hours prior to the interview and, in principle, can take any whole number between 0 and 9. WDDS can also be calculated for longer recall periods, if data are available, but the 24-hour recall is typically preferred due to its higher recall accuracy.

4.3.4. Women's employment

Our primary explanatory variables relate to women's off-farm employment, which we define as any income-generating activity outside the family farm.[28] We use two different variables to evaluate women's off-farm employment. First, we measure participation at the extensive margin with a dummy variable, which equals one if the woman had engaged in any off-farm employment activity during the 12 months prior to the interview, and zero otherwise. Second, to capture the intensive margin, we use the number of hours spent in off-farm activities during the seven days prior to the interview. Both variables have pros and cons. The 12-month window for the extensive margin is suitable to also capture short-term seasonal employment, which is common in rural Africa. Respondents can easily remember whether or not they were employed in past months, but they may not necessarily remember the exact number of hours or days of employment for the entire year. For the past seven days, however, remembering such details is easier, reflecting recent work intensity. Therefore, using both variables we capture various aspects of women's off-farm employment.

In the main analysis, we combine off-farm self-employment and wage-employment in the same dummy and continuous variables. However, as the effects may possibly differ, we also run

[28] Off-farm employment in our context includes both agricultural wage labor on other people's farms and non-agricultural work for pay (e.g., wage work and self-employed activities). Off-farm does not necessarily mean "outside the home," as some off-farm activities (such as home-based petty trade) may still take place within or around the household premises.

additional regressions where we separate these two categories of women's off-farm employment.

4.3.5. Income, decision-making, and time allocation

To better understand the mechanisms linking women's off-farm employment to dietary diversity, we also need to measure household income, women's decision-making, and time allocation. Household income is calculated as the sum of the net income from all economic activities, including farming and off-farm employment, as well as any transfers. Income is measured per capita, by dividing the total income by the number of household members. We convert national currencies to international dollars using purchasing power parity exchange rates from the World Bank's 2017 International Comparison Program.

Women's decision-making is evaluated by examining their involvement in decisions on how the household income from different sources is spent.[29] We consider four income sources, namely income from crops, from livestock, from off-farm employment, and from remittances. For each income source, we define a dummy variable that takes a value of one if the woman is involved in decision-making – either solely or jointly with her partner – and zero otherwise, according to her own responses to the respective survey questions.

Women's time allocation is evaluated based on an individual 24-hour time-use module in the questionnaire. Respondents were asked to report their activities on a typical working day[30], recorded in 30-minute intervals, from 3 a.m. to 2.59 a.m. We categorize these activities into nine groups, namely (i) household chores; (ii) self-care and maintenance; (iii) leisure; (iv) resting and sleeping; (v) cooking; (vi) care work; (vii) farming; (viii) wage-employment; and (ix) self-employment, all measured in hours per day. We apply the same approach to measure time allocation for the household's main male adult. We recognize that individuals may engage in simultaneous activities (for instance, caring for children while undertaking other tasks). In our questionnaire, these were recorded as primary and secondary activities. To ensure that total reported time did not exceed 24 hours (1,440 minutes), we followed the UNSD (2024)

[29] We acknowledge that, as Hillesland et al. (2025) show, traditional decision-making metrics may underestimate certain dimensions of agency, including situations where individuals exert influence indirectly (effective power by proxy or persuasion).

[30] To ensure the data captured routine household, farm, and non-farm activities, "typical" working days excluded special or unusual days, including religious or cultural festivals, market days, weddings, funerals, extreme weather events, or days affected by illness or other emergencies.

approach by applying weights: primary activities were assigned a weight of 0.7, while secondary activities were assigned a weight of 0.3.

4.3.6. Basic regression model

We estimate the effect of women's off-farm employment on women's dietary quality using regression models of the following type:

$$WDDS_{ij} = \beta_0 + \beta_1 E_{ij} + \beta_2' \boldsymbol{M}_{ij} + \beta_3' \boldsymbol{X_{ij}} + \tau_j + \varepsilon_{ij} \quad (4.1)$$

where $WDDS_{ij}$ is the women's dietary diversity score of individual *i* in country *j*. The variable E_{ij} represents off-farm employment of i, which in separate regressions is either a binary variable for the extensive margin or a continuous variable for the intensive margin. $\boldsymbol{M}_{ij}$ is a vector of women's characteristics such as age, marital status, household head status, education, and a dummy variable showing their involvement in own farming activities. Age is included because nutritional needs and work capacity change over the life cycle. Marital status may shape women's responsibilities and decision-making power within the household. Whether a woman is the household head matters, as this often affects her control over resources and autonomy in decisions. Education is considered since it can influence knowledge about nutrition and the ability to access better opportunities. Finally, a dummy variable captures whether the woman engages in own-farm activities, as involvement in farming may directly affect both her workload and food availability.

$\boldsymbol{X_{ij}}$ in equation (4.1) is a vector of household characteristics such as household size, farm size, asset ownership, and participation in employment by household members other than women *i*. Household size is included because larger households may face greater pressure on food resources and women's time. Farm size matters as it reflects the household's agricultural capacity and potential food production. Asset ownership is considered since it indicates wealth and the ability to smooth consumption. Finally, participation in employment by other household members is included because it can supplement household income and shape how women's own earnings translate into nutrition outcomes. Finally, τ_j are country fixed effects, and ε_{ij} is the error term.

Our parameter of main interest in Equation (4.1) is β_1, which is the estimated effect of women's off-farm employment on *WDDS*. A positive β_1 would mean that off-farm employment is associated with enhanced women's dietary quality, as hypothesized.

We estimate the models in Equation (4.1) in linear form. However, as *WDDS* is a count variable, we also use a Poisson specification to check whether the findings change. Furthermore, in addition to combining all types of women's off-farm employment in the variable E_{ij}, we also run regressions where we separate between off-farm self-employment and wage-employment.

In additional model specifications, we use dummy variables for each of the nine food groups instead of *WDDS* as the outcome variable. This is of interest to better understand how exactly women's off-farm employment affects their daily diets. These additional models are estimated with linear probability specifications.

4.3.7. Instrumental variable approach

The estimated parameter β_1 in Equation (4.1) could potentially be biased due to endogeneity stemming from unobserved heterogeneity and/or reverse causality. Even though we control for a wide range of socioeconomic characteristics, women involved in off-farm employment might still be systematically different from those not involved in terms of unobservable characteristics, such as ability, motivation, and attitudes. Reverse causality could also be an issue, especially if better dietary quality increases women's engagement in various economic activities, for instance, due to better health.

To address potential endogeneity bias, we use an instrumental variable (IV) approach. IV methods require at least one exogenous instrument that is sufficiently correlated with women's employment (instrument relevance), but uncorrelated with women's dietary diversity, except through their employment status (instrument exogeneity) (Abadie & Cattaneo, 2018). We use the share of women participating in off-farm employment within a given village (excluding the woman of interest) as our exogenous instrument. This type of instrument has been used in similar studies in other settings (Melaku et al., 2024; Rashad & Sharaf, 2019) because it reflects the local employment environment, which is exogenously determined by local economic conditions and not influenced by the individual household or woman.[31] In our approach, we combine this instrument with constructed instruments, as described by Lewbel (2012), which

[31] In principle, it is possible that households move to a specific location because of favorable employment opportunities, which could mean that our village-level instrument is not fully exogenous. However, in Tanzania and Zambia, households rarely move from one rural place to another, due to land-market restrictions. The right to use certain farmland is inherited, whereas the land is formally owned by the state (Genicot & Hernandez-de-Benito, 2022; Mulungu et al., 2025).

helps increase the efficiency of the IV estimator. In addition, constructed instruments can be useful for testing the validity of exogenous instruments (Baum & Lewbel, 2019), as we elaborate further below.

The choice of our exogenous instrument, the share of women participating in off-farm employment in a village, is supported by the literature, suggesting that individuals' participation in various rural employment activities is influenced by local social networks (Gee et al., 2017). These networks facilitate the flow of information about job opportunities, which likely increases employment participation (Barwick et al., 2023; Merfeld, 2023). We do not expect our instrument to directly influence women's diets, as it is measured at the village level and not the household or individual level. It may be argued that the availability of local employment opportunities is also a proxy of broader economic conditions, which may influence women's diets through various channels, particularly income and wealth. Yet, we control for household wealth (measured by assets) in our regressions, thus mitigating this potential concern.

It could also be argued that off-farm employed women within a village may participate in group employment activities where nutrition and related issues are discussed while working, which could violatae our instrument validity. Studies have shown that participation in such community-based groups, including self-help and savings groups, often promote self-employment by supporting women to start and manage small businesses, which then has positive welfare outcomes such as improved household nutrition (Lukwa et al., 2022; Mutesi et al., 2025; Walton et al., 2014). These groups serve as important platforms for sharing knowledge, building social networks, and empowering women to make better nutrition decisions (Kumar et al., 2024; Mutesi te al., 2025). It is also possible that rural employment schemes may exist in some areas that engage individuals in group-based work settings, where participants may naturally discuss and exchange information on nutrition and related welfare issues. We explore potential violation of the exclusion restriction originating from group membership. In particular, we tested whether our instrument—the proportion of women in off-farm employment—is correlated with the proportion of households holding group memberships within the village. As reported in Table A4.1 in the Appendix, the correlation coefficients are insignificant. We further examined whether the instrument is correlated with village-level averages of other key characteristics, including education, asset ownership, and land size. Again, none of the correlation coefficients are statistically significant (Table A4.1 in the Appendix).

Table A4.2 in the Appendix shows the first-stage IV regressions, which confirm that our village-level instrument is significantly correlated with women's off-farm employment. In addition, falsification tests, which are shown in Table A4.3 in the Appendix, confirm that the outcome variable (WDDS) is not significantly correlated with the village-level share of women involved in off-farm employment.

Combining our exogenous instrument with constructed instruments further helps to test instrument validity. Based on Lewbel's (2012) heteroscedasticity-based identification approach, the instruments are generated by multiplying the residuals from the first stage regression with the selected exogenous variables in their mean-centered form. Using both exogenous and constructed instruments improves estimation efficiency and also allows testing the overidentifying restrictions (Lewbel, 2012). These tests are shown in Table A4.4 in the Appendix. All test results suggest that our instruments are valid.

4.3.8. Robustness checks

We perform three types of robustness checks. First, we acknowledge that certain control variables, such as the employment participation of other household members, may also be endogenous. To address this concern, we conduct a robustness check in which we exclude these potentially endogenous variables from the main regression. This allows us to assess the extent to which their inclusion influences the estimated coefficients and to verify the stability of our main results.

Second, we use methods proposed by Altonji et al. (2005), Oster (2019), and Diegert et al. (2022) to assess the sensitivity of the results to unobservables. Specifically, these tests help us to determine how much stronger the influence of unobservable characteristics would need to be relative to observable factors, in order to yield a coefficient estimate of zero.

Third, we use the kinky least squares (KLS) sensitivity test developed by Kripfganz and Kiviet (2021). This test is instrument-free and involves confining the admissible correlation of the main regressor of interest (women's off-farm employment) with the error term within plausible bounds. The main output from the KLS test is graphical, indicating confidence intervals from both IV and KLS (Kripfganz & Kiviet, 2021). We, therefore, compare both IV and KLS regressions to obtain empirical insights into the plausibility of our identification strategy. If the confidence intervals from the IV regression are wider than those from KLS, the instruments would need to be considered weak.

4.3.9. Exploring potential mechanisms

To analyze potential mechanisms of the effects of women's off-farm employment on dietary quality, we employ regression models similar to those explained in Equation (4.1), but, instead of *WDDS*, we use household income, women's decision-making, and time allocation as dependent variables. The three mechanisms are estimated in separate models, using ordinary least squares (OLS) estimators. We also considered using IV approaches, but identifying valid instruments for all models was challenging. Some potential instruments failed the validity tests for certain outcome variables. With OLS models, more concerns about potential endogeneity remain.

4.4. Results

4.4.1. Descriptive statistics

Table 4.1 presents descriptive statistics of sampled women and their households, for the full sample and differentiated by country. In the pooled sample, only 17% of women consume at least five food groups, which is considered the lower threshold for micronutrient adequacy. In Zambia, WDDS is still much lower on average than in Tanzania. On average, men's dietary diversity scores are lower than women's across the full sample and in both countries.

Off-farm employment is observed for 19% of the women in our sample (22% in Tanzania and 12% in Zambia) (Table 4.1). Self-employed activities are more common than wage-employment. Typical self-employed activities for women in the study regions include food vending, tailoring and weaving, transport services, hairdressing, and beauty services, whereas wage-employment occurs in agriculture (working on other farms), education (teaching), retailing, the hospitality sector, and tourism. There are no women in the sample that are both self-employed and wage-employed simultaneously. Table 4.1 also shows household characteristics.

Table 4.1: Descriptive statistics of women in the sample

	Full sample (N=1151)		Tanzania (N=773)		Zambia (N=378)	
	mean	s.d.	mean	s.d.	mean	s.d.
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Characteristics of women						
Women's dietary diversity score (WDDS)	3.34	1.26	3.76	1.08	2.48	1.17
Consumed at least 5 food groups (0/1)	0.17		0.24		0.06	
Panel B: Men's dietary characteristics						
Men's dietary diversity score	2.60	2.32	2.84	2.26	2.12	2.37
Consumed at least 5 food groups (0/1)	0.17		0.20		0.11	
Panel C: Women's labor characteristics						
Off-farm employed (1/0)	0.19		0.22		0.12	
Self-employed (1/0)	0.15		0.18		0.10	
Wage-employed (1/0)	0.03		0.03		0.02	
Works on own farm (1/0)	0.87		0.87		0.86	
Hours of off-farm employment per week [a]	8.01	20.84	9.44	22.43	5.08	16.77
Hours of self-employment per week [a]	6.93	20.16	8.28	21.80	4.18	15.95
Hours of wage-employment per week [a]	1.07	6.55	1.16	6.86	0.89	5.88
Hours of own farm work per week [a]	49.15	38.72	49.75	35.33	47.93	44.87
Panel D: Other household members' labor characteristics	0.20		0.23		0.15	
Male household members working off-farm (1/0)						
Other women working off-farm (1/0)	0.03		0.03		0.03	
Mean hours of off-farm employment by men [a]	10.44	24.27	12.02	25.89	7.22	20.23
Mean hours of off-farm employment by other women [a]	1.47	8.96	1.53	9.27	1.34	8.28
Men are wage-employed (1/0)	0.07		0.07		0.07	
Men are self-employed (1/0)	0.14		0.17		0.08	
Mean hours of wage-employment by men [a]	3.47	13.78	3.50	14.11	3.39	13.10
Mean hours of self-employment by men [a]	7.24	21.40	8.86	23.33	3.92	16.31
Other women are wage-employed (1/0)	0.01		0.01		0.01	
Other women are self-employed (1/0)	0.02		0.03		0.02	
Mean hours of wage-employment by other women [a]	0.50	5.38	0.45	5.33	0.61	5.48
Mean hours of self-employment by other women [a]	0.97	7.23	1.09	7.65	0.73	6.28
Panel E: Women's characteristics						
Married (1/0)	0.69		0.72		0.63	
Female-headed household (1/0)	0.30		0.28		0.32	
Woman has at least secondary education (1/0)	0.22		0.09		0.49	
Panel F: Household characteristics						
Household size (number)	5.01	2.35	4.64	2.07	5.75	2.69
Number of children	2.79	1.40	2.67	1.26	3.02	1.64
Household assets (index)	4.46	2.45	4.81	2.29	3.73	2.59
Land size (ha)	1.75	1.66	1.39	1.15	2.50	2.21
Observations	1,151		773		378	

Notes: s.d., standard deviation. [a] Only including individuals employed in the respective category.

In Figure 4.1, we compare women with and without off-farm employment in terms of WDDS and the consumption of specific food groups. Figure 4.1a shows that women with off-farm employment have, on average, a higher WDDS than those without. Figure 4.1b further indicates that women with off-farm employment are significantly more likely to consume meat and fish, dark green leafy vegetables, vitamin A-rich fruits and vegetables, and other fruits and vegetables than those without off-farm employment. However, these differences in Figure 4.1 do not control for potential confounding factors, which we do below with our regression models.

(a) Kernel density for women's dietary diversity score (WDDS) (b) Food groups consumed by women

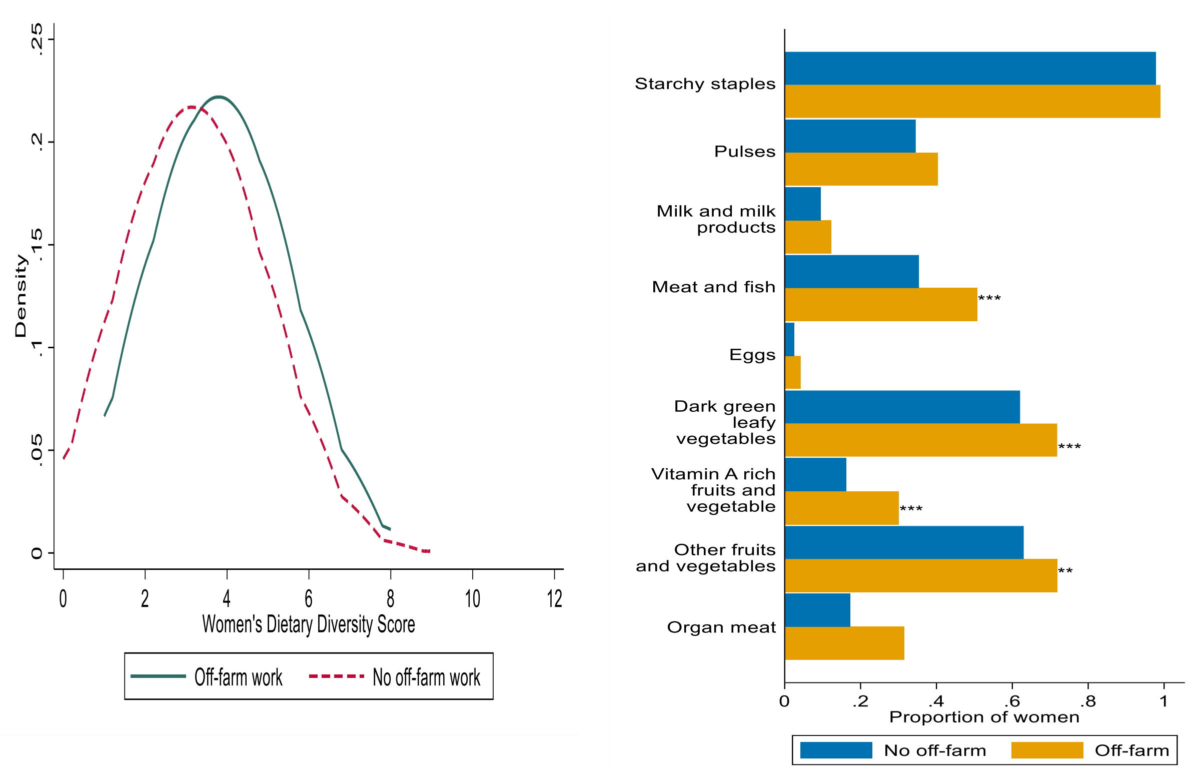

Figure 4.1: Food consumption by women

Notes: Panel (a) refers to distributions of women's dietary diversity scores (WDDS) for women with and without off-farm employment. Panel (b) refers to the proportion of women consuming different food groups. ** denotes significance at 5%, and *** denotes significance at 1% based on two-tailed tests of the proportion differences.

4.4.2. Associations between women's off-farm employment and WDDS

The regression results of the models in Equation (4.1) are shown in Table 4.2. We show results from OLS and IV regressions, which differ somewhat in terms of the magnitude of the estimated coefficients, but both support the same conclusions (Poisson estimates in Table A4.5 in the Appendix also support the same conclusions). Women's participation in off-farm employment is positively and significantly associated with WDDS. Specifically, involvement in off-farm employment (extensive margin, shown in column 2 of Table 4.2) is associated with a 0.25 increase in the daily number of food groups consumed. Relative to a sample mean of 3, this effect represents a more than 8% increase in the number of food groups consumed by women. Similarly, the number of hours worked in off-farm employment during the last seven days are also positively and significantly associated with WDDS (column 4).[32] We express the number of employment hours in terms of logarithms,[33] so the estimates are semi-elasticities, suggesting that the effect on WDDS is non-linear: it is largest for the first hour of off-farm employment and then decreases in absolute terms.

Table 4.2: Associations between women's off-farm employment and women's dietary diversity

	WDDS (OLS) (1)	WDDS (IV) (2)	WDDS (OLS) (3)	WDDS (IV) (4)
Off-farm employed (1 = yes)	0.276***	0.254***		
	(0.099)	(0.093)		
Hours worked in off-farm employment (log)			0.076***	0.067**
			(0.028)	(0.028)
Age of woman (years)	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Female-headed household (1/0)	-0.081	-0.014	-0.071	-0.010
	(0.088)	(0.081)	(0.073)	(0.075)
Woman has at least secondary education (1/0)	0.214**	0.220**	0.189**	0.221**
	(0.093)	(0.097)	(0.094)	(0.10)
Household size (number)	0.039**	0.041**	0.028	0.042**
	(0.018)	(0.016)	(0.017)	(0.017)
Household assets (index)	0.093***	0.092***	0.093***	0.092***
	(0.020)	(0.018)	(0.020)	(0.019)
Land size (ha)	-0.001	-0.005	-0.003	-0.006
	(0.026)	(0.022)	(0.026)	(0.022)
Involved in farming (1/0)	0.133	0.107	0.110	0.107
	(0.116)	(0.111)	(0.120)	(0.105)
Male household members off-farm employed (1/0)	0.006	0.005		
	(0.099)	(0.085)		
Other women working self-employed (1/0)	0.041	0.071		
	(0.181)	(0.211)		
Male hours in off-farm employment (log)			-0.001	0.006
			(0.002)	(0.088)
Other women hours in off-farm employment (log)			-0.004***	0.073
			(0.002)	(0.211)
Country fixed effects	Yes	Yes	Yes	Yes
R^2	0.298	0.298	0.304	0.297
Observations	1,151	1,151	1,151	1,151

Notes: For the OLS models, robust standard errors, for the IV models, bootstrapped standard errors with 500 replications are shown in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

[32] We replicate the analysis for men, mainly the spouse of the woman, in the household. The results, presented in Table A4.6 in the Appendix, indicate that women's off-farm employment is not significantly associated with men's diet diversity scores.

[33] As shown in Figure A4.1 in the Appendix, the number of hours worked by women are highly skewed towards zero. To account for this skewness, we log-transformed the variable in our regressions.

The other estimates in Table 4.2 show that women's education and household wealth (measured in terms of assets) are also positively associated with WDDS, which is unsurprising. Furthermore, after controlling for wealth, household size is correlated with WDDS. This is also plausible, as in larger households the food needs and preferences of more people need to be considered, which may also contribute to higher dietary diversity for individual household members.

In Tables A4.7–A4.11 in the Appendix, we run additional regressions where we separate between women's self-employment and wage-employment. The associations of both types of employment with WDDS are positive and similar in magnitude, but they are statistically significant only for self-employment. This is likely due to the fact that only 2-3% of women in our sample are wage-employed, thus limiting the efficiency of the estimates.

4.4.3. Robustness of the estimates

We conduct three types of robustness checks. First, in our IV approach, we only instrument women's off-farm employment. One may argue that some control variables, such as other household members' participation in employment, could also be endogenous. We explored constructing instruments for these variables, but they did not satisfy the IV assumptions. As a robustness check, we excluded other household members' employment from the regressions; the results remain largely unchanged (see Table A4.12 in the Appendix).

Second, we test the sensitivity of the results to unobservables. Results are shown in Table A4.13 in the Appendix. For the Oster (2019) method, the 'Delta' value for women's off-farm employment is 2.2, which is far above the recommended minimum level of 1 and indicates that the estimates are quite robust to potential omitted variable bias (Ruml & Parlasca, 2022). This conclusion is further corroborated by the Diegert et al. (2022) method, which does not require the assumption that omitted variables are uncorrelated with the included controls (Table A4.13 and Figure A4.2 in the Appendix).

Third, we use the KLS method to compare the findings with the original IV estimates. The results in Figure A4.3 in the Appendix show that the IV estimates have narrow confidence intervals, which suggests that our instruments are not weak, and that the confidence intervals of the KLS and IV approaches overlap, reinforcing the validity of our instruments.

4.4.4. Associations between women’s off-farm employment and specific food group consumption

Results of the IV models showing associations between women’s off-farm employment and women’s consumption of the nine food groups are shown in Table 4.3 (the OLS models lead to similar results and are shown in Table A4.14 in the Appendix). The coefficients for women’s off-farm employment are positive in all nine models and statistically significant for meat and fish and vitamin A-rich fruits and vegetables, both micronutrient-rich food groups. In poor rural households, these food groups are rarely consumed, and if they are consumed, they are often obtained from the market rather than from own production, which was also shown in other parts of Africa (Dzanku et al., 2024; Hülsen et al., 2024). These results further support the hypothesis that women’s off-farm employment contributes to improved dietary quality in the local contexts.

Models with separate results for women’s self-employment and wage-employment are shown in Tables A4.15 and A4.16 in the Appendix. For self-employment, the results are similar to those in Table 4.3. For wage-employment, however, we see a negative association with dark green leafy vegetable consumption. This negative association may possibly be due to time constraints, since dark green leafy vegetables are often home-produced by women and also require processing time (washing, chopping, cooking, etc.). Such activities may decline with women’s off-farm wage-employment. As the number of wage-employed women in our sample is small, this effect should be interpreted with caution. Associations between women’s off-farm employment and time allocation are further examined below.

Table 4.3: Associations between women's off-farm employment and the consumption of various food groups (IV estimates)

	Starchy staples	Pulses	Dairy	Meat and fish	Eggs	Dark green leafy vegetables	Vitamin A-rich fruits and vegetables	Other fruits and vegetables	Organ meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is off-farm employed (1/0)	0.008 (0.008)	0.047 (0.041)	0.003 (0.021)	0.075* (0.039)	0.006 (0.016)	0.012 (0.033)	0.081** (0.035)	0.021 (0.037)	0.001 (0.001)
Age of woman (years)	-0.001 (0.001)	0.001 (0.001)	0.001** (0.021)	-0.001 (0.001)	0.000 (0.000)	0.001 (0.033)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.000)
Female-headed household (1/0)	-0.015 (0.013)	-0.055 (0.038)	-0.006*** (0.023)	-0.047 (0.036)	0.021 (0.014)	0.086*** (0.029)	0.019 (0.028)	-0.011 (0.038)	-0.007 (0.011)
Woman has at least secondary education (1/0)	0.001 (0.002)	0.012* (0.007)	0.013*** (0.005)	-0.004 (0.006)	0.007* (0.004)	0.016*** (0.006)	-0.004 (0.005)	-0.000 (0.006)	-0.000 (0.002)
Household size (number)	0.000 (0.001)	-0.012* (0.006)	0.019*** (0.005)	0.034*** (0.007)	0.007** (0.003)	0.003 (0.005)	0.017*** (0.006)	0.022*** (0.006)	0.002 (0.002)
Household assets (index)	-0.008* (0.005)	0.002 (0.009)	-0.003 (0.007)	0.002 (0.009)	-0.003 (0.004)	-0.000 (0.008)	0.005 (0.006)	0.001 (0.009)	0.000 (0.002)
Land size (ha)	-0.009 (0.011)	0.044 (0.042)	0.019 (0.024)	-0.023 (0.042)	0.001 (0.014)	0.040 (0.034)	-0.017 (0.033)	0.068* (0.039)	-0.016 (0.016)
Involved in farming (1/0)	-0.012 (0.011)	-0.007 (0.037)	0.027 (0.024)	-0.016 (0.039)	0.008 (0.015)	0.019 (0.031)	-0.027 (0.032)	0.005 (0.036)	0.008 (0.010)
Male household members self-employed (1/0)	-0.002 (0.025)	0.001 (0.079)	0.047 (0.063)	0.039 (0.082)	-0.021 (0.023)	-0.027 (0.077)	0.003 (0.071)	-0.002 (0.081)	0.033 (0.034)
Other women are self-employed (1/0)	-0.001 (0.001)	0.001 (0.001)	0.001** (0.021)	-0.001 (0.001)	0.000 (0.000)	0.001 (0.033)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.000)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.050	0.039	0.109	0.092	0.052	0.312	0.093	0.093	0.081
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: Linear probability models with bootstrapped standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

4.4.5. Possible impact mechanisms

We now analyze the three mechanisms that may explain the associations between women's off-farm employment and WDDS, namely changes in household income, women' decision-making, and time allocation.

Household income. Table 4.4 shows results of a model where we regress per capita household income in logarithmic terms on women's off-farm employment while controlling for confounding factors, as explained above. The results reveal that women's off-farm employment is associated with much higher household incomes (more than 80%), suggesting that the income mechanism may play an important role for explaining the observed improvements in women's dietary quality.

Table 4.4: Associations between women's off-farm employment and household income

	Per capita income (log)
Woman is off-farm employed (1/0)	0.838***
	(0.181)
Woman controls	Yes
Household controls	Yes
Country fixed effects	Yes
R-squared	0.393
Observations	1151

Notes: OLS estimates with robust standard errors in parentheses. Full results are presented in Table A4.17. *** denotes significance at 1%.

Women's decision-making. Table 4.5 shows results of models where we regress women's involvement in income spending decisions on women's off-farm employment while controlling for other factors. For all sources of income, the coefficients are positive, but the estimate is only statistically significant for off-farm income. That is, if a woman is herself involved in off-farm employment, she is significantly more likely to be involved in deciding how the off-farm income earned by her and other household members is spent. This result suggests that involvement in off-farm employment may indeed improve women's financial autonomy.

Table 4.5: Associations between women's off-farm employment and control of different types of incomes

	Crop income	Livestock income	Off-farm income	Remittances
	(1)	(2)	(3)	(4)
Woman is off-farm employed (1/0)	0.007	0.011	0.051**	0.007
	(0.032)	(0.035)	(0.028)	(0.028)
Woman controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
R-squared	0.076	0.074	0.071	0.075
Observations	1049	715	1097	1097

Notes: OLS estimates of linear probability models with robust standard errors in parentheses. Income control is measured with a dummy that takes a value of one if the woman is involved in decisions about how the respective income is spent (alone or jointly with her partner), and zero otherwise. Full results are as shown in Table A4.18 in the Appendix. ** denotes significance at 5%.

Women's time allocation. Table 4.6 shows regression results from models with women's time allocation to various daily activities as dependent variables. The results show that women's off-farm employment is negatively associated with women's time spent on household chores, self-care and maintenance, care work, leisure, cooking, as well as resting and sleeping. Women's time is measured in terms of hours per day, meaning that off-farm employment is associated with approximately half an hour less time for household chores and 10 minutes less for cooking, which may possibly reduce dietary quality as a partial effect. Note that the association between women's off-farm employment and time allocated to own farm work is negative but not statistically significant.[34]

Additional descriptive comparisons in Table A4.20 in the Appendix show that households with women in off-farm employment have a somewhat higher farm production diversity than those without, suggesting that food diversity from own production may not be negatively affected through women working off-farm. To better understand possible shifts of tasks within households, it can also be interesting to look at associations between women's off-farm employment and men's

[34] We also performed t-tests and the results in Table A4.19 in the Appendix point in the same direction as the regression statistics and confirm the same pattern of changes.

time allocation to various activities, which we do in Table A4.21 in the Appendix. Women's off-farm employment is associated with significantly less leisure time for men, which is interesting. We also see positive coefficients for men's time spent on household chores and cooking, even though these are not statistically significant.

Table 4.6: Associations between women's off-farm employment and women's time allocation

	Household chores	Self-care and maintenance	Leisure	Resting and sleeping	Cooking	Care work	Own farm work	Self-employment	Wage-employment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is off-farm employed (1/0)	-0.466*** (0.156)	-0.279*** (0.077)	-0.749*** (0.191)	-0.530** (0.231)	-0.191** (0.092)	-0.399*** (0.072)	-0.294 (0.226)	2.224*** (0.227)	0.498*** (0.114)
Woman controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.125	0.142	0.050	0.106	0.132	0.095	0.230	0.233	0.108
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: OLS estimates with robust standard errors in parentheses. Full results are shown in Table A4.22 in the Appendix. ** denotes significance at 5%, and *** denotes significance at 1%.

Our finding that the overall association between women's off-farm employment and WDDS is positive implies that the positive partial effects through gains in household income and women's decision-making are larger than the possible negative partial effects through changes in women's time allocation.

4.5. Conclusion and policy implications

Off-farm employment generates several benefits for rural farm households in Africa. Effects on income, poverty, and other household-level welfare indicators have been analyzed in the existing literature. However, research on the effects of off-farm employment on individual-level wellbeing is much more limited, which may also depend on who in the household actually pursues off-farm employment. In this article, we have examined how women's off-farm employment is associated with women's dietary quality, using primary data from rural regions in Tanzania and Zambia. Developing and estimating an instrumental variable approach, we have found robust evidence that women's participation in off-farm employment is associated with higher women's dietary diversity scores, suggesting improvements in their dietary quality. In particular, women involved in off-farm employment have a significantly higher likelihood of consuming meat, fish, and vitamin A-rich fruits and vegetables than women not involved in off-farm employment.

We have also explored the main mechanisms through which these positive dietary quality effects may occur. Regression models show that women's off-farm employment is associated with much higher per capita household incomes. Higher incomes enable women to purchase and consume healthier diets.

We have also found that women's off-farm employment is associated with higher female financial autonomy, measured in terms of women's involvement in decisions about how the household income is spent. Other research showed that the income spending behavior of men and women is often different and that women have a higher tendency to spend on nutritious foods than men (Ogutu et al., 2020a). More generally, there is ample research suggesting that improvements in women's decision-making power are associated with better diet and nutrition outcomes for women themselves and also for children and other household members (Quisumbing and Doss, 2021).

Next to gains in household income and women's decision-making, a third mechanism that may affect dietary quality are changes in women's time allocation. We have found that women's off-farm employment is negatively associated with their time allocated to food preparation, household chores, and self-care and maintenance. This may negatively affect dietary quality. However, this potential negative partial effect seems to be smaller than the positive partial effects through gains in income and women's decision-making power.

We note that the strengths of such effects depends on the particular context. For instance, using data from rural Tanzania, Debela et al. (2021) showed that women's off-farm wage-employment beyond a certain number of hours per week has negative effects on child nutritional outcomes, suggesting that time constraints for childcare and food preparation may play an important role. Similar negative child nutrition effects of women's off-farm wage-employment were also found by Melaku et al. (2024) in Ethiopia. Child nutrition outcomes are different from women's dietary diversity scores, as child nutritional status also depends on feeding practices and other factors.

Moreover, the effects of women's wage-employment may be different from those of self-employed activities that often happen at home or nearby. Our data suggest that women's self-employment has stronger positive dietary quality effects than women's wage-employment, even though the number of wage-employed women in our sample is small.

Our results are robust to several specifications and robustness checks. Nevertheless, a few limitations deserve to be discussed. First, we use cross-section data, which have their limitations in terms of rigorous causal identification. Hence, our results can only be interpreted in terms of associations. Follow-up research with panel data would be useful to substantiate the findings. Second, our food consumption data were collected at one point in time, using a 24-hour recall, meaning that seasonal differences in diets are not captured. Third, the proportion of women in wage-employment in our sample is small, which is why we combined self-employment and wage-employment for the main analysis. It is a general phenomenon in most parts or rural Africa that wage-employment opportunities are limited, which is especially true for women (Christiaensen & Maertens, 2022; Musungu et al, 2024; Mutsami et al., 2025a).

In spite of these limitations, a few cautious conclusions and policy implications can be drawn from our results. Women's off-farm employment can contribute to improving women's diets, which is an important finding, given that women are often particularly affected by undernutrition and poor dietary quality. The main mechanism is likely gains in household income, even though we also found significant positive associations between women's off-farm employment, financial autonomy, and decision-making power. Hence, policies that enhance women's access to profitable off-farm activities support various sustainable development goals, including poverty reduction, nutrition improvements, and women's empowerment. Such policies could involve targeted skills training, improved access to credit, investments in rural infrastructure (roads, electricity, water, etc.), and the promotion of rural industries that can create new employment opportunities.

In addition to expanding job opportunities, it is essential to address the often-unfair distribution of household labor. Our findings suggest that – while women's off-farm employment reduces their time for household chores and food preparation – these responsibilities are typically not fully taken over by the husband or other household members. Development programs should promote more gender-equitable labor distribution within households and challenge cultural norms that place the burden of domestic work disproportionately on women. This is a process that will take time but could be supported through awareness campaigns, community engagement, and policies that incentivize men's participation in care work and other household tasks. Finally, improving dietary quality for women (and other household members) requires not only additional income through employment but also better food environments that enhance the accessibility and affordability of nutritious foods.

CHAPTER 5

5. Agricultural technology adoption and gendered off-farm employment in Tanzania[35]

Abstract

Agricultural intensification through the adoption of modern farming technologies has been widely promoted to enhance productivity in sub-Saharan Africa. However, relatively few studies have explored how these technologies influence off-farm labor participation, particularly differentiated by men and women. Using nationally representative household survey panel data from Tanzania, we analyze the association between the adoption of complementary agricultural technologies and participation in self-employment and wage work. By employing a multinomial endogenous treatment effects model, our findings indicate that the combined use of improved seeds, fertilizers, and mechanized or animal-traction-based land preparation is positively associated with household participation in self-employment, with the effect being particularly significant for women. In contrast, our findings suggest that male household members primarily reallocate labor toward wage employment, implying gender-differentiated off-farm labor responses. These findings have important policy implications for promoting agricultural technology adoption, facilitating structural transformation, and supporting gender-sensitive labor and income diversification strategies in rural sub-Saharan Africa.

Keywords: Agricultural intensification; Gender; Off-farm employment; Structural transformation

[35] This essay is co-authored with Martin C. Parlasca. I, Chrispinus Mutsami developed the research idea, analyzed and interpreted the data and wrote the essay with support from Martin C. Parlasca.

5.1. Introduction

Off-farm employment has emerged as an important component of rural livelihoods in developing countries, providing households with opportunities to diversify income sources, reduce vulnerability to agricultural shocks, and improve overall welfare (Khan & Morrissey, 2023; Musungu et al., 2024). Population growth, land fragmentation, and changing climate conditions have increased the pressure on traditional farming systems, making non-farm income an essential complement to agricultural earnings (Hazell et al., 2024). At the same time, the adoption of complementary farming technologies—such as improved seeds, inorganic fertilizers, animal traction, and mechanization—has the potential to enhance farm productivity, influence labor allocation decisions, and reshape the dynamics of rural labor markets. Despite the growing policy emphasis on technology adoption as a driver of rural transformation (De Janvry & Sadoulet, 2020; Reardon et al., 2019), relatively little is known about how different combinations of these technologies affect household engagement in off-farm employment, particularly in the context of gendered labor allocation.

Much of the existing empirical literature on the labor implications of agricultural technology adoption in developing countries has focused primarily on its effects on farm labor use. Overall, these studies suggest that technological innovations can both substitute for and complement labor, depending on the nature of the technology. For instance, the adoption of herbicides and genetically engineered crops has been shown to reduce household or hired labor requirements by improving labor productivity and replacing manual tasks (Bustos et al., 2016; Tamru et al., 2017). Other technologies, such as mechanized tillage, can alter labor dynamics across gender lines, disproportionately reducing women’s participation in farm work (Afridi et al., 2023). In contrast, labor-augmenting innovations like greenhouse cultivation are associated with greater labor demand due to their intensive management needs (Stemmler and Meemken, 2023). Moreover, evidence on the joint use of farming technologies, such as agro-chemicals and mechanization, indicates that combined adoption can further raise overall labor productivity (Aihounton & Christiaensen, 2024). While many of these studies show that labor-saving technologies free up family labor, they fail to systematically examine where that labor goes. In other words, far less attention has been paid to the implications of these technologies for labor allocation beyond the farm. The potential reallocation of household labor to off-farm activities—whether through time freed from agricultural tasks or increased liquidity enabling investment in non-farm enterprises—remains relatively understudied.

A few existing studies examining the effects of farm technologies on off-farm employment present mixed findings. For example, evidence from Nigeria and India indicates that the use of tractors and/or combine harvesters leads to a greater reallocation of female labor from farm to non-farm activities compared to male household members (Takeshima, 2024). Similarly, Belton et al. (2025) show that access to combine harvesters through outsourcing services in Myanmar increases household participation in off-farm employment, particularly in self-employment. By contrast, evidence from China suggests that while mechanization does not significantly affect women's participation in self-employment, it does increase the probability of their participation in local non-farm wage employment (Ma et al., 2024). In addition, Ricker-Gilbert (2014) reports that the use of inorganic fertilizers in Malawi is associated with a decline in the number of days allocated to agricultural off-farm employment. Such studies primarily focus on individual technologies and overlook a broader understanding of how bundled technologies collectively influence household off-farm labor allocation. Assessing technology bundles is important because farmers often adopt complementary innovations together—such as agro-chemicals alongside improved seeds and/or mechanization—which can generate synergistic or offsetting effects on labor use. Bundling of agricultural technologies is promoted as one of the ways to increase land and labor productivity (Suri & Udry, 2022; Tabe-Ojong Jr & Geffersa, 2024; Vemireddy & Choudhary, 2021), yet little is known about the effect of such bundled technologies on gendered off-farm labor outcomes.

We address this research gap and therefore contribute to the broader literature on structural transformation by exploring how the use of different combinations of farm technologies by households influence gender-differentiated participation in off-farm employment, specifically wage and self-employment. In doing so, we provide new evidence on the wider off-farm labor market implications of agricultural innovations in rural sub-Saharan Africa. Our analysis advances the understanding of how different levels of agricultural intensification shape the allocation of labor by household individuals away from farming. Understanding gendered patterns in off-farm labor allocation is particularly important, as men and women often face different opportunities and constraints in accessing non-farm work, which can have implications for household income diversification, women's economic empowerment, and rural poverty reduction. The findings from this study offer valuable insights for designing agricultural and labor policies that promote inclusive rural transformation.

The rest of this article is structured as follows. In Section 5.2, we discuss the conceptual framework. In Section 5.3, we discuss survey data and how we measure key variables. We explain the estimation strategy in Section 5.4 before presenting and discussing both descriptive and regression results in Section 5.5. Section 5.6 summarizes and concludes.

5.2. Conceptual framework

In Figure 5.1, we show how the use of farm technologies is conceptually linked to gendered off-farm employment. There is a wide range of studies showing that farm technology adoption decisions are shaped by different household characteristics, including the age, gender, education, and risk preferences of the household head, as well as family size, landholdings, asset ownership, and livestock endowments (Gouse et al., 2016; Sunding & Zilberman, 2001; Suri & Udry, 2022; Vemireddy & Choudhary, 2021). Adoption is also shaped by institutional factors, such as access to credit, insurance, and extension services, which can facilitate or constrain the uptake of new technologies (Lobell et al., 2020; Suri & Udry, 2022).

Adoption of more advanced or complementary technologies can affect off-farm labor allocation through two primary mechanisms. First, labor-saving effects of technologies such as tractors, animal traction, and herbicides may reduce the demand for household labor in farming, thereby freeing up time for members to engage in off-farm work (Aihounton & Christiaensen, 2024; Vemireddy & Choudhary, 2021). Second, higher agricultural productivity associated with the use of improved farming technologies may encourage farmers to commercialize their produce, with the additional income potentially being invested in off-farm enterprises or used to support job search and labor mobility (Aihounton & Christiaensen, 2024).

The effects of farm technologies on labor outcomes may be different for men and women due to gender-specific constraints and opportunities (Vemireddy & Choudhary, 2021). For example, in many rural areas of developing countries, men often have greater mobility and access to wage employment, while women may face more limited access to labor markets due to unpaid household chores, childcare responsibilities or restrictive cultural norms (Mutsami et al., 2025; Pearse &

Connell, 2016). As a result, labor-saving technologies may allow men to move more easily into wage-based off-farm work, while women may redirect freed up time into home-based self-employment or unpaid household work. This distinction is important because wage employment tends to offer higher and more stable earnings but often comes with less flexibility in terms of time and location. In contrast, self-employment—though generally less profitable—provides greater flexibility, allowing women to combine income-generating activities with domestic responsibilities. However, in areas where technology adoption increases agricultural income, women's involvement in off-farm activities may be reduced if they are drawn into more on-farm activities.

Seasonality and regional differences play a key role in shaping both off-farm employment and the adoption of agricultural technologies (De Janvry et al., 2022). Seasonal fluctuations in labor demand on the farm influence the timing and choice of technologies, as households may adopt labor-saving inputs or mechanization during peak periods to manage workload efficiently. In turn, these adoption decisions affect the availability of household members for off-farm employment during slack seasons. Regional variations in climate, infrastructure, and market access further determine which technologies are feasible and the extent to which households can engage in off-farm work (Suri & Udry, 2022).

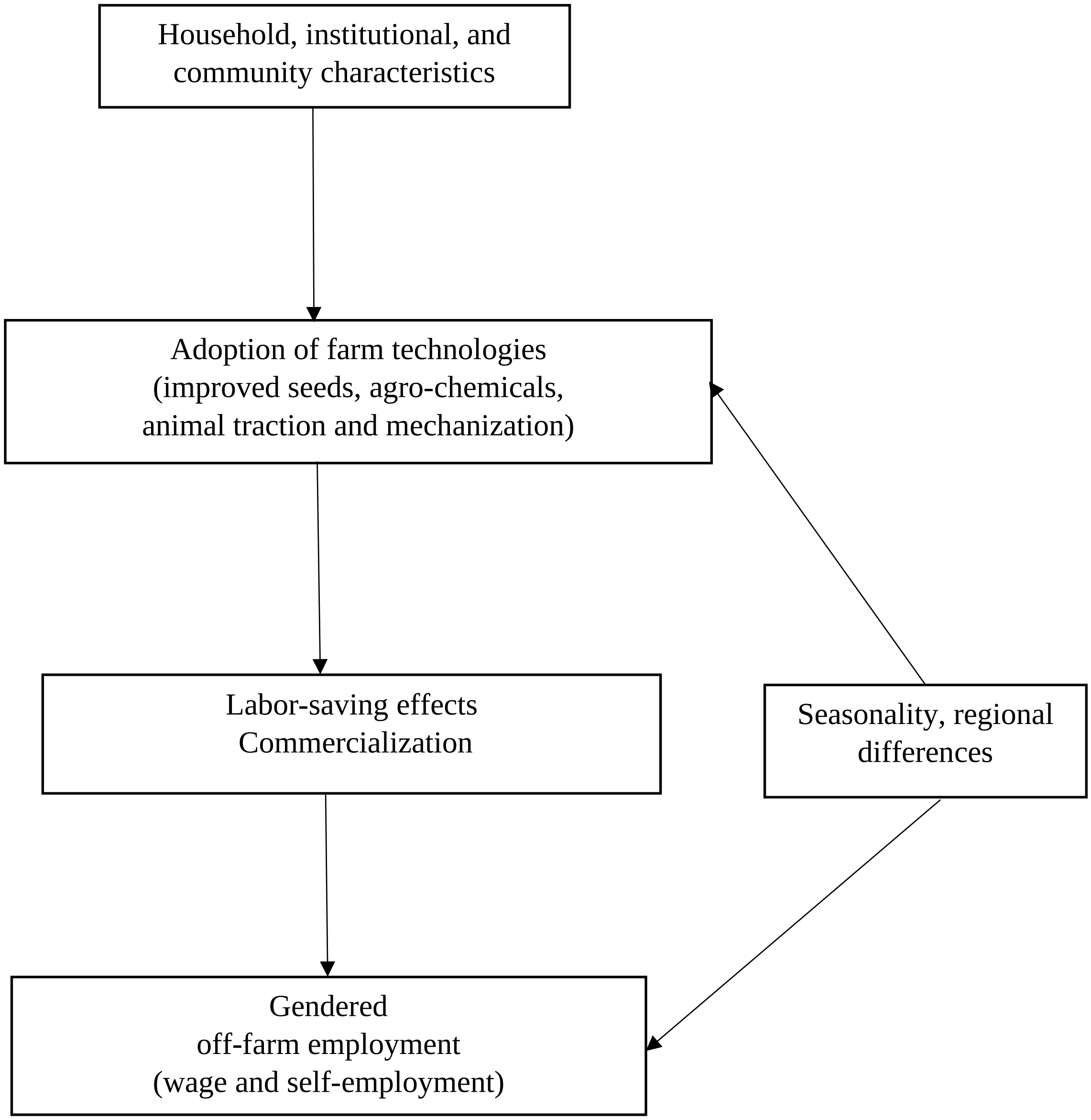

Figure 5.1: Conceptual framework linking farm technology adoption to gendered off-farm employment

Source: Own presentation

5.3. Data and variable measurement

5.3.1. Farm household survey

We use nationally representative panel data from the Tanzanian Living Standards Measurement Study (LSMS), specifically the National Panel Survey (NPS), covering two waves in which households were surveyed in 2014/2015 and 2019/2020.[36] The surveys were jointly implemented by Tanzania's National Bureau of Statistics (NBS) and the World Bank Group. Our analysis focuses on crop farming households, yielding a sample of 1,055 households in 2014/2015 and 1,477 households in 2019/2020, for a total of 2,532 household observations across the two survey rounds.

The datasets from both survey rounds contain detailed information on agricultural production, including the types of crops cultivated and the farming technologies employed, such as the use of fertilizers, improved seeds, animal traction, and tractors. They also include rich demographic and socio-economic data on farmers, such as age, sex, educational attainment, household assets, land size, participation of individual members in both off-farm and on-farm activities, and access to extension and credit services. The definition of each variable is presented in Table A5.1.

5.3.2. Measurement of key variables

We begin by outlining the construction of our key explanatory variables, namely the technologies used by households. The technologies considered in this study include the use of improved seeds, inorganic fertilizers, animal traction, and tractors. To capture the progression and intensification of farmers' technology choices, we follow the approach by Aihounton and Christiaensen (2024) and define six mutually exclusive technology categories.

The first category, referred to as the traditional technology, consists of manual land preparation with no use of productivity-improving inputs, such as inorganic fertilizers or improved seeds. The second category comprises farmers who prepare their land manually and use improved seeds, but do not apply inorganic fertilizers (IS). The third category includes farmers who prepare land manually and use inorganic fertilizers, but not improved seeds (IF). The fourth category captures farmers who prepare land manually and use both improved seeds and inorganic fertilizers (IS+IF). The fifth category represents farmers who prepare land using animal traction in combination with both improved seeds and inorganic fertilizers (IS+IF+AT). The final category includes farmers

[36] The raw datasets can be downloaded from https://microdata.worldbank.org/index.php/catalog/2862 and https://microdata.worldbank.org/index.php/catalog/5639

who prepare land using tractors and apply both improved seeds and inorganic fertilizers (IS+IF+T).[37]

Our main outcome variable is gendered off-farm employment. We measure off-farm employment based on the number of hours an individual reported spending on each activity during the seven days before the survey. The analysis focuses on two main categories of off-farm employment: self-employment and wage employment. Self-employment, for both men and women, is defined as time spent working in a household-owned non-agricultural enterprise. In the Tanzanian context, such enterprises commonly include food vending, retail general shops, grocery selling either in open-air markets or small shops, tailoring and weaving, transport services, hairdressing, and beauty services.

We define wage employment as having been employed at any time during the past week preceding the survey in exchange for remuneration (either in cash or in kind) paid by someone from outside the household. Examples of wage employment activities include work in agriculture (on other farms), construction, health, education (teaching), public administration, retail trade, the hospitality sector, and tourism (Mutsami et al., 2025a). Household employment whether in self-employment or wage employment, is calculated as the total number of hours worked by all men and women in the household in their respective activities.

5.4. Estimation strategy

5.4.1. Multinomial endogenous treatment effect model (METE)

We examine how the adoption of different farm technologies influences gendered off-farm employment within farm households. To address potential selection bias and endogeneity in technology adoption, we employ a multinomial endogenous treatment effects (METE) model, which jointly estimates the technology adoption decision and the labor outcome equation in a simultaneous two-stage framework (Deb & Trivedi, 2006a, 2006b). Since we work with a panel dataset, we integrate the METE framework with the Mundlak–Chamberlain correlated random effects (CRE) approach to account for time-invariant unobserved household characteristics that

[37] Although other combinations exist, such as IS-AT, IF-AT, IS-T, and IF-T, including all possible categories results in model convergence issues. These additional packages were practiced by less than 5% of households and hence they were dropped from the sample.

may be correlated with observed covariates. In this specification, we include household-specific means of time-varying explanatory variables as additional regressors, thereby controlling for unobserved factors, such as risk attitudes, ability, and motivation, that could otherwise bias the estimates (Wooldridge, 2010).

The first stage of METE is estimated using a multinomial logit specification. In this first stage, household i chooses one of the six mutually exclusive farming technology categories. The technology variable is categorical, taking the value 1 for the chosen category and 0 otherwise, where the categories are defined as: traditional technology (j = 0), IS (j = 1), IF (j = 2), IS+IF (j = 3), IS+IF+AT (j = 4), and IS+IF+T (j = 5). Let m denote a vector of binary variables,

$$m = (m_{it1}, m_{it2}, m_{it3}, m_{it4}, m_{it5}) \tag{5.1}$$

representing the set of technologies adopted by household i at time t. The traditional technology, mi0, serves as the base category. The probability of adopting technology j can be expressed as

$$Pr\left(m_{itj} = 1 | z_{it}, I_{itj}\right) = g\left(z_{it}'\alpha_j + \delta_j I_{itj}\right), \quad j = 1,2,3,4,5 \tag{5.2}$$

where z_{it} denotes the vector of exogenous covariates, including instruments, with associated parameters α_j , I_{itj} represents unobserved characteristics common to household i's adoption of the jth alternative and the outcome variable of interest (gendered employment), δ_j are the associated parameters, and $g(\cdot)$ is a function with a multinomial probability distribution.

Following Deb and Trivedi (2006b), we assume that g has a mixed multinomial logit structure, such that,

$$Pr\left(m_{itj} = 1 | \boldsymbol{z}_{it}, I_{itj}\right) = \frac{exp(\boldsymbol{z}_{it}'\alpha_j + \delta_j I_{itj})}{1 + \sum_{k=1}^{5} exp(\boldsymbol{z}_{it}'\alpha_k + \delta_j I_{itk})} \tag{5.3}$$

In the second stage, we estimate the influence of adopting various farm technologies on gendered off-farm employment using ordinary least squares (OLS), incorporating a selectivity correction term from the first stage. The expected outcome equation is given by

$$E\left(y_{it} | m_{itj}, \boldsymbol{X}_{it}, \overline{\boldsymbol{X}}_{it}, I_{it}\right) = \boldsymbol{X}_{it}'\beta + \overline{\boldsymbol{X}}_{it}'\eta + \sum_{j=1}^{5} \gamma_j m_{itj} + \sum_{j=1}^{5} \lambda_j I_{itj}, \tag{5.4}$$

where y_{it} is the outcome variable of interest, such as household, male or female participation in off-farm self-employment and wage employment, for household i at time t. The coefficient γ_j measures the effect of the jth farming technology relative to the base category (traditional technology). The vector $\boldsymbol{X}_{it}$ contains control variables, particularly household characteristics, while $\overline{\boldsymbol{X}}_{it}$ denotes the means of all time-varying variables, following the Mundlak–Chamberlain correlated random effects (CRE) approach. Given that farming in rural areas of many sub-Saharan African countries is highly seasonal (De Janvry et al., 2022), the vector xit also includes the month of the survey to account for seasonal effects.[38] Dummy variables for the different crops produced by the household are included in the estimation. We also include an interaction term consisting of the survey year and the region to capture any region-specific time trends or differential effects over time across regions. This allows us to account for the possibility that changes observed in the outcome variable may vary not only by year but also by geographic location, reflecting heterogeneous regional developments, policies, or external factors that evolve differently over time, such as rainfall, drought, rise or decline of industries in certain regions, and development of various infrastructure projects such as roads, electricity, and water.

The coefficients λ_j capture the relationship between the unobserved characteristics I_{it} and the outcome variable. If $\lambda_j > 0$ ($\lambda_j < 0$), the treatment and outcome are positively (negatively) associated with the unobserved variables, implying positive (negative) selection. Equation (5.4) is estimated using a simulated maximum likelihood approach with 600 Halton sequence-based quasi-random draws per observation.

5.4.2 Identification strategy

Even after controlling for a wide range of observed farm and household characteristics, and applying the Mundlak estimator to account for unobserved heterogeneity in Equation (5.4), the possibility of endogeneity bias cannot be entirely eliminated, particularly that arising from reverse causality. For example, households adopting technologies such as tractors, improved seeds, or inorganic fertilizers may be those whose members are already engaged in off-farm employment. To reduce potential bias from endogeneity, Deb and Trivedi (2006b) recommend the inclusion of

[38] As shown in Table A5.2, household data collection interviews were fairly evenly distributed across the calendar year in both survey rounds.

instrumental variables (IVs). In line with this approach, we include as instruments the proportion of households in the village or enumeration area—excluding the household of interest—that adopt improved seeds, inorganic fertilizers, animal traction, and tractors. These instruments are expected to be correlated with the respective technology adoption but uncorrelated with the unobserved determinants of gendered employment, thus aiding in the identification of the METE model.

The use of the proportion of households that used the farm technologies as instruments is inspired by studies such as Aihounton and Christiaensen (2024), Tabe-Ojong Jr and Geffersa (2024), and Takeshima (2024). We employ these instruments because prior research demonstrates that social networks among farmers in developing countries are an important channel for the diffusion of agricultural technologies, influencing both awareness and uptake (BenYishay & Mobarak, 2019; Tessema et al., 2016). Households are therefore likely to make decisions based on the choices of their neighbors and peers, particularly in regions where formal extension services are poorly developed. By leveraging this insight, our instruments may be strongly correlated with the use of farm technologies. First stage results shown in Table A5.3 confirm that our instruments are significantly correlated with the different technologies, thus satisfying the relevance assumption.

We argue that our instruments are plausibly exogenous[39]—that is, uncorrelated with the error term—because they are constructed at the village level while explicitly excluding the household under study. By aggregating neighbors' technology adoption decisions without including the focal household, we minimize the risk that the instruments capture unobserved household-specific shocks affecting gendered off-farm employment. Following Di Falco et al. (2011), we perform falsification tests and the results confirm that our instruments are not directly correlated with our outcome variables (Table A5.4). Furthermore, the use of panel data allows us to control for time-invariant unobserved heterogeneity through the Mundlak estimator, which helps absorb any residual endogeneity that might otherwise bias the results.

[39] The exogeneity (exclusion restriction) assumption requires that the instrument affects the outcome, gendered off-farm employment, only through its effect on the household's technology adoption. The instrument should not correlate with any unobserved factors that confound the relationship between technology adoption and gendered off-farm employment.

5.5. Results

5.5.1. Descriptive statistics

Table 5.1 shows household socioeconomic characteristics. The results indicate that the average household size is about six members, with roughly one-quarter being female-headed. Household heads are on average 47 years old with low levels of education, though schooling improved slightly between 2014 and 2020. Notably, access to extension services dropped sharply in 2020 compared to 2014, whereas access to credit remained very limited in both periods.

Focusing on the different technologies used by farmers, the results in Figure 5.2 show that relatively low adoption rates of modern farm technologies across households. Use of inorganic fertilizers is limited (18%) but shows an increase from 15% in 2014 to 20% in 2020, while adoption of improved seeds remains moderate (around 47%) with little change over time. Animal traction is used by about one-third of households, with a slight rise in 2020 compared to 2014. Tractor use is the least common but shows notable growth, more than doubling from 5% in 2014 to 11% in 2020.

Table 5.1: Household characteristics

	Full sample	2020	2014
Number of household members	5.66	5.82	5.46
	(3.27)	(3.39)	(3.11)
Female-headed household (1/0)	0.26	0.27	0.26
	(0.44)	(0.44)	(0.44)
Age of household head (years)	47.46	48.14	46.56
	(14.84)	(14.81)	(14.84)
Education of household head (years)	5.33	5.66	4.90
	(3.75)	(3.88)	(3.53)
Land owned (ha)	2.54	2.46	2.64
	(4.68)	(4.34)	(5.09)
Asset value(log)	14.64	14.92	14.27
	(2.02)	(2.01)	(1.98)
Credit access (1/0)	0.02	0.02	0.02
	(0.13)	(0.13)	(0.13)
Extension service access (1/0)	0.32	0.23	0.43
	(0.46)	(0.42)	(0.49)
Livestock ownership (TLU)	1.98	1.81	2.21
	(5.45)	(5.13)	(5.83)
Observations	2,444	1,441	1,003

Notes: This table reports mean values of household socioeconomic characteristics with standard deviations shown in parentheses. TLU refers to tropical livestock units, where we used standard conversion factors based on Storck et al. (1991): camel = 1.25, sheep and goat = 0.13, cow = 1, calf = 0.25, heifer =0.75, donkey = 0.70, and chicken = 0.013, where 1TLU is equivalent to 250 kg live animal weight.

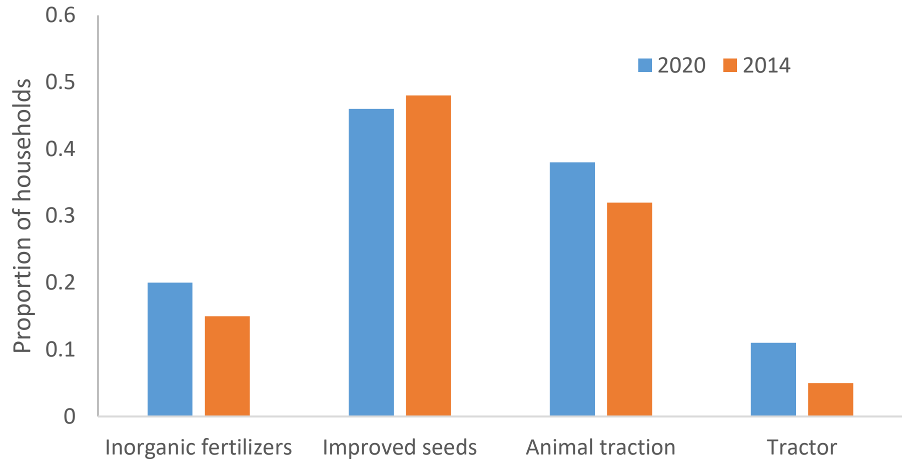

Figure 5.2: Farming technologies

Table 5.2 shows that about one-quarter of households participate in both business and wage work, with slightly higher participation in wage employment. Women's participation in business activities (16%) is comparable to men's (15%), but men participate more in wage work (22%) compared to women (10%). In terms of hours, households spend more time in wage employment (13.4 hours on average) than in business activities (10.5 hours), with men contributing the most of wage hours.

Table 5.2: Household and individual participation in off-farm employment

	Full sample	2020	2014
Panel A: Participation rates			
Household self-employment (1/0)	0.26	0.27	0.25
Women self-employment (1/0)	0.16	0.17	0.16
Men self-employment (1/0)	0.15	0.16	0.14
Household wage work (1/0)	0.28	0.28	0.29
Women wage work (1/0)	0.10	0.09	0.12
Men wage work (1/0)	0.22	0.21	0.22
Panel B: Hours worked			
Household self-employment (hours)	10.54	10.82	10.16
	(22.22)	(22.52)	(21.82)
Women self-employment (hours)	6.15	6.07	6.27
	(17.44)	(17.33)	(17.59)
Men self-employment (hours)	5.87	6.18	5.47
	(18.64)	(19.58)	(17.34)
Household wage work (hours)	13.43	12.87	14.16
	(26.50)	(26.88)	(25.97)
Women wage work (hours)	3.78	3.47	4.19
	(13.32)	(13.22)	(13.44)
Men wage work (hours)	10.66	10.08	11.44
	(24.96)	(24.96)	(24.95)
Observations	2,444	1,441	1,003

Notes: This table reports the means of labor participation for men and women. Standard deviations are shown in parentheses.

Next, we show the number of hours spent in off-farm activities by households adopting different types of technologies. Table 5.3 shows that farmers adopting complementary technologies, particularly those involving mechanization, spend substantially more hours in both business and wage work compared to non-adopters. Women's business work increases notably when multiple farm technologies are used jointly, particularly in households that use mechanical or animal traction for land preparation and use improved seeds and fertilizers. Wage work hours also rise with technology adoption, with men showing the largest gains, especially under joint use of improved seeds, inorganic fertilizers, and tractor (IS+IF+T). It is important to note that these are descriptive patterns, and we do not control for potential confounding factors at this stage; such controls are introduced in the regression results presented in Section 5.5.2.

Table 5.3: Agricultural technologies and off-farm employment

	Full sample	No technology	IS	IF	IS+IF	IS+IF+AT	IS+IF+T
Household self-employment	10.54	9.03	10.05	12.65	13.37	15.43	17.53
(hours)	(22.22)	(20.49)	(22.72)	(24.36)	(24.09)	(24.27)	(25.70)
Women self-employment	6.15	5.50	4.96	6.21	4.03	11.97	12.79
(hours)	(17.44)	(15.86)	(14.90)	(17.21)	(11.83)	(23.03)	(23.15)
Men self-employment	5.87	5.26	4.38	6.18	6.90	7.86	11.68
(hours)	(18.64)	(17.70)	(12.12)	(19.12)	(20.31)	(18.74)	(30.81)
Household wage work	13.43	13.55	12.24	17.62	6.52	20.86	25.60
(hours)	(26.50)	(28.17)	(24.11)	(26.56)	(15.64)	(28.15)	(30.79)
Women wage work (hours)	3.78	3.83	3.06	4.47	2.82	5.73	7.41
	(13.32)	(14.64)	(11.77)	(13.54)	(11.68)	(14.66)	(16.89)
Men wage work (hours)	10.66	11.07	5.02	13.20	8.41	13.11	21.10
	(24.96)	(26.79)	(12.79)	(24.69)	(19.83)	(23.60)	(29.16)
Observations	2,444	1,076	242	374	291	307	154

Notes: This table reports labor and employment activities for households and individuals using different technologies. No technology refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). The technologies are measured as dummy variables with 1 = Yes and 0 otherwise.

5.5.2. Regression results

We present regression estimates of the association between agricultural technologies and gendered off-farm employment in Table 5.4. The results show that the individual adoption of improved seeds (IS) or inorganic fertilizer (IF) is associated with a significant reduction in women's self-employment hours, whereas the combined use of these inputs (IS+IF) is associated with a reversal of this pattern. Specifically, compared to the traditional package, the combined use of IS and IF is associated with a 3.1-hour increase in the number of hours women allocate to self-employment activities. This finding suggests that complementarities between the two inputs may enhance farm productivity and generate marketable surpluses, thereby enabling women to engage more actively in self-employment, as income from sales can be invested in off-farm enterprises. Table A5.5 supports this finding by showing that the level of commercialization under IS+IF is statistically higher than when no output-enhancing inputs are used. In addition, previous studies suggest that the joint use of improved seeds and fertilizers is linked to increased agricultural productivity and commercialization (Amankwah & Gwatidzo, 2024; Tabe-Ojong Jr & Geffersa, 2024), resulting in improved incomes that can be invested in non-farm enterprises by households. Furthermore, the combined use of IS and IF is associated with a reduction in the number of hours women work on the farm, potentially freeing time for off-farm self-employment activities, as shown in Table A5.6 in the Online Appendix.

Table 5.4: Effect of technologies on gendered off-farm employment

	HH self-employment (1)	Women self-employment (2)	Men self-employment (3)	HH wage work (4)	Women wage work (5)	Men wage work (6)
IS	-4.304	-3.619**	-1.624	-1.805	-1.644	0.252
	(3.402)	(1.549)	(1.207)	(2.261)	(4.27)	(1.902)
IF	-4.398	-4.124***	0.218	-4.941**	-2.004*	-3.730
	(2.237)	(1.769)	(1.352)	(2.391)	(1.40)	(2.351)
IS+IF	3.268	3.078**	0.129	3.004	1.117	2.907
	(2.177)	(1.341)	(1.501)	(1.126)	(1.132)	(3.062)
IS+IF+AT	4.049	3.615***	1.096	4.974*	1.293	4.692*
	(2.580)	(1.808)	(1.665)	(2.379)	(1.92)	(1.957)
IS+IF+T	8.399*	5.763**	4.743*	8.708***	2.293	7.756***
	(3.026)	(2.348)	(2.635)	(3.130)	(1.921)	(3.039)
Household controls	Yes	Yes	Yes	Yes	Yes	Yes
Mundlak controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-region interaction	Yes	Yes	Yes	Yes	Yes	Yes
Survey month	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2444	2444	2444	2444	2444	2444

Notes: This table shows the coefficient estimates of the second stage of Multinomial Endogenous Treatment Effect (METE) regressions with the Mundlak approach, and robust standard errors clustered at the household level are in parentheses. Employment is measured by the hours worked in the last week before the survey. No technology is the base category, which refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). The control variables include household size, the sex and age of the household head, the household head's education level, total land size, asset and livestock ownership, access to extension services and credit, main crops produced, and the interaction term between year and region. The full results are presented in Table A5.8. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

The use of animal traction or tractors, in combination with improved seeds and chemical fertilizers, is positively associated with the number of hours women allocate to self-employment. This finding suggests that mechanized or semi-mechanized land preparation may reduce the time rural women allocate to agricultural production (as confirmed in Table A5.6), thereby allowing them to participate in off-farm employment activities. In addition, the joint use of these technologies together with output-enhancing inputs such as improved seeds and inorganic fertilizers may lead to improved productivity, which in turn promotes commercialization—as confirmed in Table A5.5—thereby increasing household income that can be reinvested in non-farm enterprises.

The results in Columns 2 and 5 of Table 5.4 indicate a negative and statistically significant association between the use of inorganic fertilizers and manual land preparation and household participation in wage employment, with the effect being particularly pronounced for women. Specifically, women in households adopting inorganic fertilizers allocate fewer hours to wage work, suggesting that the labor demands associated with manual land preparation may reduce their availability for off-farm wage activities.

The adoption of improved seeds and chemical fertilizers, when combined with land preparation using animal traction and/or tractors, is positively associated with increased household hours devoted to wage employment. This relationship is mainly observed in men, as no significant association is observed in women's wage work hours. The absence of a significant positive relationship among women may reflect their low participation in wage labor activities as observed in Table 5.2, which could be explained by the limited availability of off-farm wage opportunities for women in many rural areas in sub-Saharan Africa (Mutsami et al., 2025a; Van den Broeck & Kilic, 2019).

One potential concern is how labor saved during land preparation could lead household members to engage in off-farm activities, given that other tasks, such as weeding and harvesting, still require substantial labor. To explore this issue, we examine the association between agricultural technologies and hired labor through a regression analysis (see results in Table A5.7). The findings indicate that the use of improved seeds, inorganic fertilizers, and animal traction or tractors is positively associated with the hiring of labor in terms of person-days per hectare. This suggests that households may reallocate their saved labor towards non-farm enterprises or wage employment, while hiring additional workers to manage farm tasks. Notably, the number of person-days saved (Table A5.6) exceeds the number of person-days hired (Table A5.7), showing a net labor-saving effect that allows households to diversify their income sources by participating in off-farm activities while maintaining or even increasing agricultural production. In addition, evidence suggests that mechanized or semi-mechanized land preparation not only reduces the time and effort required for initial cultivation but also makes subsequent tasks, such as weeding, easier and less labor-intensive (Aihounton & Christiaensen, 2024; Daum et al., 2021). This reduction in drudgery can lower the overall workload of household members, particularly women who often bear a disproportionate share of weeding responsibilities, thereby freeing up time for engagement in other productive activities.

5.6 Conclusions

The adoption of agricultural technologies is promoted as important for improving food security and rural livelihoods in sub-Saharan Africa. However, relatively few studies have explored how agricultural intensification influences gendered participation in off-farm employment, which is increasingly recognized as an important component of income diversification in the region. We aimed to fill this research gap by assessing the link between agricultural technologies and household and individual off-farm employment. We used a nationally representative panel dataset from Tanzania.

Using a multinomial endogenous treatment effect (METE) model, our results indicate that the use of complementary technologies—such as improved seeds and inorganic fertilizers—together with mechanization or animal traction for land preparation is associated with an increase in household participation in self-employment activities, with this relationship being particularly significant for women. Our mechanism analysis suggests that this relationship may be driven by time saved from farming tasks, which enables women to engage more actively in non-farm enterprises. Furthermore, the analysis indicates that the use of such technologies is positively associated with the commercialization of farm output, which suggests that the income earned provide additional resources that can be reinvested in non-farm self-employment activities, especially by women.

Another interesting finding is that the combined use of improved seeds, inorganic fertilizers, and mechanized land preparation is associated with an increase in the number of hours households spend in wage employment. However, this relationship is only observed among male members. Hence, the use of such technologies seems to lead to a reallocation of men’s labor to off-farm activities, while women’s participation in wage employment remains largely unaffected. This observation suggests that the labor-saving effects of mechanized or semi-mechanized land preparation primarily free up men’s time for nonfarm wage work, whereas women may continue to allocate their time to self-employment or household enterprises. This finding reflects the limited availability of wage employment opportunities for women in rural areas in African, which may prevent their participation in such jobs.

Two policy implications emerge from our findings. First, the combined use of output-enhancing inputs, such as improved seeds and inorganic fertilizers, together with mechanized or semi-mechanized land preparation, can facilitate structural transformation by releasing labor for off-farm activities. Given the relatively low adoption of these technologies in many African countries (De Janvry & Sadoulet, 2020; Sheahan & Barrett, 2017), sustained efforts are needed to promote their uptake, including strengthening local seed systems, improving rural infrastructure, and expanding access to credit, extension, and insurance services. Second, our results also suggest a gender-differentiated relationship between the adoption of combined technologies and off-farm employment. Specifically, men tend to reallocate labor toward wage employment, whereas women are more likely to engage in self-employment activities. This finding underscores the need for gender-sensitive policies that support both women and men access off-farm wage and self-employment opportunities, including targeted training, financial services, market linkages, development of infrastructure (such as industries, roads, electricity, and water) to ensure that technological adoption benefits all household members equitably.

There is room for future research to build on the data and evidence generated here to expand the understanding of the linkages between agricultural intensification and household off-farm employment outcomes. Although we account for seasonal variation by including the survey month as a control in our estimations, future research could more explicitly capture seasonality by conducting repeated surveys across all seasons or months for the same households and individuals. Such an approach would provide a more precise understanding of how labor allocation and technology adoption fluctuate throughout the agricultural calendar, enabling stronger inferences on seasonal labor reallocation and off-farm engagement.

CHAPTER 6

6. Conclusion and policy recommendations

6.1. Main findings

We have examined the role of various income sources for households and individuals in sub-Saharan Africa. We have also explored how women's participation in off-farm employment influences both household and individual nutritional outcomes. We have also assessed potential mechanisms such as household income, women's decision-making, and time allocation. Lastly, we have investigated how the adoption of complementary agricultural technologies influences gendered off-farm employment outcomes.

In the first essay (Chapter 2), using recent primary survey data from four African countries, Kenya, Namibia, Tanzania and Zambia, we analyzed the role of various income sources for households and individuals. Although most rural households are involved in small-scale farming, we challenged the conventional notion that own agricultural activities still constitute the main source of income. On average, off-farm sources—including wage employment, self-employment, remittances, and transfers—account for 60% of total household income. The off-farm income share increases with total income, meaning that the poorest households are the ones most dependent on agriculture. These patterns are similar across all four countries. Most off-farm employment involves self-employed activities in small informal businesses. More lucrative formal employment opportunities are rare and mostly pursued by individuals with post-secondary education and training. Men are more likely to be involved in wage employment than women. Furthermore, individual social networks and access to road and market infrastructure are positively associated with off-farm employment.

The second essay (Chapter 3) investigated the link between women's off-farm employment and household dietary quality in Malawi, using a ten-year panel dataset. Employing fixed effects regression approach, we found that women's participation in off-farm work, especially in self-employment and wage employment, is positively associated with household consumption of calories and key micronutrients, including vitamin A, iron, and zinc. In contrast, casual labor showed no significant dietary effects. Our pathway analyses suggested that increased income from off-farm employment enhances consumption of calories and micronutrients from purchased foods, while reliance on own-produced food declines.

In the third essay (Chapter 4), we used survey data collected from a sample of households in Tanzania and Zambia to examine how women's off-farm employment influences their individual-level dietary quality. Regression estimates with instrumental variables showed that women's off-farm employment is associated with improved dietary diversity, including more frequent consumption of nutritious foods such as meat, fish, fruits, and vegetables. We also explored the main mechanisms through which these positive dietary quality effects may occur. Regression models showed that women's off-farm employment is associated with much higher per capita household incomes. Higher incomes enable women to purchase and consume healthier diets. We also found that women's off-farm employment is associated with higher female financial autonomy, measured in terms of women's involvement in decisions about how the household income is spent. We also observed that women's off-farm employment is negatively associated with their time allocated to food preparation, household chores, and self-care and maintenance. This may negatively affect dietary quality. However, this potential negative partial effect seems to be smaller than the positive partial effects through gains in income and women's decision-making power.

Finally, the fourth essay (Chapter 5) assessed the link between agricultural technologies and household and individual off-farm employment using a nationally representative panel dataset from Tanzania. Our results indicated that the use of complementary technologies, such as improved seeds and inorganic fertilizers, together with mechanization or animal traction for land preparation is associated with an increase in household participation in self-employment activities, with the effect being particularly significant for women. In contrast, our findings suggested that male household members primarily reallocate labor toward wage employment, implying gender-differentiated off-farm labor responses.

6.2. Policy implications

It is evident from the first essay that off-farm income sources are important for rural households and should be considered more explicitly in the formulation of rural development policies. One key policy recommendation is that more rural job opportunities need to be created, as most employment types currently observed are small-scale, informal, and not very lucrative. This will require larger public and private investments in rural infrastructure, including roads, electricity, water, and network connections. Better off-farm employment opportunities can reduce households' vulnerability to climate change and can also help to reduce poverty, as households with larger off-farm income shares are typically less poor. Another important policy implication is to improve rural education and vocational training to facilitate people's access to higher-paying jobs. While agriculture remains important, fair employment in various other sectors needs to increase for sustainable rural development.

We find that women's off-farm employment can contribute to improving household and women's dietary quality. The main mechanism is likely gains in household income, even though we also found a significant positive association between women's off-farm employment, financial autonomy, and decision-making power. Therefore, policies that improve women's access to profitable and decent off-farm activities are essential, as they contribute to several sustainable development goals, including poverty reduction, better nutrition, and women's empowerment. Such policies could involve targeted skills training, improved access to credit, investments in rural infrastructure (roads, electricity, water, etc.), and the promotion of rural industries that can create new employment opportunities.

It is important to note that the reallocation of women's time toward off-farm activities may also potentially lead to negative dietary and nutritional outcomes, depending on the context. Such potential trade-offs highlight the need for carefully designed policy interventions that support women's economic participation without compromising household well-being. For instance, it is essential to address the often-unfair distribution of household labor. Our findings suggest that, while women's off-farm employment reduces their time for household chores and food preparation, these responsibilities are typically not fully taken over by the husband or other household members. Development programs should promote more gender-equitable labor distribution within households and challenge cultural norms that place the burden of domestic work disproportionately on women.

Since income from employment is a key factor in improved dietary outcomes, ensuring the availability and affordability of diverse, nutritious foods in rural markets is important. Investments in infrastructure, market linkages, and value chains for nutrient-rich foods can help households translate income gains into better nutrition.

Finally, our results suggest that the combined use of output-enhancing inputs, such as improved seeds and inorganic fertilizers, together with mechanized or semi-mechanized land preparation, can facilitate structural transformation by releasing labor for off-farm activities. Given the relatively low adoption of these technologies in many African countries, policies are needed to promote their uptake, including improving rural infrastructure, expanding access to credit, extension, and insurance services. Our results also suggest a gender-differentiated relationship between the adoption of combined technologies and off-farm employment. Specifically, men reallocate labor toward wage employment, while women engage in self-employment activities. This finding underscores the need for gender-sensitive policies that support both women and men access off-farm wage and self-employment opportunities, including targeted training, financial services, market linkages, development of infrastructure (such as industries, roads, electricity, and water) to ensure that technological adoption benefits all household members equitably.

6.3. Limitations of the study and future research

We would like to highlight a few limitations of our study. First, our first (Chapter 2) and third (Chapter 4) essays use cross-sectional data, which restricts our ability to analyze income dynamics and also draw causal inferences. While these analyses reveal important findings, they do not capture changes over time. In addition, our study regions in these essays are not fully representative of the study countries. For instance, the study regions are somewhat poorer than the national rural averages. Future research employing nationally representative longitudinal or panel data could provide stronger evidence on causal relationships.

Second, although our second essay (Chapter 3) focuses on household food consumption and the third essay (Chapter 4) centers on women, our analysis does not capture the food consumption patterns of all individual household members. Future research could explore how women's employment affects individual food consumption by age and gender, offering more nuanced insights into intra-household food allocation and nutritional outcomes.

Third, our analysis in the fourth essay (Chapter 5) does not fully capture seasonality. The lack of detailed seasonal information may bias our results, since both agricultural technology use and labor allocation often fluctuate with the agricultural calendar. Although we account for seasonal variation by including the survey month as a control in our estimations, future research could more explicitly capture seasonality by conducting repeated surveys across all seasons or months for the same households and individuals.

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Appendices

Chapter 2 Appendices

Table A2.1: Description of employment sectors

Sector	Description and examples
Agriculture	Crop and animal production, hunting and related service activities, Support activities to agriculture
Retail business	Retail sale of food, household equipment, textiles, hardware, stationary materials; sale of second-hand goods; buying of agricultural produce from farmers with the aim of selling to consumers. Retail trade can be in specialized or non-specialized shops, stalls or open-air markets
Health	Doctors, dentists, nurses, pharmacists, veterinarians, medical assistants, dental hygienists, lab technicians, medical sales professionals
Education	Pre-primary and primary education; Secondary education; Technical and vocational secondary education; Higher education; Cultural education; Educational support services
Other public	Individuals employed at central, state and local levels of government
Construction	Construction of buildings such as houses, malls; civil engineering – construction of roads and railways; specialized construction activities such demolitions, site preparation, electrical, plumbing and other construction installation activities; building completion and finishing activities.
Beauty	Hairdressing and other beauty treatment
Transport	Passenger road transport, transport of cargo or agricultural produce from one place to another; warehousing and support activities for transportation; postal and courier activities
House work	Activities of households as employers of domestic personnel
Fishing	Marine, lake or lake fishing; aquaculture (pond fishing)
Forest	Logging, Gathering of non-wood forest products, Support services to forestry
Hospitality	Short term accommodation activities; camping grounds; event catering and other service activities
Tourism	Activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure like watching wildlife visiting historical sites
Other	Religion-related activities like working as a priest and related activities; Funeral and related activities

Table A2.2: Definition of key variables

Variable	Definition
Socioeconomic characteristics	
Age	Age of a household member in years
Male	=1 if a household member is male, 0 otherwise
Married	=1 if a household member is married, 0 otherwise
Primary education	=1 if a household member has completed primary education, 0 otherwise
Secondary education	=1 if a household member has completed secondary education, 0 otherwise
Household size	Total number of household members
Asset ownership	Asset index of a household calculated using principal components analysis
Electricity access	=1 if a household has access to electricity, 0 otherwise
Time to nearest road	Time (in minutes) taken by individuals from homesteads to the nearest proper road
Time to nearest market	Time (in hours) taken by individuals from homesteads to the nearest market serving about 250,000 people.
Group membership	=1 if any household member belongs to any voluntary association in the village
Shock -illness/death	=1 if a household member was ill or died in the last 12 months, 0 otherwise
Employment characteristics	
Self-employment	=1 if a household member is self-employed, 0 otherwise
Wage employment	=1 if a household member is wage employed, 0 otherwise
Cash crop production	=1 if a household member practices cash crop farming, 0 otherwise
Food crop production	=1 if a household member practices food crop farming, 0 otherwise
Livestock production	=1 if a household member practices livestock farming, 0 otherwise

Table A2.3: Socioeconomic characteristics of individuals

	All	Kenya	Namibia	Tanzania	Zambia
	(1)	(2)	(3)	(4)	(5)
Age (years)	40.341	37.583	40.700	42.371	40.229
	(18.078)	(17.021)	(18.369)	(17.736)	(19.228)
Male (dummy)	0.463	0.478	0.437	0.465	0.473
	(0.499)	(0.500)	(0.496)	(0.499)	(0.499)
Married (dummy)	0.532	0.568	0.432	0.598	0.512
	(0.499)	(0.496)	(0.496)	(0.490)	(0.500)
Primary education (dummy)	0.367	0.273	0.185	0.671	0.238
	(0.482)	(0.445)	(0.388)	(0.470)	(0.426)
Secondary education (dummy)	0.388	0.239	0.641	0.177	0.601
	(0.487)	(0.426)	(0.480)	(0.382)	(0.490)
Tertiary education (dummy)	0.054	0.103	0.069	0.020	0.023
	(0.227)	(0.304)	(0.253)	(0.139)	(0.151)
Household size (number)	5.198	5.890	5.061	4.505	5.666
	(2.488)	(2.634)	(2.375)	(2.119)	(2.696)
Asset index (index)	4.127	2.688	5.049	4.800	3.725
	(2.639)	(2.292)	(2.697)	(2.308)	(2.629)
Land size (ha)	1.689	0.522	2.730	1.421	2.544
	(2.234)	(0.623)	(3.409)	(1.175)	(2.246)
Illness/death (dummy)	0.332	0.195	0.410	0.308	0.487
	(0.471)	(0.396)	(0.492)	(0.462)	(0.500)
Group membership (dummy)	0.140	0.080	0.037	0.297	0.080
	(0.347)	(0.271)	(0.188)	(0.457)	(0.272)
Time to nearest road (minutes)	4.980	3.185	8.157	6.003	5.582
	(6.170)	(2.413)	(30.534)	(8.319)	(7.582)
Time to nearest market (minutes)	9.495	5.638	11.252	9.942	12.358
	(3.187)	(1.959)	(1.837)	(2.335)	(1.446)
N	6,722	1,717	1,765	2,086	1,154

Notes: Means are shown with standard deviations in parentheses.

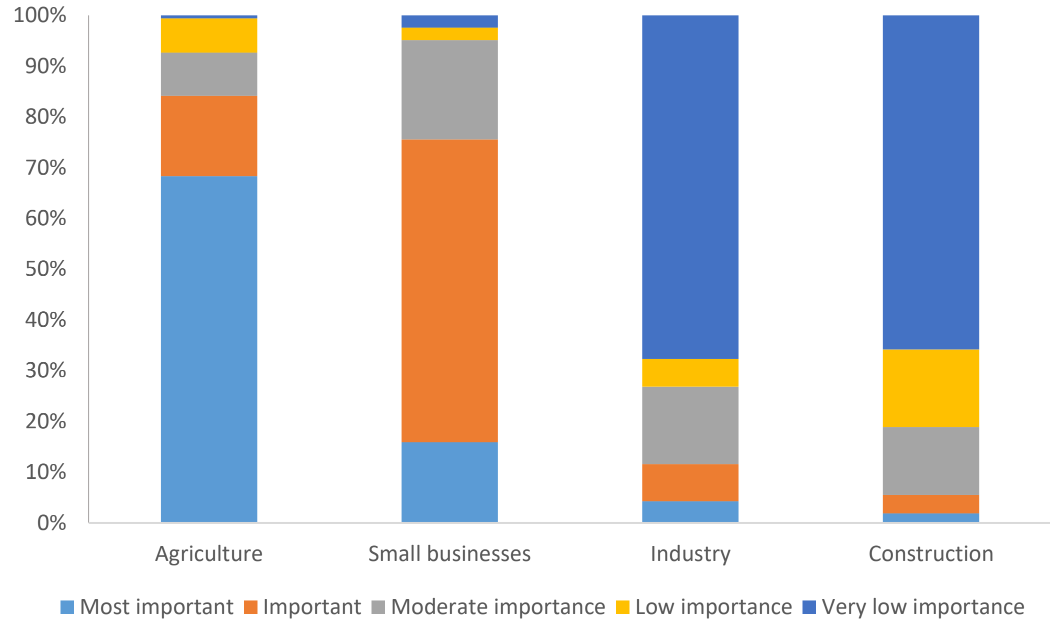


Figure A2.1: Ranking of the most important economic activities in the villages by village leaders (pooled sample, N=164)

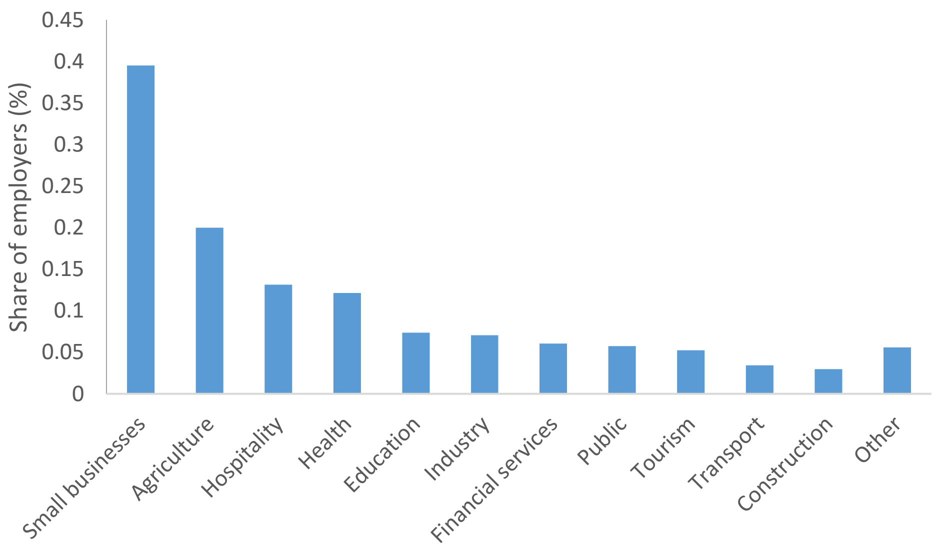


Figure A2.2: Proportion of rural employers in different sectors (pooled sample, N=610)

Notes*: A further breakdown by country is shown in Figure A2.3. Small businesses include small-scale activities in trading, artisanal crafts, and selling of forest products such as charcoal and timber.*

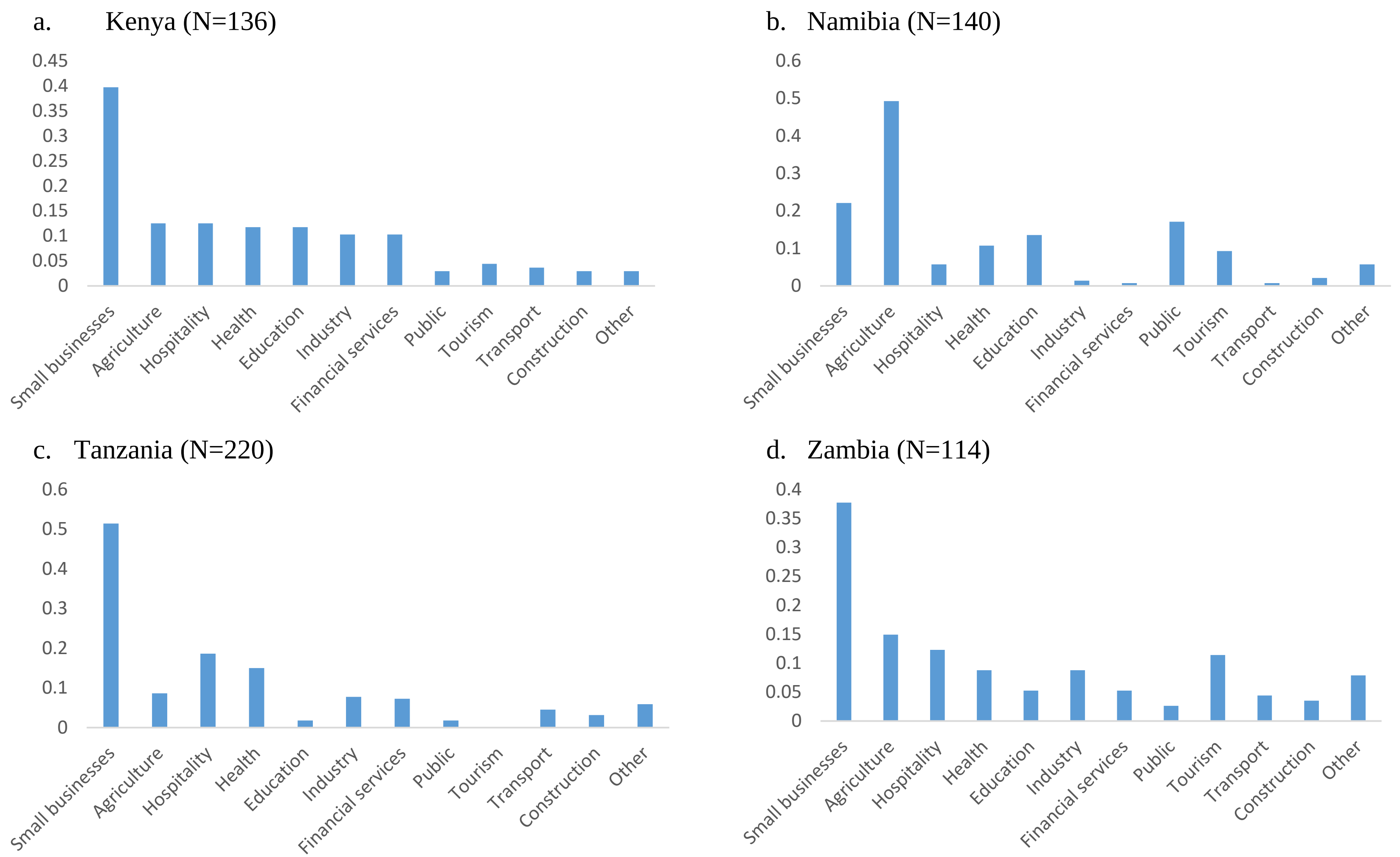


Figure A2.3: Proportion of rural employers in different sectors (by country)

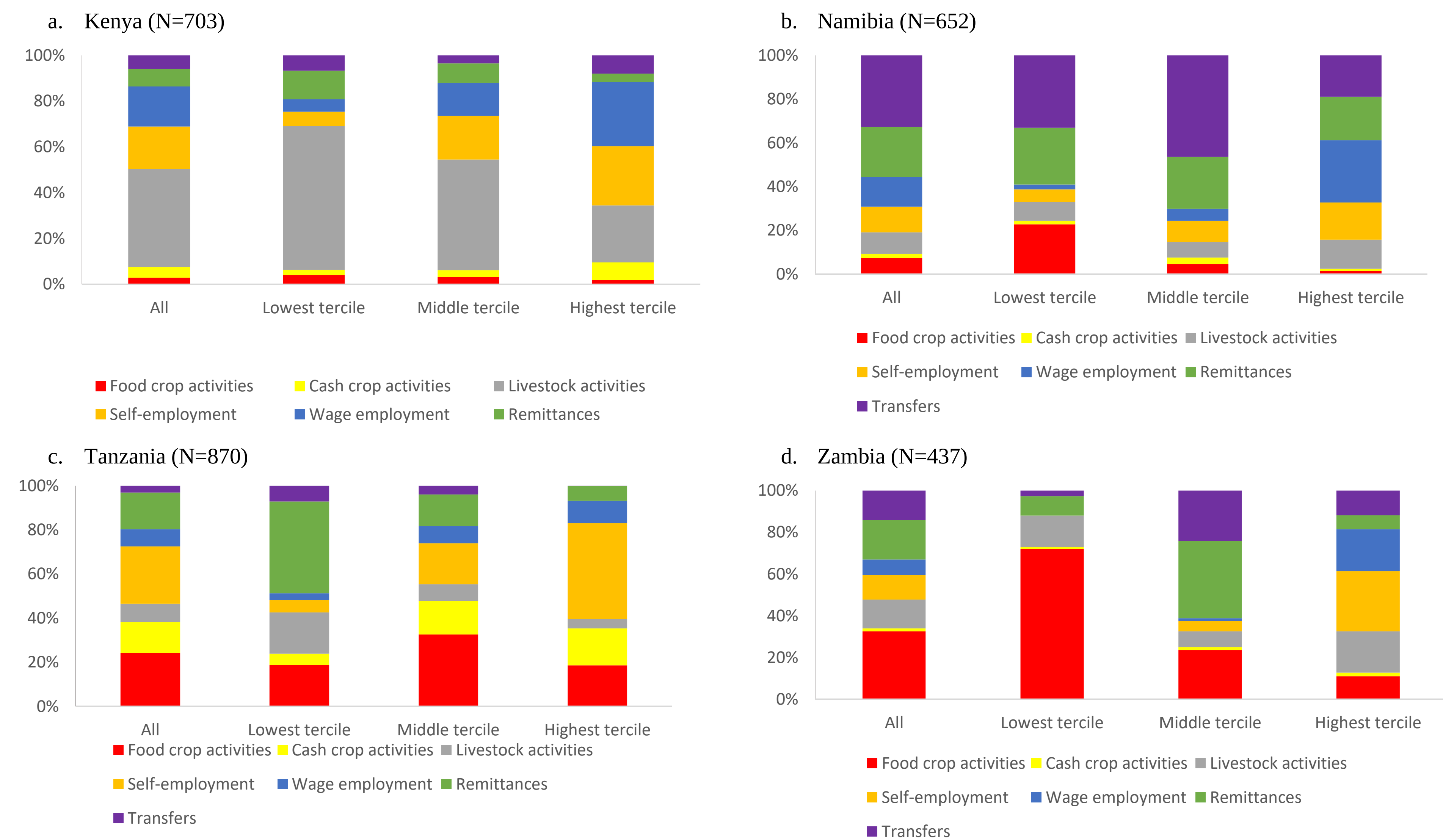


Figure A2.4: Structure of rural household income by income tercile by country

Table A2.4: Proportion of individuals participating in different activities by sex

	Kenya			Namibia			Tanzania			Zambia		
	All	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Off-farm employment												
Self-employment	0.103	0.088	0.116	0.063	0.077	0.052	0.162	0.169	0.155	0.071	0.068	0.074
	(0.303)	(0.283)	(0.320)	(0.243)	(0.266)	(0.223)	(0.368)	(0.375)	(0.362)	(0.257)	(0.252)	(0.262)
Wage employment	0.107	0.143	0.075	0.062	0.096	0.035	0.048	0.069	0.030	0.042	0.060	0.026
	(0.309)	(0.350)	(0.263)	(0.241)	(0.295)	(0.184)	(0.215)	(0.254)	(0.172)	(0.202)	(0.239)	(0.160)
Total off-farm employment	0.210	0.230	0.191	0.125	0.173	0.088	0.209	0.237	0.186	0.114	0.128	0.100
	(0.407)	(0.421)	(0.393)	(0.330)	(0.378)	(0.283)	(0.407)	(0.425)	(0.389)	(0.317)	(0.335)	(0.301)
Panel B: Own farm activities												
Cash crop activities	0.153	0.175	0.133	0.137	0.144	0.131	0.323	0.361	0.290	0.383	0.363	0.401
	(0.360)	(0.381)	(0.340)	(0.343)	(0.351)	(0.337)	(0.468)	(0.481)	(0.454)	(0.486)	(0.481)	(0.491)
Food crop activities	0.356	0.404	0.311	0.166	0.171	0.162	0.702	0.701	0.703	0.717	0.696	0.735
	(0.479)	(0.491)	(0.463)	(0.372)	(0.377)	(0.369)	(0.457)	(0.458)	(0.457)	(0.451)	(0.460)	(0.442)
Livestock activities	0.448	0.525	0.378	0.075	0.100	0.056	0.390	0.369	0.408	0.391	0.447	0.340
	(0.497)	(0.500)	(0.485)	(0.264)	(0.300)	(0.231)	(0.488)	(0.483)	(0.492)	(0.488)	(0.498)	(0.474)
Total own-farm activities	0.489	0.571	0.413	0.175	0.183	0.168	0.737	0.744	0.731	0.746	0.733	0.758
	(0.500)	(0.495)	(0.493)	(0.380)	(0.387)	(0.374)	(0.440)	(0.437)	(0.444)	(0.435)	(0.443)	(0.429)
Observations	1,717	821	896	1,765	771	994	2,086	971	1,115	1,154	546	608

Notes: Proportions are shown with standard deviations in parentheses. The sample includes all individuals in the household aged 18 and above.

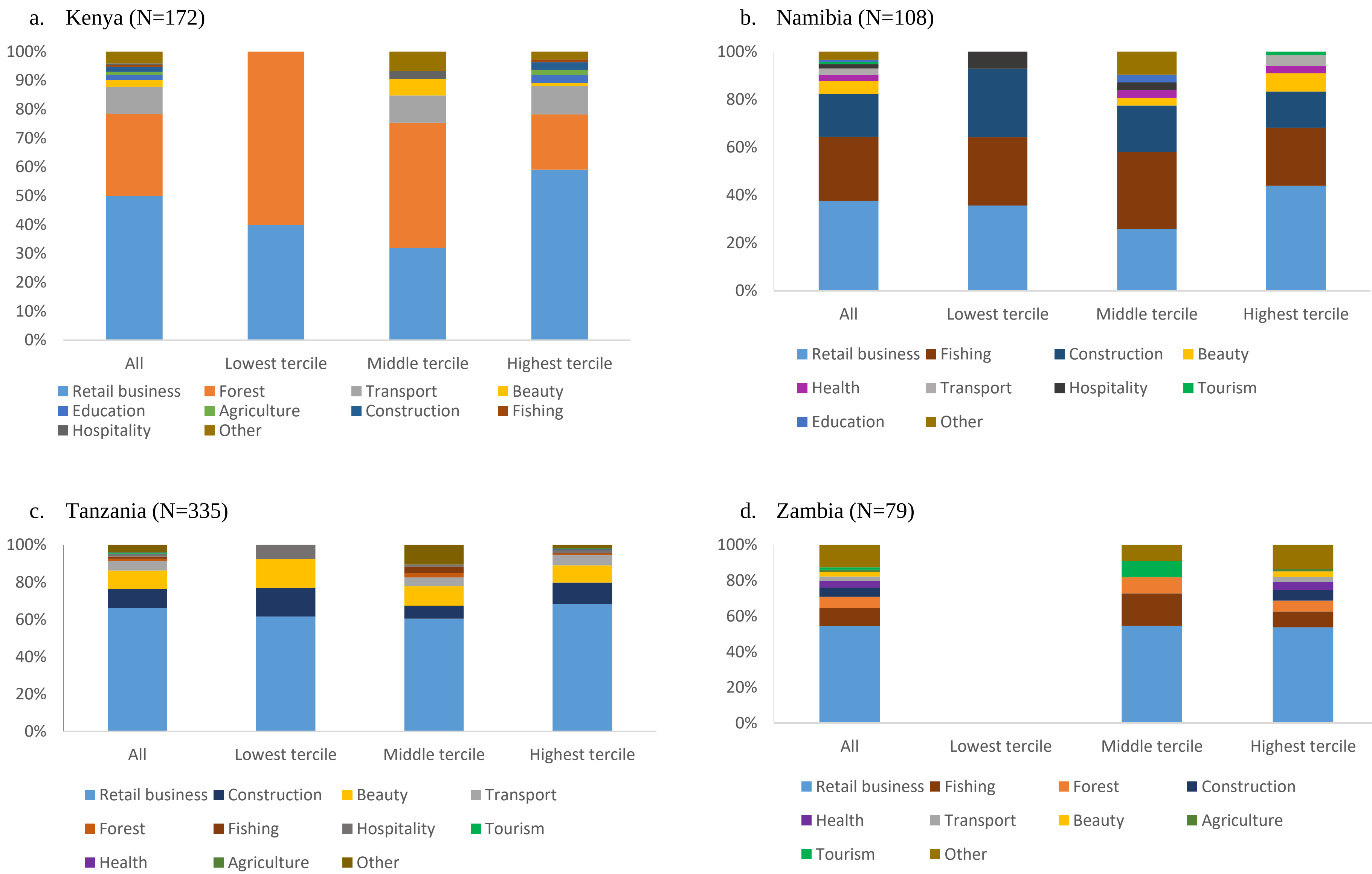


Figure A2.5: Proportion of individuals involved in self-employment sectors by country and income tercile (There are no self-employed individuals in the lowest tercile in Zambia)

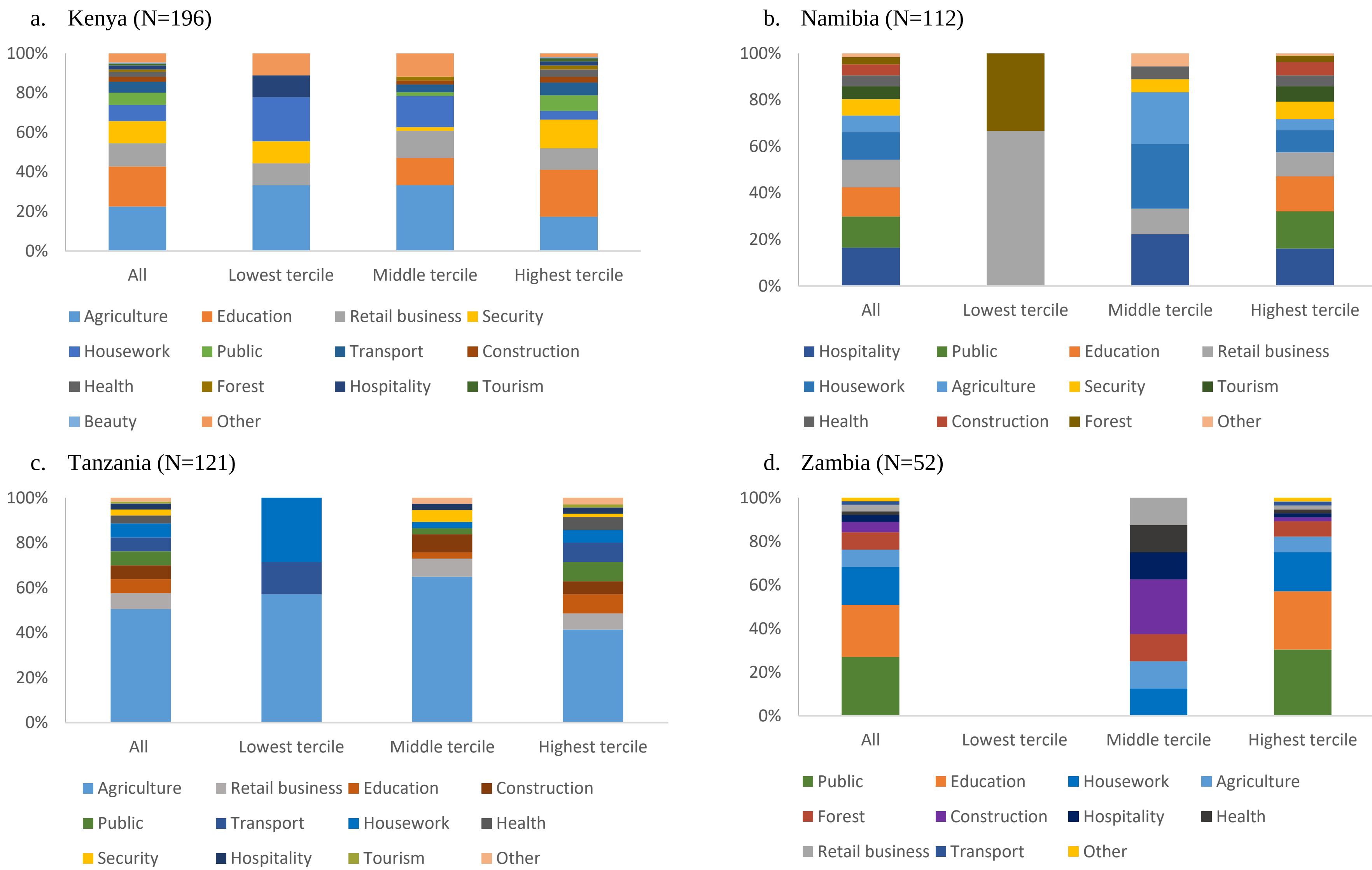


Figure A2.6: Proportion of individuals involved in wage employment sectors by country and income tercile (there are no wage employed individuals in the lowest tercile in Zambia)

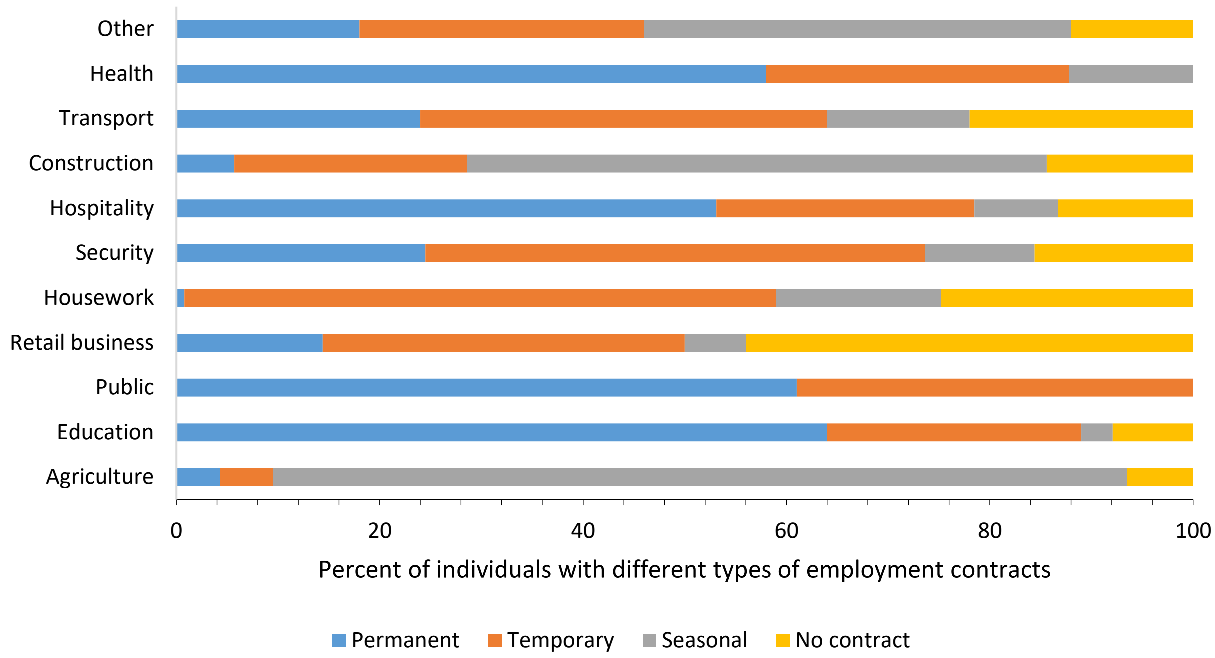


Figure A2.7: Wage employment contracts by sector

Table A2.5: Correlation matrix from the multivariate probit (MVP) model estimating participation in different employment activities

	Cash crop activities	Food crop activities	Livestock activities	Self-employment
Food crop activities	0.794*** (0.03)			
Livestock activities	0.534*** (0.025)	0.894*** (0.029)		
Self-employment	0.04 (0.029)	-0.029 (0.028)	-0.002 (0.027)	
Wage employment	-0.049 (0.035)	-0.099*** (0.035)	-0.130*** (0.035)	-0.293*** (0.031)

Notes: Correlation coefficients are shown with standard errors in parentheses. The likelihood ratio test of zero correlation between the error terms is rejected at the 1% level; $\chi2$ (10)=2,418. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table A2.6: Correlation matrix from multivariate probit (MVP) model estimating participation in different wage employment sectors

	Agricultural sector	Retail sector	Service sector	Public sector	Construction
Retail sector	-0.293*** (0.026)				
Service sector	-0.122*** (0.028)	-0.364*** (0.031)			
Public sector	-0.358*** (0.032)	-0.274*** (0.031)	-0.281*** (0.034)		
Construction	-0.192*** (0.029)	-0.407*** (0.027)	-0.175*** (0.049)	-0.251 (0.027)	
Education	-0.166*** (0.030)	-0.246*** (0.025)	-0.088 (0.08)	-0.294*** (0.026)	-0.194*** (0.018)

Notes: Correlation coefficients are shown with standard errors in parentheses. The likelihood ratio test of zero correlation between the error terms is rejected at the 1% level; $\chi2$ (15) = 101. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Chapter 3 Appendices

Table A3.1: Survey panels Aand B balance test

	Full sample (1)	Panel A (2)	Panel B (3)	Diff. (4)	p-value (5)
Female-headed household (1/0)	0.23	0.21	0.24	-0.02	0.39
	(0.42)	(0.41)	(0.42)		
Women age (years)	34.35	34.20	34.50	-0.30	0.70
	(14.05)	(14.24)	(13.87)		
Women education (years)	4.77	4.76	4.77	-0.01	0.96
	(4.01)	(3.87)	(4.14)		
Household size (number)	4.96	4.96	4.96	0.00	1.00
	(2.25)	(2.29)	(2.25)		
Credit access (1/0)	0.02	0.02	0.02	0.00	0.69
	(0.15)	(0.15)	(0.14)		
Land size (ha)	2.03	2.03	2.03	0.00	1.00
	(2.72)	(2.35)	(3.02)		
Asset value (1000 MK)	29.71	24.92	34.14	-9.22	0.30
	(58.22)	(13.62)	(19.43)		
Distance to market (km)	7.34	7.30	7.38	0.00	0.77
	(5.35)	(5.20)	(5.49)		
Northern region (0/1)	0.10	0.10	0.10	-0.01	0.70
	(0.30)	(0.30)	(0.30)		
Central region (0/1)	0.43	0.44	0.43	0.01	0.86
	(0.50)	(0.50)	(0.50)		
Southern region (0/1)	0.47	0.47	0.47	0.00	0.96
	(0.50)	(0.50)	(0.50)		
Observations	1,287	619	668		

Notes: Mean values are shown with standard deviations in parentheses. MK = Malawian Kwacha.

Table A3.2: Panel tracking and attrition across survey rounds

	2010	2013	2016	2019
Total number of households	1,287	1,595	1,813	2,339
Households from previous round	n.a.	1,229	1,247	1,701

Note: n.a., not applicable.

Table A3.3: Labor switching by women between survey rounds

	2010		2013		2016		2019	
	Off-farm	No off-farm	Off-farm	No off-farm	Off-farm	No off-farm	Off-farm	No off-farm
Observations	299	988	393	1,202	722	1,091	973	1,366
Labor switching from previous round	n.a	n.a	50 (20.4%)	155 (19.2%)	67 (23.7%)	265 (28.4%)	132 (22.5%)	223 (24.0%)

Note: n.a., not applicable.

Table A3.4: Women's off-farm employment and household calorie and micronutrient consumption - dummy variable for employment

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (1/0)	120.840**	66.320***	0.981***	1.207***
	(49.694)	(18.419)	(0.303)	(0.296)
Household size (number)	-287.174***	-75.617***	-1.387***	-1.699***
	(17.520)	(6.779)	(0.110)	(0.111)
Female-headed household (1/0)	696.827**	1.832	2.960	1.529
	(316.661)	(222.145)	(3.163)	(2.984)
Women age (years)	0.649	6.617***	0.078***	0.107***
	(3.127)	(1.422)	(0.022)	(0.024)
Credit access (1/0)	122.340**	44.542**	0.568	1.255***
	(60.083)	(21.493)	(0.349)	(0.364)
Women education (years)	22.204**	12.925***	0.152**	0.189***
	(10.023)	(3.915)	(0.061)	(0.061)
Asset value (log)	38.664***	11.337***	0.240***	0.233***
	(7.739)	(2.967)	(0.049)	(0.048)
Land size (log)	156.470***	27.940*	0.375	0.695***
	(42.801)	(15.646)	(0.263)	(0.259)
Rainfall (log)	-39.839	243.257***	3.403**	4.861***
	(111.028)	(85.924)	(1.397)	(1.511)
Men off-farm employment (hours)	2.870***	0.591	0.014**	0.019***
	(1.053)	(0.371)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.162	0.189	0.275	0.348
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.5: Household income from different sources

	Mean					Difference		
	Total income	Own farm (OF)	Self-employment (SE)	Wage employment (WE)	Casual labor (CL)	SE-OF	WE-OF	CL-OF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income (MK)	124,694	96,009	146,540	333,242	95,592	5,0531***	237,233***	-417
	(319,749)	(219,899)	(283,139)	(744,635)	(168,575)			
Observations	7,034	2,493	989	286	1,112			

Notes: Mean values are shown with standard deviations in parentheses. MK = Malawian Kwacha.

Table A3.6: Relationship between women's off-farm employment and household calorie and micronutrient consumption - full results

	Calories	Vitamin A	Iron	Zinc
	(1)	(2)	(3)	(4)
Off-farm employment (hours)	6.222***	1.805***	0.021*	0.024**
	(2.010)	(0.685)	(0.011)	(0.011)
Household size (number)	-288.442***	-81.108***	-1.479***	-1.802***
	(17.443)	(6.652)	(0.107)	(0.106)
Female-headed household (1/0)	742.063**	115.388	5.210*	3.842
	(316.596)	(206.472)	(2.962)	(2.613)
Women age (years)	-0.688	3.269**	0.017	0.041*
	(3.195)	(1.422)	(0.022)	(0.023)
Credit access (1/0)	99.079**	-18.912	-0.580	0.013
	(62.270)	(21.618)	(0.357)	(0.366)
Women education (years)	19.818**	18.912***	0.580	0.061
	(10.086)	(21.618)	(0.357)	(0.059)
Asset value (log)	36.036***	4.977*	0.125***	0.108**
	(7.934)	(2.907)	(0.048)	(0.046)
Land size (log)	160.065***	33.805**	0.431	0.795***
	(42.701)	(15.282)	(0.259)	(0.249)
Rainfall (log)	-125.416	-47.030	-0.567*	-0.538
	(164.939)	(38.160)	(0.468)	(0.577)
Men off-farm employment (hours)	2.557**	0.315	0.009	0.014*
	(1.056)	(0.364)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.164	0.224	0.305	0.387
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.7: Relationship between women's self-employment and household calorie and micronutrient consumption - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Self-employment (hours)	5.468**	2.332***	0.027*	0.030**
	(2.730)	(0.894)	(0.015)	(0.014)
Household size (number)	-285.146***	-80.827***	-1.469***	-1.788***
	(17.539)	(6.649)	(0.107)	(0.107)
Female-headed household (1/0)	770.704**	125.813	5.296*	3.931
	(319.219)	(207.571)	(2.971)	(2.642)
Women age (years)	-0.750	3.239**	0.017	0.041*
	(3.216)	(1.421)	(0.022)	(0.023)
Credit access (1/0)	96.754**	-20.010	-0.591	-0.002
	(62.425)	(21.673)	(0.358)	(0.368)
Women education (years)	20.970**	6.534*	0.039	0.065
	(10.161)	(3.827)	(0.060)	(0.060)
Asset value (log)	35.860***	4.842*	0.124**	0.108**
	(7.969)	(2.915)	(0.048)	(0.046)
Land size (log)	155.610***	32.190**	0.416	0.777***
	(43.091)	(15.297)	(0.260)	(0.249)
Rainfall (log)	-124.023	-46.289	0.563	-0.536
	(165.565)	(38.233)	(0.468)	(0.579)
Men off-farm employment (hours)	1.556	0.312	0.002	0.006
	(1.591)	(0.625)	(0.010)	(0.009)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.161	0.223	0.305	0.385
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.8: Relationship between women's wage employment and household calorie and micronutrient consumption - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Wage employment (hours)	12.027***	3.155***	0.027	0.039*
	(4.025)	(1.191)	(0.021)	(0.021)
Household size (number)	-283.965***	-80.114***	-1.466***	-1.783***
	(17.441)	(6.655)	(0.107)	(0.107)
Female-headed household (1/0)	739.191**	117.802	5.217*	3.816
	(298.535)	(207.531)	(3.027)	(2.634)
Women age (years)	-0.673	3.270**	0.017	0.041*
	(3.199)	(1.421)	(0.022)	(0.023)
Credit access (1/0)	103.197*	-17.842	-0.565	0.031
	(62.225)	(21.655)	(0.357)	(0.366)
Women education (years)	19.991**	6.360*	0.037	0.063
	(10.033)	(3.825)	(0.060)	(0.060)
Asset value (log)	36.907***	5.149*	0.128***	0.113**
	(7.970)	(2.910)	(0.048)	(0.047)
Land size (log)	163.840**	34.492	0.442*	0.812***
	(42.613)	(15.286)	(0.260)	(0.249)
Rainfall (log)	-125.544	-46.955	-0.555	-0.530
	(166.658)	(38.170)	(0.469)	(0.579)
Men off-farm wage employment (hours)	1.826	0.234	0.016*	0.017*
	(1.562)	(0.505)	(0.008)	(0.009)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.162	0.223	0.305	0.386
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.9: Relationship between women's casual labor and household calorie and micronutrient consumption - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Casual labor (hours)	1.433 (3.775)	0.203 (1.403)	0.006 (0.025)	0.001 (0.023)
Household size (number)	-284.130*** (17.441)	-79.987*** (6.657)	-1.461*** (0.107)	-1.780*** (0.106)
Female-headed household (1/0)	774.846** (305.106)	125.072 (207.126)	5.285* (2.999)	3.962 (2.614)
Women age (years)	-0.493 (3.198)	3.298** (1.422)	0.018 (0.022)	0.042* (0.023)
Credit access (1/0)	105.228* (62.324)	-17.784 (21.648)	-0.565 (0.357)	0.036 (0.367)
Women education (years)	21.274** (10.100)	6.721* (3.831)	0.041 (0.060)	0.067 (0.059)
Asset value (log)	36.60*** (7.946)	5.075* (2.906)	0.127*** (0.048)	0.111** (0.046)
Land size (log)	159.526*** (43.096)	33.316** (15.326)	0.430* (0.259)	0.794*** (0.250)
Rainfall (log)	-125.502 (167.049)	-46.480 (38.208)	-0.566 (0.469)	-0.541 (0.584)
Men casual labor (hours)	4.199** (1.846)	0.368 (0.645)	0.006 (0.011)	0.016 (0.011)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.161	0.222	0.304	0.385
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.\

Table A3.10: Relationship between women's off-farm employment and household calorie and micronutrient consumption from purchases - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	4.409**	1.536**	0.025**	0.024***
	(1.729)	(0.736)	(0.012)	(0.008)
Household size (number)	-142.110***	-39.345***	-0.893***	-0.925***
	(13.567)	(5.609)	(0.095)	(0.065)
Female-headed household (1/0)	78.951	-89.748	-0.951	-0.830
	(440.484)	(113.837)	(1.681)	(0.862)
Women age (years)	-0.745	1.585	-0.015	0.002
	(2.360)	(1.247)	(0.017)	(0.013)
Credit access (1/0)	9.705	-5.441	0.041	0.249
	(48.980)	(24.157)	(0.333)	(0.240)
Women education (years)	-1.689	-2.155	-0.069	-0.026
	(8.266)	(4.200)	(0.060)	(0.045)
Asset value (log)	9.811	3.089	0.046	0.067**
	(6.972)	(2.862)	(0.051)	(0.034)
Land size (log)	-61.280*	4.212	-0.388	-0.011
	(34.871)	(15.826)	(0.254)	(0.174)
Rainfall (log)	-136.598	-28.439	-0.080	-0.285
	(107.345)	(30.649)	(0.592)	(0.352)
Men off-farm employment (hours)	1.936***	0.147	0.013**	0.014***
	(0.749)	(0.420)	(0.005)	(0.004)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.056	0.036	0.057	0.104
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from purchases are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.11: Relationship between women's self-employment and household calorie and micronutrient consumption from purchases - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Self-employment (hours)	5.423**	2.049**	0.035**	0.034***
	(2.376)	(0.910)	(0.016)	(0.011)
Household size (number)	-140.297***	-39.135***	-0.879***	-0.914***
	(13.610)	(5.597)	(0.095)	(0.066)
Female-headed household (1/0)	99.327	-81.187	-0.869	-0.734
	(442.828)	(113.286)	(1.714)	(0.916)
Women age (years)	-0.817	1.569	-0.015	0.002
	(2.372)	(1.246)	(0.017)	(0.013)
Credit access (1/0)	6.796	-6.050	0.030	0.227
	(49.074)	(24.244)	(0.334)	(0.242)
Women education (years)	-0.986	-1.989	-0.064	-0.022
	(8.303)	(4.209)	(0.060)	(0.046)
Asset value (log)	9.559	3.022	0.047	0.065*
	(6.994)	(2.872)	(0.051)	(0.034)
Land size (log)	-65.041*	3.068	-0.402	-0.034
	(35.003)	(15.806)	(0.254)	(0.174)
Rainfall (log)	-135.659	-27.724	-0.077	-0.283
	(107.809)	(30.650)	(0.597)	(0.355)
Men off-farm self-employment (hours)	1.287	-0.111	-0.001	0.010
	(1.284)	(0.616)	(0.009)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.054	0.036	0.055	0.101
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from purchases are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.12: Relationship between women's wage employment and household calorie and micronutrient consumption from purchases - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Wage employment (hours)	10.386***	2.979**	0.037	0.035**
	(3.751)	(1.469)	(0.026)	(0.018)
Household size (number)	-139.023***	-38.401***	-0.874***	-0.905***
	(13.482)	(5.625)	(0.095)	(0.065)
Female-headed household (1/0)	72.141	-87.216	-0.961	-0.848
	(432.224)	(115.709)	(1.614)	(0.750)
Women age (years)	-0.742	1.583	-0.014	0.002
	(2.365)	(1.248)	(0.017)	(0.013)
Credit access (1/0)	12.793	-4.667	0.059	0.266
	(49.078)	(24.212)	(0.333)	(0.241)
Women education (years)	-1.777	-2.143	-0.067	-0.023
	(8.217)	(4.199)	(0.060)	(0.045)
Asset value (log)	10.502	3.190	0.051	0.071**
	(6.962)	(2.854)	(0.051)	(0.034)
Land size (log)	-57.752*	4.664	-0.373	0.003
	(34.970)	(15.837)	(0.255)	(0.175)
Rainfall (log)	-137.002	-28.998	-0.071	-0.281
	(108.460)	(30.840)	(0.594)	(0.353)
Men off-farm wage employment (hours)	1.566	-0.438	0.016*	0.013**
	(1.242)	(0.653)	(0.009)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.056	0.036	0.056	0.101
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from purchases are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.13: Relationship between women's employment in casual labor and household calorie and micronutrient consumption from purchases - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Casual labor (hours)	-2.818	-0.975	0.005	-0.005
	(2.818)	(1.385)	(0.023)	(0.014)
Household size (number)	-138.374***	-38.661***	-0.874***	-0.903***
	(13.513)	(5.629)	(0.095)	(0.065)
Female-headed household (1/0)	116.497	-72.950	-0.811	-0.681
	(433.903)	(116.108)	(1.638)	(0.779)
Women age (years)	-0.713	1.595	-0.014	0.003
	(2.364)	(1.247)	(0.017)	(0.013)
Credit access (1/0)	13.657	-3.951	0.069	0.273
	(49.192)	(24.179)	(0.334)	(0.242)
Women education (years)	-0.647	-1.906	-0.063	-0.020
	(8.288)	(4.205)	(0.060)	(0.046)
Asset value (log)	9.982	3.077	0.049	0.069**
	(6.966)	(2.851)	(0.051)	(0.034)
Land size (log)	-63.187*	3.330	-0.389	-0.016
	(35.123)	(15.819)	(0.254)	(0.175)
Rainfall (log)	-136.274	-27.995	-0.084	-0.289
	(108.937)	(30.739)	(0.601)	(0.358)
Men casual labor (hours)	2.867**	1.237	0.022**	0.018***
	(1.271)	(0.759)	(0.010)	(0.007)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.053	0.036	0.055	0.099
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from purchases are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.14: Relationship between women's off-farm employment and household calorie and micronutrient consumption from own production - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	-3.772**	-1.007***	-0.035***	-0.015***
	(1.510)	(0.315)	(0.011)	(0.005)
Household size (number)	-98.717***	-6.548*	-0.736***	-0.328***
	(13.323)	(3.555)	(0.106)	(0.054)
Female-headed household (1/0)	128.185	85.337	1.594	-0.013
	(440.452)	(75.442)	(3.510)	(1.560)
Women age (years)	-0.805	0.320	-0.004	-0.002
	(2.425)	(0.630)	(0.020)	(0.010)
Credit access (1/0)	109.040**	-11.359	0.023	0.194
	(45.984)	(11.331)	(0.375)	(0.192)
Women education (years)	4.195	0.629	0.044	0.009
	(7.995)	(1.924)	(0.065)	(0.032)
Asset value (log)	20.376***	0.086	0.113**	0.053**
	(6.191)	(1.521)	(0.051)	(0.025)
Land size (log)	190.638***	31.890***	1.683***	0.754***
	(33.971)	(7.856)	(0.268)	(0.134)
Rainfall (log)	-144.160**	-39.485**	-1.534**	-0.701**
	(65.832)	(17.227)	(0.677)	(0.323)
Men off-farm employment (hours)	-1.408*	-0.098	-0.015***	-0.007***
	(0.763)	(0.162)	(0.006)	(0.003)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.145	0.070	0.109	0.110
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.15: Relationship between women's self-employment and household calorie and micronutrient consumption from own production - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Self-employment (hours)	-4.149**	-1.230***	-0.047***	-0.020***
	(1.896)	(0.408)	(0.014)	(0.007)
Household size (number)	-100.228***	-6.633*	-0.748***	-0.334***
	(13.287)	(3.542)	(0.106)	(0.054)
Female-headed household (1/0)	109.693	78.947	1.423	-0.082
	(436.580)	(74.040)	(3.482)	(1.555)
Women age (years)	-0.751	0.338	-0.003	-0.001
	(2.422)	(0.629)	(0.020)	(0.010)
Credit access (1/0)	111.125**	-10.727	0.051	0.206
	(46.028)	(11.369)	(0.375)	(0.191)
Women education (years)	3.595	0.530	0.039	0.007
	(7.999)	(1.925)	(0.065)	(0.032)
Asset value (log)	20.574***	0.178	0.116**	0.054**
	(6.197)	(1.517)	(0.051)	(0.025)
Land size (log)	193.737***	32.851***	1.716***	0.767***
	(34.126)	(7.872)	(0.269)	(0.134)
Rainfall (log)	-145.135**	-39.956**	-1.542**	-0.704**
	(65.691)	(17.320)	(0.675)	(0.322)
Men off-farm self-employment (hours)	-1.018	-0.234	-0.012	-0.005
	(1.329)	(0.220)	(0.010)	(0.005)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.143	0.070	0.107	0.109
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.16: Relationship between women's wage employment and household calorie and micronutrient consumption from own production - full results

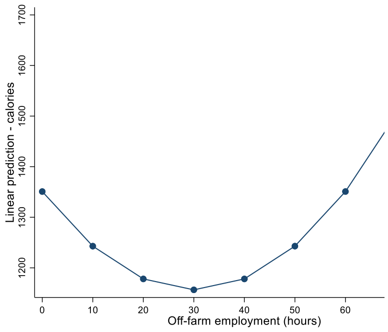
	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Wage employment (hours)	-3.395	-1.009	-0.047**	-0.015
	(2.979)	(0.616)	(0.019)	(0.009)
Household size (number)	-101.182***	-7.081**	-0.758***	-0.338***
	(13.245)	(3.530)	(0.105)	(0.054)
Female-headed household (1/0)	121.576	81.961	1.578	-0.022
	(444.138)	(72.839)	(3.481)	(1.558)
Women age (years)	-0.829	0.317	-0.004	-0.002
	(2.419)	(0.631)	(0.020)	(0.010)
Credit access (1/0)	106.566**	-11.901	-0.002	0.182
	(46.002)	(11.355)	(0.375)	(0.191)
Women education (years)	3.731	0.539	0.042	0.008
	(8.045)	(1.926)	(0.065)	(0.032)
Asset value (log)	19.906***	0.020	0.108**	0.051**
	(6.189)	(1.517)	(0.051)	(0.025)
Land size (log)	189.642***	31.841***	1.665***	0.746***
	(34.110)	(7.869)	(0.270)	(0.134)
Rainfall (log)	-146.103**	-39.746**	-1.552**	-0.713**
	(65.645)	(17.166)	(0.675)	(0.323)
Men off-farm wage employment (hours)	-1.995*	-0.093	-0.024***	-0.014***
	(1.147)	(0.263)	(0.009)	(0.004)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.143	0.069	0.107	0.109
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

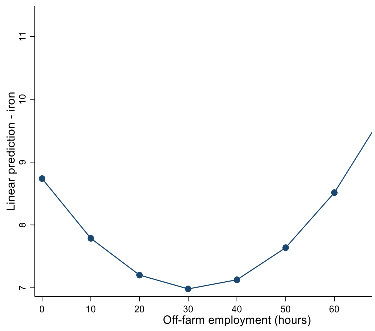
Table A3.17: Relationship between women's casual labor and household calorie and micronutrient consumption from own production - full results

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Casual labor (hours)	-3.770	0.139	-0.004	-0.010
	(3.049)	(0.622)	(0.022)	(0.011)
Household size (number)	-101.399***	-7.197**	-0.768***	-0.343***
	(13.248)	(3.536)	(0.106)	(0.054)
Female-headed household (1/0)	125.788	79.241	1.466	-0.020
	(442.906)	(73.548)	(3.473)	(1.556)
Women age (years)	-0.964	0.316	-0.004	-0.002
	(2.426)	(0.631)	(0.020)	(0.010)
Credit access (1/0)	106.365**	-11.811	0.002	0.186
	(45.987)	(11.353)	(0.375)	(0.192)
Women education (years)	3.218	0.416	0.035	0.005
	(8.041)	(1.929)	(0.065)	(0.032)
Asset value (log)	19.856***	0.057	0.110**	0.051**
	(6.210)	(1.518)	(0.051)	(0.026)
Land size (log)	189.956***	32.314***	1.688***	0.752***
	(34.125)	(7.902)	(0.269)	(0.134)
Rainfall (log)	-144.377**	-39.937**	-1.539**	-0.702**
	(65.288)	(17.217)	(0.668)	(0.320)
Men casual labor (hours)	-0.687	0.006	-0.004	0.001
	(1.329)	(0.288)	(0.010)	(0.005)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.143	0.068	0.105	0.107
Observations	7,034	7,034	7,034	7,034

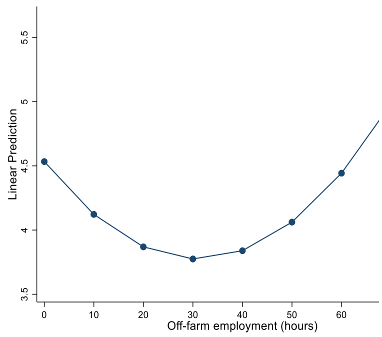
Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.



(a) Calories



(b) Iron



(c) Zinc

Figure A3.1: Relationship between maternal hours spent in off-farm and household consumption of calories and micronutrients

Notes: Predictions are based on the estimates of Table 5, except for vitamin A, which has insignificant coefficients.

Table A3.18: Women's off-farm employment and household income

	Household income (1)
Off-farm employment (hours)	0.252***
	(0.049)
Household size (number)	-0.134***
	(0.019)
Female-headed household (1/0)	-0.827
	(0.594)
Women age (years)	0.034***
	(0.004)
Credit access (1/0)	0.568***
	(0.070)
Women education (years)	0.075***
	(0.011)
Asset value (log)	0.089***
	(0.010)
Land size (log)	-0.225***
	(0.048)
Rainfall (log)	1.828***
	(0.510)
Men off-farm employment (hours)	0.006***
	(0.001)
Region dummies × year dummies	Yes
Survey month dummies	Yes
R-squared	0.318
Observations	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Household income is transformed using Inverse Hyperbolic Sine Transformation (IHS). * denotes significant at 10% level, ** denotes significant at 5% level and *** denotes significant at 1% level.

Table A3.19: Household income and consumption of calories and micronutrients

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Household income per capita (log)	59.444***	50.516***	0.930***	1.040***
	(15.939)	(6.337)	(0.104)	(0.098)
Household size (number)	-275.517***	-66.987***	-1.236***	-1.526***
	(17.294)	(6.656)	(0.107)	(0.106)
Female-headed household (1/0)	781.50***	61.593	3.980	2.706
	(299.702)	(202.402)	(2.959)	(2.602)
Women age (years)	-1.342	4.905	0.047**	0.071***
	(3.153)	(1.408)	(0.022)	(0.023)
Credit access (1/0)	93.951	18.569	0.077	0.712*
	(60.806)	(21.722)	(0.354)	(0.367)
Women education (years)	19.154*	9.860**	0.093	0.123**
	(10.060)	(3.883)	(0.061)	(0.061)
Asset value (log)	33.416***	6.861**	0.158***	0.141***
	(7.881)	(2.945)	(0.048)	(0.047)
Land size (log)	169.289***	39.015**	0.580**	0.924***
	(42.996)	(15.694)	(0.259)	(0.255)
Rainfall (log)	-132.320	159.106**	1.817*	3.104**
	(128.258)	(68.891)	(1.040)	(1.105)
Men off-farm employment (hours)	2.694**	0.377	0.010	0.014**
	(1.063)	(0.366)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.164	0.202	0.291	0.366
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. Household income is transformed using Inverse Hyperbolic Sine Transformation (IHS). * denotes significant at 10% level, ** denotes significant at 5% level and *** denotes significant at 1% level.

Table A3.20: Women's off-farm employment and farm production diversity

	Total production diversity (1)	Crop diversity (2)	Livestock diversity (3)
Off-farm employment (1/0)	-0.145*	-0.086***	-0.070
	(0.081)	(0.031)	(0.050)
Household size (number)	0.119***	0.031***	0.034*
	(0.028)	(0.011)	(0.018)
Female-headed household (1/0)	-0.292	0.022	-0.557
	(0.774)	(0.310)	(0.362)
Women age (years)	0.015***	-0.002	0.017***
	(0.005)	(0.002)	(0.004)
Credit access (1/0)	0.168*	-0.064*	0.196***
	(0.095)	(0.036)	(0.067)
Women education (years)	0.040**	0.002	0.036***
	(0.018)	(0.007)	(0.011)
Asset value (log)	0.051***	0.016***	0.022***
	(0.013)	(0.005)	(0.008)
Land size (log)	0.512***	0.097***	0.491***
	(0.077)	(0.029)	(0.051)
Rainfall (log)	0.192	0.029	0.559**
	(0.198)	(0.051)	(0.268)
Men off-farm employment (hours)	-0.002	-0.001*	0.000
	(0.002)	(0.001)	(0.001)
Region dummies × year dummies	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes
R-squared	0.092	0.204	0.094
Observations	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. * denotes significant at 10% level, ** denotes significant at 5% level and *** denotes significant at 1% level.

Table A3.21: Crops and off-farm employment

Crops	Pooled (1)	Off-farm employment (1/0) (2)	No off-farm employment (1/0) (3)	Difference (4)
Maize (1/0)	0.95	0.95	0.96	-0.01*
Tobacco (1/0)	0.11	0.08	0.12	-0.05***
Groundnuts (1/0)	0.31	0.27	0.33	-0.06***
Rice (1/0)	0.03	0.03	0.04	-0.003
Sweet potato (1/0)	0.06	0.06	0.07	-0.01*
Irish potato (1/0)	0.01	0.01	0.01	0.002
Finger millet (1/0)	0.01	0.01	0.01	0.001
Sorghum (1/0)	0.11	0.10	0.11	-0.01
Beans (1/0)	0.11	0.13	0.10	0.02***
Soy beans (1/0)	0.11	0.09	0.11	-0.01
Pigeon pea (1/0)	0.24	0.23	0.25	-0.02

Notes: Values are means. Stars indicate significance of the difference between off-farm and no off-farm employment: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A3.22: Women's off-farm employment and income decision-making

	Business income (1)	Wage income (2)	Other income (3)
Off-farm employment (hours)	0.007***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)
Household size (number)	0.015***	0.036***	0.035***
	(0.005)	(0.006)	(0.006)
Female-headed household (1/0)	-0.013	0.052	0.473***
	(0.109)	(0.134)	(0.153)
Women age (years)	0.002**	0.003***	0.006***
	(0.001)	(0.001)	(0.001)
Credit access (1/0)	0.061***	0.023	0.074***
	(0.017)	(0.021)	(0.019)
Women education (years)	0.007***	0.016***	0.021***
	(0.003)	(0.003)	(0.004)
Asset value (log)	0.003	0.002	0.005*
	(0.002)	(0.003)	(0.003)
Land size (log)	0.016	-0.003	0.005
	(0.011)	(0.015)	(0.014)
Rainfall (log)	0.034	0.243***	0.229***
	(0.022)	(0.079)	(0.081)
Men off-farm employment (hours)	0.000*	0.002***	0.001***
	(0.000)	(0.000)	(0.000)
Region dummies × year dummies	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes
R-squared	0.079	0.126	0.102
Observations	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clustered at the household level in parentheses. * denotes significant at 10% level, ** denotes significant at 5% level and *** denotes significant at 1% level.

Table A3.23: Relationship between women's off-farm employment and household calorie and micronutrient consumption (Mundlak estimator)

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	6.718***	2.029***	0.034***	0.040***
	(1.509)	(0.452)	(0.008)	(0.008)
Household size (number)	-312.165***	-82.079***	-1.466***	-1.801***
	(20.401)	(6.543)	(0.107)	(0.107)
Female-headed household (1/0)	441.647***	162.438***	3.463***	2.798***
	(54.490)	(17.144)	(0.286)	(0.280)
Women age (years)	1.089	3.234**	0.032	0.049**
	(3.814)	(1.372)	(0.021)	(0.022)
Credit access (1/0)	150.587***	9.300	-0.144	0.149
	(51.940)	(15.419)	(0.265)	(0.261)
Women education (years)	22.061*	8.102**	0.068	0.088
	(11.363)	(3.830)	(0.060)	(0.060)
Asset value (log)	51.974***	9.562***	0.197***	0.201***
	(7.821)	(2.599)	(0.043)	(0.042)
Land size (log)	119.966***	17.728	0.050	0.408*
	(44.484)	(13.644)	(0.223)	(0.221)
Rainfall (log)	-139.309	-24.427	-0.285	-0.233
	(96.114)	(24.071)	(0.441)	(0.388)
Men casual labor (hours)	2.268	0.213	0.007	0.009
	(1.577)	(0.445)	(0.008)	(0.008)
Mundlak controls	Yes	Yes	Yes	Yes
R-squared	0.262	0.272	0.317	0.398
Observations	7,033	7,033	7,033	7,033

Notes: Coefficient estimates from the Mundlak estimator are shown with robust standard errors in parentheses. Calorie, vitamin A, iron, and zinc consumption are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level and *** denotes significant at 1% level.

Table A3.24: Women's off-farm employment and household calorie and micronutrient consumption - at least two waves

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	6.222***	1.805***	0.021*	0.024**
	(2.012)	(0.685)	(0.011)	(0.011)
Household size (number)	-288.442***	-81.108***	-1.479***	-1.802***
	(17.454)	(6.656)	(0.107)	(0.106)
Female-headed household (1/0)	742.063**	115.388	5.210*	3.842
	(316.792)	(206.599)	(2.964)	(2.614)
Women age (years)	-0.688	3.269**	0.017	0.041*
	(3.197)	(1.423)	(0.022)	(0.023)
Credit access (1/0)	99.079	-18.912	-0.580	0.013
	(62.308)	(21.632)	(0.357)	(0.366)
Women education (years)	19.818**	6.332*	0.035	0.061
	(10.092)	(3.820)	(0.060)	(0.059)
Asset value (log)	36.036***	4.977*	0.125***	0.108**
	(7.939)	(2.909)	(0.048)	(0.046)
Land size (log)	160.065***	33.805**	0.431*	0.795***
	(42.728)	(15.291)	(0.260)	(0.249)
Rainfall (log)	-125.416	-47.030	-0.567	-0.538
	(165.041)	(38.184)	(0.469)	(0.577)
Men off-farm employment (hours)	2.557**	0.315	0.009	0.014**
	(1.057)	(0.364)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.164	0.224	0.305	0.387
Observations	5,684	5,684	5,684	5,684

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

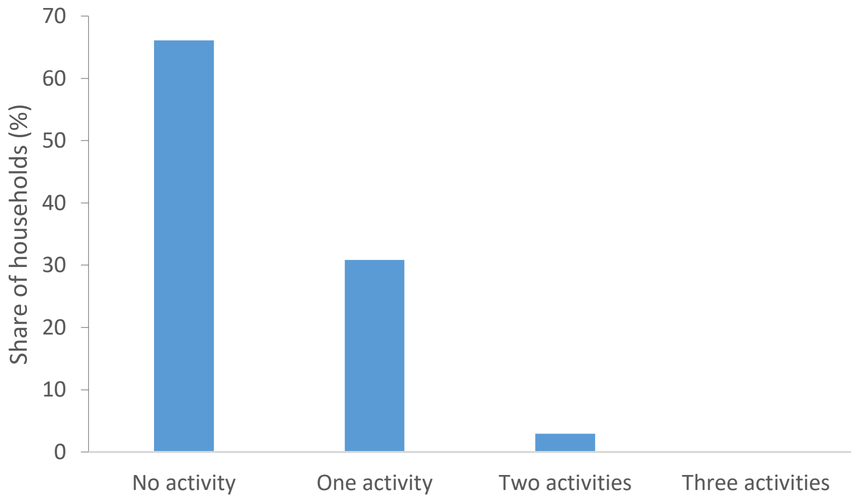


Figure A3.2: Share of households with women participating in different types of off-farm activities

Table A3.25: Women's off-farm employment and household calorie and micronutrient consumption - multiple activities

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	5.554**	1.248**	0.023*	0.021*
	(2.238)	(0.765)	(0.012)	(0.012)
Household size (number)	-297.475***	-81.178***	-1.491***	-1.839***
	(18.021)	(6.932)	(0.111)	(0.110)
Female-headed household (1/0)	735.211**	112.936	5.019*	3.608
	(318.469)	(207.875)	(2.960)	(2.617)
Women age (years)	-0.210	3.470**	0.020	0.045*
	(3.260)	(1.436)	(0.022)	(0.023)
Credit access (1/0)	122.773*	-21.438	-0.494	0.158
	(64.069)	(21.983)	(0.364)	(0.369)
Women education (years)	23.335**	7.358*	0.045	0.076
	(10.423)	(3.978)	(0.062)	(0.061)
Asset value (log)	35.007***	5.292*	0.110**	0.107**
	(8.225)	(3.014)	(0.050)	(0.049)
Land size (log)	178.890***	36.049**	0.406	0.752***
	(44.262)	(15.991)	(0.269)	(0.256)
Rainfall (log)	-115.942	-38.966	-0.533	-0.442
	(165.727)	(37.105)	(0.470)	(0.552)
Men off-farm employment (hours)	2.767**	0.474	0.009	0.016**
	(1.108)	(0.387)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.163	0.226	0.306	0.389
Observations	6,815	6,815	6,815	6,815

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.26: Women's off-farm employment and household calorie and micronutrient consumption - total hours worked

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	5.519***	2.058***	0.024**	0.028***
	(1.867)	(0.648)	(0.010)	(0.010)
Household size (number)	-285.519***	-74.254***	-1.364***	-1.670***
	(17.364)	(6.785)	(0.110)	(0.110)
Female-headed household (1/0)	705.192**	12.081	3.146	1.768
	(319.833)	(218.129)	(3.104)	(2.918)
Women age (years)	0.604	6.612***	0.078***	0.107***
	(3.123)	(1.424)	(0.022)	(0.024)
Credit access (1/0)	124.151**	46.297**	0.598*	1.294***
	(60.115)	(21.528)	(0.351)	(0.365)
Women education (years)	22.625**	13.360***	0.160***	0.198***
	(10.001)	(3.921)	(0.061)	(0.062)
Asset value (log)	38.352***	11.230***	0.239***	0.232***
	(7.743)	(2.982)	(0.049)	(0.048)
Land size (log)	158.037***	28.419*	0.380	0.701***
	(42.670)	(15.652)	(0.263)	(0.259)
Rainfall (log)	-28.984	250.555***	3.519**	5.007***
	(110.420)	(86.503)	(1.406)	(1.522)
Men off-farm employment (hours)	2.693**	0.563	0.014**	0.019***
	(1.055)	(0.375)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.163	0.189	0.274	0.346
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.27: Women's off-farm employment and household calorie and micronutrient consumption - maximum hours

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	5.447***	2.138***	0.027***	0.031***
	(1.709)	(0.595)	(0.009)	(0.009)
Household size (number)	-285.860***	-74.439***	-1.367***	-1.673***
	(17.376)	(6.788)	(0.110)	(0.110)
Female-headed household (1/0)	703.299**	10.704	3.121	1.743
	(319.515)	(218.020)	(3.101)	(2.919)
Women age (years)	0.677	6.638***	0.079***	0.107***
	(3.123)	(1.425)	(0.022)	(0.024)
Credit access (1/0)	123.325**	45.888**	0.592*	1.287***
	(60.109)	(21.517)	(0.351)	(0.364)
Women education (years)	22.544**	13.305***	0.159***	0.197***
	(10.000)	(3.921)	(0.061)	(0.062)
Asset value (log)	38.489***	11.276***	0.239***	0.232***
	(7.748)	(2.981)	(0.049)	(0.048)
Land size (log)	158.999***	28.839*	0.385	0.707***
	(42.672)	(15.651)	(0.263)	(0.258)
Rainfall (log)	-31.111	249.570***	3.505**	4.991***
	(110.738)	(86.255)	(1.403)	(1.518)
Men off-farm employment (hours)	2.648**	0.538	0.013**	0.019***
	(1.051)	(0.374)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.163	0.189	0.275	0.346
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Table A3.28: Women's off-farm employment and household calorie and micronutrient consumption - wives or household heads

	Calories (1)	Vitamin A (2)	Iron (3)	Zinc (4)
Off-farm employment (hours)	4.865***	1.703***	0.018*	0.024**
	(1.877)	(0.629)	(0.010)	(0.010)
Household size (number)	-284.502***	-73.840***	-1.358***	-1.664***
	(17.356)	(6.805)	(0.110)	(0.111)
Female-headed household (1/0)	702.810**	11.977	3.159	1.761
	(313.218)	(218.405)	(3.131)	(2.917)
Women age (years)	0.419	6.550***	0.078***	0.106***
	(3.133)	(1.423)	(0.022)	(0.024)
Credit access (1/0)	124.141**	46.392**	0.601*	1.295***
	(60.096)	(21.523)	(0.351)	(0.365)
Women education (years)	23.030**	13.527***	0.162***	0.201***
	(10.023)	(3.931)	(0.061)	(0.062)
Asset value (log)	38.360***	11.241***	0.239***	0.232***
	(7.738)	(2.982)	(0.049)	(0.048)
Land size (log)	157.780***	28.280*	0.377	0.699***
	(42.759)	(15.686)	(0.263)	(0.259)
Rainfall (log)	-25.862	251.822***	3.536**	5.023***
	(110.017)	(86.753)	(1.410)	(1.525)
Men off-farm employment (hours)	2.751***	0.593	0.014**	0.019***
	(1.059)	(0.377)	(0.006)	(0.006)
Region dummies × year dummies	Yes	Yes	Yes	Yes
Survey month dummies	Yes	Yes	Yes	Yes
R-squared	0.163	0.188	0.274	0.346
Observations	7,034	7,034	7,034	7,034

Notes: Coefficient estimates from fixed effects regressions are shown with robust standard errors clus- tered at the household level in parentheses. Calorie, vitamin A, iron, and zinc consumption from own production are calculated in terms of male adult equivalent. * denotes significant at 10% level, ** denotes significant at 5% level, and *** denotes significant at 1% level.

Chapter 4 Appendices

Table A4.1: Correlation between instruments and mean wealth characteristics at EA level

	Proportion of women in off-farm employment	
	Correlation coefficient	*p*-value
Mean household assets (index)	0.037	0.213
Proportion of households in groups (0-1)	-0.001	0.981
Proportion of educated women (0-1)	-0.042	0.156
Mean farm size (ha)	-0.0003	0.993

Notes: Socioeconomic characteristics were computed by averaging across all sample households in the EA.

Table A4.2: First-stage regressions, showing association between the external instrument and women's off-farm employment

	Off-farm employment (1)	Self-employment (2)	Wage-employment (3)
Share of women in off-farm employment	0.337*** (0.121)		
Share of women in self-employment		0.339*** (0.130)	
Share of women in wage-employment			0.282*** (0.136)
Age of woman (years)	-0.002*** (0.001)	-0.001** (0.001)	-0.001 (0.000)
Female-headed household (1/0)	0.117*** (0.029)	0.094*** (0.028)	0.025** (0.014)
Woman has at least secondary education (1/0)	0.082** (0.032)	0.065** (0.029)	0.025 (0.014)
Household size (number)	0.013** (0.005)	0.008 (0.005)	0.004 (0.002)
Household assets (index)	0.018*** (0.005)	0.016*** (0.005)	0.002 (0.003)
Land size (ha)	-0.013* (0.007)	-0.005 (0.006)	-0.009*** (0.003)
Involved in farming (1/0)	-0.071** (0.033)	-0.037 (0.031)	-0.033** (0.015)
Male household members off-farm employed (1/0)	0.153*** (0.028)		
Other women off-farm employed (1/0)	0.098 (0.062)		
Male household members self-employed (1/0)		0.162*** (0.039)	
Other women self-employed (1/0)		0.099 (0.086)	
Male household members wage-employed (1/0)			0.175*** (0.020)
Other women wage-employed (1/0)			0.087* (0.051)
R-squared	0.108	0.083	0.094
Country fixed effects	Yes	Yes	Yes
Observations	1,151	1,151	1,151

Notes: OLS estimates; robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.3: Falsification test

	WDDS (1)	WDDS (2)	WDDS (3)
Share of women in off-farm employment (0-1)	-0.210		
	(0.351)		
Share of women in self-employment (0-1)		-0.342	
		(0.399)	
Share of women in wage-employment (0-1)			0.720
			(0.873)
Age of woman (years)	-0.001	-0.002	-0.001
	(0.002)	(0.002)	(0.002)
Female-headed household (1/0)	0.015	0.011	0.016
	(0.083)	(0.082)	(0.082)
Woman has at least secondary education (1/0)	0.245***	0.238**	0.232**
	(0.092)	(0.099)	(0.093)
Household size (number)	0.044***	0.046***	0.044***
	(0.015)	(0.017)	(0.015)
Household assets (index)	0.098***	0.101***	0.096***
	(0.015)	(0.018)	(0.014)
Land size (ha)	-0.009	-0.009	-0.006
	(0.021)	(0.021)	(0.021)
Involved in farming (1/0)	0.087	0.075	0.093
	(0.094)	(0.094)	(0.094)
Male household members off-farm employed (1/0)	0.047		
	(0.082)		
Other women working off-farm employed (1/0)	0.102		
	(0.179)		
Male household members self-employed (1/0)		-0.096	
		(0.094)	
Other women working self-employed (1/0)		-0.009	
		(0.211)	
Male household members wage-employed (1/0)			0.198
			(0.127)
Other women working wage-employed (1/0)			0.320
			(0.326)
R-squared	0.292	0.293	0.287
Country fixed effects	Yes	Yes	Yes
Observations	1,151	1,151	1,151

Notes: OLS estimates of association between the external instruments and WDDS. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.4: Instrumental Variable (IV) tests

	Kleibergen-Paap rk LM statistic (1)	Cragg-Donald Wald F statistic (2)	Sargan statistic (3)
Panel A: Dummy variable for work by women			
Woman is off-farm employed (1/0)	282.3 p-value = 0.000	6524.4	0.695 p-value = 0.404
Woman is self-employed (1/0)	228.4 p-value = 0.000	7283	1.212 p-value = 0.271
Woman is wage-employed (1/0)	38.82 p-value = 0.000	5700.9	0.676 p-value = 0.411
Panel B: Hours worked by women			
Hours worked in off-farm employment (log)	238.8 p-value = 0.000	6613.0	0.700 (0.403)
Hours worked in self-employment (log)	190.6 p-value = 0.000	7238.2	1.06 p-value 0.303
Hours worked in wage-employment (log)	34.58 P-value = 0.000	6427.7	0.695 p-value = 0.404
Replications	500	500	500

Notes: Following Lewbel (2012), the IV regressions are conducted using the external instrument combined with heteroskedasticity-based instruments. The Kleibergen-Paap Wald rk F-statistic is used to test the relevance of the instruments; in all cases, the statistic is large enough and the p-values show significance at 1%, allowing us to reject the null hypothesis of weak instruments. The Sargan statistic and its corresponding p-value are used as tests for overidentification; in all regressions, we fail to reject the null hypothesis that all instruments are exogenous. The values of the Cragg-Donald Wald F statistic are large, indicating that the constructed instruments are not weak. The total number of observations is 1,151.

Table A4.5: Poisson estimates of women's off-farm employment and WDDS

	WDDS	WDDS
Woman is off-farm employed (1/0)	0.243***	
	(0.089)	
Hours worked in off-farm employment (log)		0.066***
		(0.025)
Age of woman (years)	-0.001	-0.001
	(0.002)	(0.002)
Female-headed household (1/0)	-0.017	-0.015
	(0.070)	(0.071)
Woman has at least secondary education (1/0)	0.258***	0.260***
	(0.096)	(0.096)
Household size (number)	0.044***	0.046***
	(0.016)	(0.017)
Household assets (index)	0.088***	0.090***
	(0.019)	(0.019)
Land size (ha)	-0.005	-0.005
	(0.028)	(0.028)
Involved in farming (1/0)	0.115	0.106
	(0.125)	(0.125)
Male household members working off-farm (1/0)	0.001	
	(0.092)	
Other women working off-farm (1/0)	0.054	
	(0.016)	
Mean of off-farm employed male members (hours)		-0.001***
		(0.001)
Mean of off-farm employed other women (hours)		-0.002
		(0.003)
Country fixed effects	Yes	Yes
Observations	1,151	1,151

Notes: Poisson marginal effects with robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

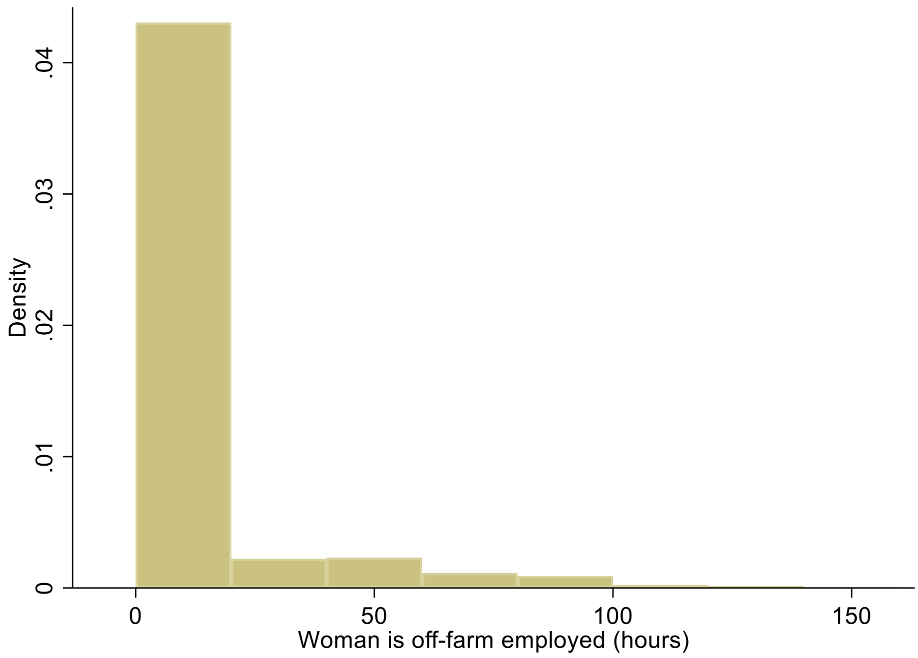


Figure A4.1: Histogram for women's number of hours worked in off-farm employment

Table A4.6: Effects of women's off-farm employment on men's dietary diversity

	WDDS (OLS) (1)	WDDS (IV) (2)	WDDS (OLS) (3)	WDDS (IV) (4)
Off-farm employed (1 = yes)	0.058 (0.075)	0.031 (0.073)		
Hours worked in off-farm employment (log)			0.020 (0.021)	0.013 (0.021)
Age of woman (years)	-0.004 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)
Female-headed household (1/0)	-0.097 (0.067)	-0.094 (0.066)	-0.108 (0.069)	-0.095 (0.063)
Woman has at least secondary education (1/0)	0.228*** (0.072)	0.231*** (0.097)	0.228*** (0.071)	0.229*** (0.081)
Household size (number)	0.011 (0.014)	0.011 (0.016)	0.012 (0.015)	0.011 (0.015)
Household assets (index)	0.076*** (0.017)	0.077*** (0.017)	0.075*** (0.017)	0.076*** (0.016)
Land size (ha)	-0.005 (0.020)	-0.005 (0.019)	-0.006 (0.020)	-0.006 (0.019)
Involved in farming (1/0)	0.122 (0.097)	-0.124 (0.096)	0.118 (0.095)	0.122 (0.089)
Male household members off-farm employed (1/0)	0.149* (0.078)	0.153* (0.081)		
Other women working self-employed (1/0)	-0.114 (0.121)	-0.111 (0.143)		
Male hours in off-farm employment (log)			-0.002 (0.001)	0.151* (0.081)
Other women hours in off-farm employment (log)			-0.003 (0.002)	-0.112 (0.148)
Country fixed effects	Yes	Yes	Yes	Yes
R^2	0.213	0.213	0.212	0.213
Observations	1,151	1,151	1,151	1,151

Notes: For the OLS models, robust standard errors, for the IV models, bootstrapped standard errors with 500 replications are shown in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.7: Women's wage and self-employment and WDDS – OLS full results

	WDDS (1)
Woman is self-employed (1/0)	0.291*** (0.108)
Woman is wage-employed (1/0)	0.246 (0.228)
Age of woman (years)	-0.001 (0.002)
Female-headed household (1/0)	-0.020 (0.069)
Woman has at least secondary education (1/0)	0.215** (0.093)
Household size (number)	0.042*** (0.016)
Household assets (index)	0.093*** (0.019)
Land size (ha)	-0.004 (0.025)
Involved in farming (1/0)	0.111 (0.123)
Male household members self-employed (1/0)	-0.131 (0.102)
Other women working self-employed (1/0)	-0.061 (0.249)
Male household members wage-employed (1/0)	0.155 (0.181)
Other women wage-employed (1/0)	0.304 (0.264)
R-squared	0.301
Country fixed effects	Yes
Observations	1,151

Notes: ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.8: Women's wage and self-employment hours and WDDS – OLS full results

	WDDS (1)
Hours worked in self-employment (log)	0.076** (0.030)
Hours worked in wage-employment (log)	0.086 (0.069)
Age of woman (years)	-0.001 (0.002)
Female-headed household (1/0)	-0.010 (0.070)
Woman has at least secondary education (1/0)	0.218** (0.092)
Household size (number)	0.044** (0.017)
Household assets (index)	0.095*** (0.019)
Land size (ha)	-0.001 (0.026)
Mean of male members in wage-employment (hours)	0.002 (0.003)
Mean of male members in self-employment (hours)	-0.003* (0.002)
Mean of other women wage-employed (hours)	0.002 (0.001)
Mean of other women self-employed (hours)	-0.004 (0.004)
R-squared	0.301
Country fixed effects	Yes
Observations	1,151

Notes: * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.9: Women’s self-employment and WDDS – IV full results

	WDDS (1)	WDDS (2)
Woman is self-employed (1/0)	0.249** (0.101)	
Hours worked in self-employment (log)		0.067*** (0.025)
Age of woman (years)	-0.001 (0.002)	-0.001 (0.002)
Female-headed household (1/0)	-0.016 (0.081)	-0.006 (0.080)
Woman has at least secondary education (1/0)	0.228** (0.099)	0.230** (0.094)
Household size (number)	0.044*** (0.016)	0.045** (0.018)
Household assets (index)	0.096*** (0.017)	0.098*** (0.018)
Land size (ha)	-0.008 (0.022)	-0.005 (0.022)
Involved in farming (1/0)	0.088 (0.101)	0.080 (0.104)
Male household members self-employed (1/0)	-0.140 (0.094)	
Other women working self-employed (1/0)	-0.038 (0.288)	
Male hours in self employment (log)		-0.003** (0.001)
Other women hours in self-employment (log)		-0.004 (0.006)
R-squared	0.298	0.298
Country fixed effects	Yes	Yes
Observations	1,151	1,151

Notes: Bootstrapped standard errors in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.10: Women's wage-employment and WDDS – IV full results

	WDDS (1)	WDDS (2)
Woman is wage-employed (1/0)	0.202 (0.219)	
Hours worked in wage-employment (log)		0.077 (0.069)
Age of woman (years)	-0.001 (0.002)	-0.001 (0.002)
Female-headed household (1/0)	0.014 (0.085)	0.013 (0.083)
Woman has at least secondary education (1/0)	0.235** (0.102)	0.233** (0.101)
Household size (number)	0.044*** (0.017)	0.044*** (0.016)
Household assets (index)	0.095*** (0.018)	0.096*** (0.018)
Land size (ha)	-0.005 (0.023)	-0.005 (0.022)
Involved in farming (1/0)	0.101 (0.108)	0.099 (0.103)
Male household members self-employed (1/0)	0.164 (0.162)	
Other women working self-employed (1/0)	0.305 (0.343)	
Male hours in wage-employment (log)		0.002 (0.003)
Other women hours in wage-employment (log)		0.002 (0.007)
R-squared	0.294	0.294
Country fixed effects	Yes	Yes
Observations	1,151	1,151

Notes: Bootstrapped standard errors in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.11: Poisson estimates of women's wage and self-employment and WDDS

	WDDS (1)	WDDS (2)
Woman is self-employed (1/0)	0.260***	
	(0.096)	
Woman is wage-employed (1/0)	0.213	
	(0.202)	
Hours worked in self-employment (log)		0.070**
		(0.027)
Hours worked in wage-employment (log)		0.069
		(0.060)
Age of woman (years)	-0.001	-0.001
	(0.002)	(0.002)
Female-headed household (1/0)	-0.021	-0.007
	(0.070)	(0.071)
Woman has at least secondary education (1/0)	0.258***	0.249**
	(0.096)	(0.096)
Household size (number)	0.046***	0.048***
	(0.016)	(0.017)
Household assets (index)	0.088***	0.092***
	(0.019)	(0.019)
Land size (ha)	-0.004	0.000
	(0.028)	(0.028)
Involved in farming (1/0)	0.118	0.012
	(0.125)	(0.006)
Male household members self-employed (1/0)	-0.132	
	(0.094)	
Other women are self-employed (1/0)	-0.079	
	(0.229)	
Male household members wage-employed (1/0)	0.150	
	(0.163)	
Other women are wage-employed (1/0)	0.313	
	(0.252)	
Mean of self-employed male members (hours)		-0.003**
		(0.001)
Mean of wage-employed male members (hours)		0.002
		(0.003)
Other women hours in self-employment (log)		-0.005
		(0.005)
Other women hours in wage-employment (log)		0.002
		(0.004)
Country fixed effects	Yes	Yes
Observations	1,151	1,151

Notes: Poisson marginal effects with robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.12: Effects of women's off-farm employment on women's dietary diversity (without other members' labor participation variables)

	WDDS (OLS) (1)	WDDS (IV) (2)	WDDS (OLS) (3)	WDDS (IV) (4)
Off-farm employed (1 = yes)	0.271***	0.251***		
	(0.099)	(0.090)		
Hours worked in off-farm employment (log)			0.070**	0.067**
			(0.027)	(0.024)
Age of woman (years)	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Female-headed household (1/0)	-0.014	-0.012	-0.010	-0.009
	(0.072)	(0.080)	(0.073)	(0.080)
Woman has at least secondary education (1/0)	0.213**	0.214**	0.214**	0.215**
	(0.094)	(0.099)	(0.094)	(0.10)
Household size (number)	0.043**	0.043**	0.044**	0.044**
	(0.017)	(0.016)	(0.017)	(0.018)
Household assets (index)	0.094***	0.094***	0.093***	0.094***
	(0.020)	(0.017)	(0.020)	(0.018)
Land size (ha)	-0.005	-0.006	-0.005	-0.006
	(0.026)	(0.023)	(0.026)	(0.022)
Country fixed effects	Yes	Yes	Yes	Yes
R^2	0.30	0.30	0.30	0.30
Observations	1,151	1,151	1,151	1,151

Notes: For the OLS models, robust standard errors, for the IV models, bootstrapped standard errors with 500 replications are shown in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.13: Sensitivity analysis

	Off-farm employment (1)
Panel A: Sensitivity analysis (exogenous controls; Oster, 2019)	
Delta	2.246
R^2_{max}	0.385
Woman controls	Yes
Household controls	Yes
Country fixed effects	Yes
Observations	1151
Panel B: Sensitivity analysis (endogenous controls; Diegert et al., 2022)	
Breakdown point (%)	64.7
Observations	1,151

Notes: Oster test is performed using the 'psacalc' command in Stata based on Oster (2019). The outcome variable is WDDS.

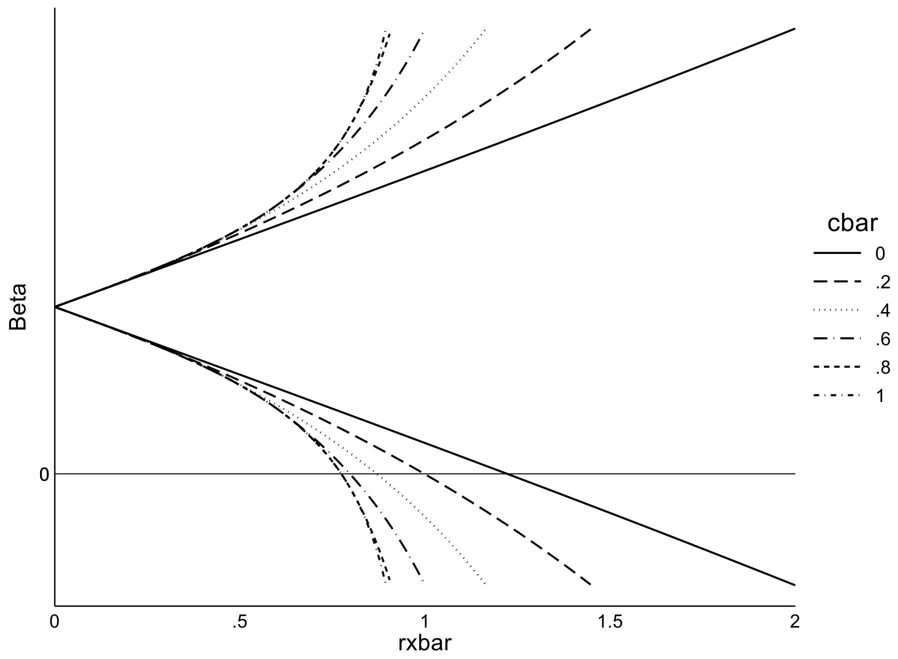


Figure A4.2: Sensitivity test following Diegert et al. (2022)

Notes: The values of *rxbar* represent the magnitude of how large the selection on unobservables relative to observables would have to be to overturn our results (breakdown point). The different line patterns indicate different levels of assumed endogeneity between included controls and omitted variables (*cbar*). The dotted line is the strictest setting, with full endogeneity assumed.

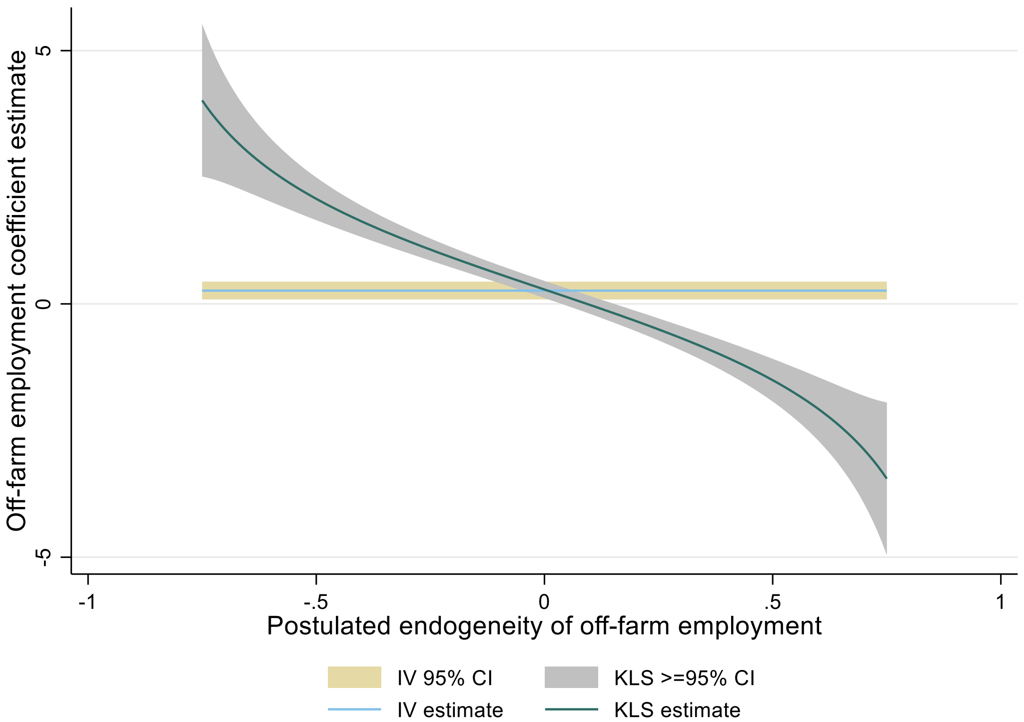


Figure A4.3: KLS and 2SLS coefficient estimates and confidence intervals

Table A4.14: Women's off-farm employment and food groups consumed (OLS estimates)

	Starchy staples	Pulses	Dairy	Meat and fish	Eggs	Dark green leafy vegetables	Vitamin A-rich fruits and vegetables	Other fruits and vegetables	Organ meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is off-farm employed (1/0)	0.003 (0.011)	0.046 (0.044)	0.015 (0.024)	0.082** (0.040)	0.008 (0.012)	0.013 (0.034)	0.092** (0.036)	0.026 (0.030)	-0.004 (0.011)
Age of woman (years)	-0.001 (0.000)	0.001 (0.001)	0.002** (0.001)	-0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.000)
Female-headed household (1/0)	-0.015 (0.010)	-0.055 (0.035)	-0.007 (0.017)	-0.048 (0.036)	0.021 (0.014)	0.087*** (0.031)	-0.018 (0.025)	-0.012 (0.033)	-0.007 (0.013)
Woman has at least secondary education (1/0)	-0.012 (0.017)	0.033 (0.041)	0.076** (0.030)	0.043 (0.036)	0.018 (0.015)	0.058 (0.040)	0.007 (0.027)	-0.015 (0.040)	0.011 (0.015)
Household size (number)	0.001 (0.002)	0.012* (0.007)	0.013** (0.004)	-0.004 (0.008)	0.007 (0.004)	0.016** (0.007)	-0.004 (0.006)	-0.000 (0.006)	-0.000 (0.002)
Household assets (index)	0.001 (0.002)	-0.012* (0.007)	0.018** (0.004)	0.034*** (0.007)	0.007** (0.003)	0.003 (0.006)	0.017*** (0.006)	0.022*** (0.007)	0.002 (0.003)
Land size (ha)	-0.008 (0.005)	0.002 (0.008)	-0.003 (0.007)	0.002 (0.009)	-0.003 (0.004)	-0.001 (0.010)	0.005 (0.005)	0.001 (0.008)	0.000 (0.002)
Involved in farming (1/0)	-0.009 (0.011)	0.044 (0.048)	0.020 (0.026)	-0.022 (0.042)	0.001 (0.014)	0.039 (0.037)	-0.016 (0.037)	0.068 (0.049)	-0.016 (0.016)
Male household members off-farm employed (1/0)	-0.012 (0.013)	-0.007 (0.039)	0.025 (0.024)	-0.017 (0.039)	0.008 (0.015)	0.021 (0.032)	-0.028 (0.031)	0.005 (0.033)	0.007 (0.009)
Other women are off-farm employed (1/0)	-0.001 (0.024)	0.000 (0.039)	0.048 (0.051)	0.039 (0.089)	-0.021 (0.025)	-0.026 (0.081)	0.002 (0.066)	-0.002 (0.073)	0.032 (0.034)
R-squared	0.051	0.029	0.109	0.092	0.033	0.312	0.093	0.093	0.080
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.15: Women's self-employment and food groups consumed (IV estimates)

	Starchy staples	Pulses	Dairy	Meat and fish	Eggs	Dark green leafy vegetables	Vitamin A-rich fruits and vegetables	Other fruits and vegetables	Organ meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is self-employed (1/0)	0.006 (0.008)	0.032 (0.040)	0.009 (0.025)	0.061* (0.041)	0.006 (0.016)	0.046 (0.039)	0.082** (0.038)	0.011 (0.040)	-0.005 (0.009)
Age of woman (years)	-0.000 (0.000)	0.000 (0.001)	0.002** (0.001)	-0.001 (0.001)	0.000 (0.000)	0.001 (0.001)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.000)
Female-headed household (1/0)	-0.014 (0.013)	-0.055 (0.037)	-0.006 (0.021)	-0.045 (0.033)	0.020 (0.015)	0.083*** (0.029)	0.020 (0.029)	-0.011 (0.037)	-0.007 (0.010)
Woman has at least secondary education (1/0)	-0.012 (0.016)	0.035 (0.041)	0.077*** (0.029)	0.047 (0.041)	0.018 (0.015)	0.055 (0.038)	0.009 (0.031)	-0.013 (0.043)	0.012 (0.013)
Household size (number)	0.002 (0.002)	0.012* (0.007)	0.014*** (0.005)	-0.004 (0.007)	0.007* (0.004)	0.016*** (0.006)	-0.003 (0.005)	0.001 (0.007)	0.000 (0.002)
Household assets (index)	0.000 (0.002)	-0.012 (0.007)	0.020*** (0.005)	0.035*** (0.006)	0.007** (0.003)	0.003 (0.006)	0.018*** (0.006)	0.023*** (0.006)	0.002 (0.003)
Land size (ha)	-0.008* (0.005)	0.001 (0.009)	-0.003 (0.007)	0.001 (0.009)	-0.003 (0.004)	-0.000 (0.008)	0.004 (0.007)	0.001 (0.009)	0.000 (0.002)
Involved in farming (1/0)	-0.009 (0.011)	0.042 (0.043)	0.016 (0.024)	-0.027 (0.039)	-0.000 (0.014)	0.040 (0.036)	-0.021 (0.034)	0.064* (0.038)	-0.018 (0.015)
Male household members self-employed (1/0)	-0.010 (0.011)	-0.014 (0.043)	0.003 (0.026)	-0.027 (0.044)	-0.008 (0.015)	0.007 (0.036)	-0.0057 (0.035)	-0.029 (0.041)	-0.006 (0.009)
Other women are self-employed (1/0)	-0.014 (0.037)	0.072 (0.102)	-0.034 (0.061)	0.056 (0.092)	-0.012 (0.032)	-0.064 (0.092)	-0.003 (0.084)	-0.058 (0.095)	-0.018 (0.015)
R-squared	0.05	0.029	0.107	0.092	0.051	0.313	0.094	0.093	0.081
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: Bootstrapped standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.16: Women's wage-employment and food groups consumed (IV estimates)

	Starchy staples	Pulses	Dairy	Meat and fish	Eggs	Dark green leafy vegetables	Vitamin A-rich fruits and vegetables	Other fruits and vegetables	Organ meat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is wage-employed (1/0)	0.014 (0.011)	0.088 (0.088)	-0.030 (0.053)	0.117 (0.076)	0.007 (0.038)	-0.144* (0.075)	0.052 (0.090)	0.076 (0.071)	0.024 (0.037)
Age of woman (years)	-0.000 (0.000)	0.001 (0.001)	0.001** (0.001)	-0.001 (0.001)	0.000 (0.000)	0.000 (0.001)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.000)
Female-headed household (1/0)	-0.014 (0.013)	-0.050 (0.037)	-0.005 (0.028)	-0.040 (0.035)	0.021 (0.016)	0.088*** (0.030)	0.030 (0.030)	-0.011 (0.035)	-0.006 (0.011)
Woman has at least secondary education (1/0)	-0.012 (0.017)	0.035 (0.039)	0.076*** (0.028)	0.048 (0.038)	0.018 (0.015)	0.061 (0.037)	0.013 (0.030)	-0.015 (0.042)	0.010 (0.013)
Household size (number)	0.001 (0.002)	0.013* (0.004)	0.013*** (0.005)	-0.003 (0.007)	0.007* (0.004)	0.017*** (0.006)	-0.003 (0.005)	-0.001 (0.007)	0.000 (0.002)
Household assets (index)	0.001 (0.002)	-0.012* (0.006)	0.019*** (0.004)	0.036*** (0.007)	0.006* (0.003)	0.004 (0.006)	0.018*** (0.006)	0.022*** (0.006)	0.002 (0.002)
Land size (ha)	-0.008* (0.005)	0.002 (0.009)	-0.003 (0.007)	0.002 (0.009)	-0.003 (0.004)	-0.002 (0.009)	0.004 (0.007)	0.002 (0.009)	0.001 (0.002)
Involved in farming (1/0)	-0.008 (0.011)	0.041 (0.043)	0.021 (0.022)	-0.025 (0.041)	0.000 (0.014)	0.035 (0.035)	-0.020 (0.035)	0.072* (0.041)	-0.015 (0.014)
Male household members wage-employed (1/0)	-0.014 (0.020)	0.011 (0.056)	0.081* (0.046)	-0.040 (0.062)	0.029 (0.028)	0.039 (0.052)	0.007 (0.051)	0.028 (0.053)	0.025 (0.024)
Other women are wage-employed (1/0)	0.026** (0.012)	-0.175 (0.119)	0.226 (0.156)	0.006 (0.165)	-0.044** (0.017)	0.071 (0.107)	0.013 (0.123)	0.122 (0.149)	0.060 (0.098)
R-squared	0.051	0.029	0.117	0.090	0.053	0.315	0.086	0.094	0.081
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: Bootstrapped standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.17: Association between women's off-farm employment and household income (full model results)

	Per capita income (log) (1)
Woman is off-farm employed (1/0)	0.838*** (0.181)
Age of woman (years)	0.022*** (0.005)
Female-headed household (1/0)	0.837*** (0.188)
Woman has at least secondary education (1/0)	0.107 (0.209)
Household size (number)	-0.592*** (0.054)
Household assets (index)	0.052 (0.032)
Land size (ha)	0.086** (0.032)
Involved in farming (1/0)	-0.195 (0.208)
Male household members off-farm employed (1/0)	-0.077 (0.123)
Other women are wage-employed (1/0)	-0.636** (0.256)
R-squared	0.393
Country fixed effects	Yes
Observations	1,151

Notes: OLS regression results with robust standard errors in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.18: Associations between women's off-farm employment and control of different types of incomes (full model results)

	Crop income	Livestock income	Off-farm income	Remittances
	(1)	(2)	(3)	(4)
Woman is off-farm employed (1/0)	0.007	0.011	0.051**	0.007
	(0.032)	(0.035)	(0.028)	(0.028)
Age of woman (years)	0.002***	0.003***	0.001*	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Female-headed household (1/0)	0.122***	0.104**	0.133***	0.139***
	(0.017)	(0.025)	(0.018)	(0.021)
Woman has at least secondary education (1/0)	0.042*	0.017	-0.031	0.028
	(0.024)	(0.033)	(0.023)	(0.026)
Household size (number)	-0.011*	-0.012*	-0.008	-0.006
	(0.006)	(0.007)	(0.006)	(0.006)
Household assets (index)	0.008*	0.011*	0.009**	0.007
	(0.004)	(0.006)	(0.005)	(0.005)
Land size (ha)	-0.003	0.013*	0.002	0.009
	(0.008)	(0.006)	(0.006)	(0.006)
Involved in farming (1/0)	0.049	0.011	0.029	-0.005
	(0.042)	(0.006)	(0.030)	(0.026)
Male household members off-farm employed (1/0)	-0.054	-0.082	-0.052	-0.051
	(0.036)	(0.046)	(0.034)	(0.032)
Other female members off-farm employed (1/0)	0.125***	0.044	0.112***	0.081**
	(0.022)	(0.056)	(0.021)	(0.033)
Country fixed effects	Yes	Yes	Yes	Yes
R-squared	0.076	0.074	0.071	0.075
Observations	1,049	715	1,097	1,097

Notes: OLS regression results with robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%

Table A4.19: Time allocation to various activities among self – and non-self-employed households

	Off-farm employment (1)	No off-farm employment (2)	Difference (1)-(2)
Household chores	2.303	2.865	-0.562***
	(2.1.962)	(2.073)	
Self-care and maintenance	2.232	2.508	-0.276***
	(0.967)	(0.972)	
Leisure	1.531	2.239	-0.709***
	(2.181)	(2.303)	
Resting and sleeping	10.073	10.975	-0.902***
	(2.541)	(2.791)	
Cooking	2.016	2.196	-0.179**
	(1.226)	(1.129)	
Care work	0.451	0.667	-0.216**
	(0.908)	(1.236)	
Own farm work	1.453	1.682	-0.229
	(2.581)	(2.689)	
Observations	213	938	

Notes: Mean values in hours per day are shown with standard deviations in parentheses. ** denotes significance at 5%, and *** denotes significance at 1%.

Table A4.20: Farm-level production diversity by women's off-farm employment

	Full sample (1)	Off-farm (2)	No off-farm (3)	Difference (2)-(3)
Farm production diversity	2.74 (0.13)	2.92 (0.12)	2.69 (0.05)	0.22*
Number of crop species	1.83 (0.03)	1.92 (0.07)	1.81 (0.03)	0.12*
Number of livestock species	1.45 (0.03)	1.45 (0.03)	1.46 (0.06)	-0.01

Notes: * denotes significance at 10%.; Standard deviations in parentheses

Table A4.21: Associations between women's off-farm employment and men's time allocation

	Household chores	Self-care and maintenance	Leisure	Rest and sleeping	Cooking	Care work	Own farm work	Off-farm work
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Woman is off-farm employed (1/0)	0.151 (0.143)	-0.178 (0.111)	-0.559** (0.249)	-0.030 (0.218)	0.090 (0.127)	-0.009 (0.022)	-0.426 (0.320)	0.287 (0.290)
Age of woman (years)	0.000 (0.143)	0.003 (0.003)	-0.001 (0.008)	0.028*** (0.007)	-0.009*** (0.003)	-0.001 (0.001)	-2.41*** (0.008)	-0.019*** (0.005)
Female-headed household (1/0)	0.449** (0.170)	-1.16*** (0.121)	-1.14*** (0.315)	-0.838** (0.334)	-0.056 (0.106)	-0.039** (0.019)	-1.57*** (0.310)	-0.377 (0.225)
Woman has at least secondary education (1/0)	-0.106 (0.189)	-0.033 (0.102)	0.304 (0.264)	-0.502* (0.299)	-0.034 (0.133)	0.056** (0.023)	-0.209 (0.293)	-0.165 (0.221)
Household size (number)	0.010 (0.189)	0.022 (0.021)	0.002 (0.046)	0.043 (0.052)	0.006 (0.025)	-0.004 (0.004)	0.089 (0.058)	-0.139*** (0.042)
Household assets (index)	0.027 (0.024)	0.027 (0.019)	0.081 (0.047)	-0.218*** (0.029)	0.005 (0.020)	0.000 (0.005)	0.091 (0.055)	0.058 (0.045)
Land size (ha)	0.036 (0.043)	0.036 (0.029)	-0.096 (0.068)	0.048 (0.065)	0.019 (0.022)	-0.012 (0.011)	0.119 (0.087)	0.048 (0.075)
Involved in farming (1/0)	0.369* (0.194)	-0.113 (0.144)	0.043 (0.281)	0.368 (0.293)	0.315 (0.20)	-0.058 (0.073)	0.474* (0.281)	-0.898** (0.437)
Male household members off-farm employed (1/0)	0.286** (0.133)	-0.192 (0.132)	-1.38*** (0.231)	-0.488** (0.212)	-0.003 (0.101)	-0.033 (0.023)	-1.36*** (0.240)	3.43*** (0.383)
Other female members off-farm employed (1/0)	0.252 (0.374)	-0.298 (0.216)	-0.031 (0.499)	0.262 (0.838)	0.069 (0.243)	0.023 (0.031)	-0.938* (0.552)	-0.667 (0.499)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.144	0.112	0.086	0.119	0.132	0.095	0.100	0.237
Observations	938	938	938	762	938	762	938	938

Notes: OLS regression results with robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%

Table A4.22: Associations between women's off-farm employment and women's time allocation - full results

	Household chores	Self-care and maintenance	Leisure	Rest and sleeping	Cooking	Care work	Own farm work	Self-employment	Wage-employment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Woman is off-farm employed (1/0)	-0.466*** (0.156)	-0.279*** (0.077)	-0.749** (0.191)	-0.530** (0.231)	-0.191* (0.092)	-0.399** (0.072)	-0.294 (0.226)	2.224*** (0.227)	0.498*** (0.114)
Age of woman (years)	-0.017*** (0.004)	0.004* (0.002)	0.002 (0.004)	0.039*** (0.004)	-0.152 (0.099)	-0.014** (0.002)	0.007 (0.005)	-0.006** (0.003)	-0.001 (0.002)
Female-headed household (1/0)	-0.353** (0.157)	-0.080 (0.071)	0.275 (0.184)	0.387** (0.191)	-0.314 (0.091)	-0.031 (0.002)	-0.171 (0.201)	0.023 (0.150)	0.117 (0.082)
Woman has at least secondary education (1/0)	-0.300 (0.208)	0.180** (0.070)	-0.246 (0.167)	-0.170 (0.221)	-0.051 (0.109)	-0.103 (0.088)	0.020 (0.221)	0.350 (0.210)	0.130 (0.096)
Household size (number)	0.001 (0.031)	-0.003 (0.014)	-0.077** (0.034)	0.052 (0.035)	-0.018 (0.019)	0.066*** (0.014)	0.038 (0.031)	-0.098*** (0.019)	0.025 (0.018)
Household assets (index)	-0.016 (0.025)	0.029** (0.013)	0.132*** (0.039)	-0.306** (0.033)	0.024 (0.015)	0.020* (0.011)	0.049 (0.039)	0.025 (0.023)	0.034** (0.016)
Land size (ha)	0.025 (0.040)	0.011 (0.022)	-0.020 (0.039)	-0.080* (0.045)	0.026 (0.024)	-0.072** (0.015)	0.095 (0.059)	0.075** (0.035)	-0.043*** (0.015)
Involved in farming (1/0)	0.116 (0.181)	-0.162 (0.099)	0.038 (0.158)	-0.880** (0.244)	0.179 (0.096)	-0.113 (0.127)	0.947*** (0.175)	-0.226 (0.197)	-0.168 (0.116)
Male household members off-farm employed (1/0)	0.288* (0.151)	-0.068 (0.093)	-0.376** (0.158)	0.409* (0.229)	0.003 (0.077)	0.144 (0.090)	-0.362* (0.190)	0.012 (0.154)	-0.003 (0.085)
Other women are off-farm employed (1/0)	0.601** (0.257)	-0.024 (0.157)	-0.404 (0.354)	-0.041 (0.440)	-0.018 (0.205)	0.332 (0.228)	-0.209 (0.397)	-0.251 (0.335)	-0.135 (0.123)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151

Notes: OLS regression results with robust standard errors in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%

Chapter 5 Appendices

Table A5.1: Description of variables used in the analysis

Variable	Description
Outcome variable: Gendered employment outcomes	
Household employment	Total number of hours worked by men and women in either wage or self-employment in the past one week.
Women employment	Number of hours worked by women in either wage or self-employment in the past one week.
Men employment	Number of hours worked by men in either wage or self-employment in the past one week.
Independent variable of interest: Technology adoption indicators	
No technology	Household prepares land manually and does not use improved seeds or inorganic fertilizers.
IS	Equal to 1 if the household uses improved seeds and prepares land manually; zero otherwise.
IF	Equal to 1 if the household uses inorganic fertilizers and prepares land manually; zero otherwise.
IS+IF	Equal to 1 if the household uses improved seeds and inorganic fertilizers and prepares land manually; zero otherwise.
IS+IF+AT	Equal to 1 if the household uses improved seeds and inorganic fertilizers and prepares land using animal traction; zero otherwise.
IS+IF+T	Equal to 1 if the household uses improved seeds and inorganic fertilizers and prepares land using tractors; zero otherwise.
Control variables: Household characteristics	
Age	Age of the head of the household (in years).
Gender	Equal to 1 for a male household head; zero otherwise.
Education level	Number of years of schooling of the household head.
Family size	Number of household members.
Land size	Total land size owned (in hectares).
Livestock ownership	Value of livestock owned by the household (in tropical livestock units, TLU).
Asset ownership	Value of assets owned by the household (in Tanzanian shillings).
Region dummies	
Region dummies	A dummy for each of the 26 regions.
Year dummies (cropping seasons)	
2014/15	A dummy for the production season 2014/15.
2019/20	A dummy for the production season 2019/20.
Instrumental variables (IV) in the reduced form equations	
IV1	EA adoption rate of improved seeds.
IV2	EA adoption rate of inorganic fertilizers.
IV3	EA adoption rate of animal traction.
IV4	EA adoption rate of tractors.

Notes: Livestock ownership was measured in TLU (Total Livestock units) excluding oxen. For the conversion of the TLU, we used standard conversion factors based on Storck et al. (1991): camel = 1.25, sheep and goat = 0.13, cow = 1, calf = 0.25, heifer =0.75, donkey = 0.70, and chicken = 0.013, where 1TLU is equivalent to 250 kg live animal weight. Tanzanian shilling (Tsh.) is a local currency where 1 USD was equivalent to Tshs. 1,663.73 in 2014 and Tshs. 2,317 in 2020.

Table A5.2: Survey month

Month	Pooled sample (1)	2020 (2)	2014 (3)
January	13.57	13.36	13.73
February	7.86	8.52	7.35
March	6.87	3.81	9.19
April	3.60	7.86	0.37
May	9.21	10.28	8.41
June	8.98	8.04	9.69
July	11.38	12.09	10.84
August	9.37	10.58	8.45
September	3.11	0.54	5.05
October	8.30	8.83	7.90
November	7.99	7.98	7.99
December	9.76	8.10	11.02
Observations	2,444	1,441	1,003

Notes: The table shows the proportion of households surveyed in each month.

Table A5.3: Factors affecting adoption of technologies

	IS	IF	IS-IF	IS-IF-AT	IS-IF-T
	(1)	(2)	(3)	(4)	(5)
Female-headed household (1/0)	-0.157	-0.282	-0.036	-0.608***	-1.092**
	(0.199)	(0.174)	(0.197)	(0.232)	(0.323)
Number of household members	0.131	0.006	0.127	0.149	0.165
	(0.111)	(0.085)	(0.102)	(0.104)	(0.129)
Age of household head (years)	0.252***	-0.137**	0.167***	-0.017	-0.120**
	(0.049)	(0.036)	(0.037)	(0.036)	(0.044)
Education of household head (years)	0.088***	0.046**	0.111***	0.044*	0.068*
	(0.028)	(0.022)	(0.026)	(0.027)	(0.037)
Land owned (ha)	-0.188**	0.097*	0.173***	0.085	0.167**
	(0.083)	(0.058)	(0.064)	(0.083)	(0.081)
Asset value(log)	0.306***	-0.070	-0.053	0.046	0.040
	(0.106)	(0.098)	(0.129)	(0.134)	(0.163)
Tropical Livestock Units as of 12 months ago	0.014	-0.023	-0.056	-0.059	-0.107
	(0.127)	(0.095)	(0.116)	(0.086)	(0.089)
Extension service access (1/0)	-1.078***	0.291	-0.212	0.505	0.158
	(0.345)	(0.294)	(0.317)	(0.315)	(0.445)
Credit access (1/0)	0.932	-0.151	1.800*	-0.314	3.856***
	(1.324)	(0.974)	(1.058)	(1.366)	(1.106)
Maize (1/0)	1.133***	1.413***	1.062***	2.208***	0.746**
	(0.281)	(0.263)	(0.274)	(0.439)	(0.366)
Rice (1/0)	-0.028	0.456**	-0.246	0.687***	0.449
	(0.255)	(0.195)	(0.263)	(0.232)	(0.283)
Beans (1/0)	0.120	-0.072	-0.106	-0.536***	-0.865***
	(0.175)	(0.150)	(0.169)	(0.183)	(0.257)
Share of households using tractor (0-1)	0.574	0.488	-1.505	1.402	5.602***
	(1.058)	(0.995)	(1.044)	(0.935)	(0.897)
Share of households using animal traction (0-1)	1.367**	-0.040	-0.024	3.639***	3.442***
	(0.545)	(0.524)	(0.595)	(0.419)	(0.523)
Share of households using inorganic fertilizers (0-1)	0.587	2.540***	4.606***	4.494***	3.903***
	(0.582)	(0.488)	(0.460)	(0.479)	(0.561)
Share of households using improved seeds (0-1)	1.191***	0.457	0.725**	0.934**	0.887*
	(0.353)	(0.351)	(0.362)	(0.379)	(0.477)
Mundlak controls	Yes	Yes	Yes	Yes	Yes
Year-region interaction	Yes	Yes	Yes	Yes	Yes
Observations	2,444	2,444	2,444	2,444	2,444

Notes: This table shows the coefficient estimates of the first stage of Multinomial Endogenous Treatment Effect (METE) regressions with the Mundlak approach, and robust standard errors clustered at the household level are in parentheses. No technology is the base category, which refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A5.4: Falsification tests

	HH self-employment (1)	Women self-employment (2)	Men self-employment (3)	HH wage work (4)	Women wage work (5)	Men wage work (6)
Share of households using tractor (0-1)	2.04 (3.199)	1.356 (3.099)	-0.051 (1.108)	-1.104 (2.039)	0.211 (11.609)	6.042 (4.234)
Share of households using animal traction (0-1)	-1.948 (1.290)	-0.673 (0.270)	-0.861 (0.666)	-1.475 (1.101)	0.619 (0.911)	0.955 (1.681)
Share of households using inorganic fertilizers (0-1)	-1.417 (1.811)	0.311 (2.283)	-1.093 (0.989)	-0.479 (1.421)	0.810 (1.228)	3.452 (2.432)
Share of households using improved seeds (0-1)	0.364 (2.840)	1.320 (3.181)	0.005 (1.128)	-0.877 (2.114)	3.060 (2.632)	3.413 (3.673)
Female-headed household (1/0)	3.435*** (0.830)	-2.909*** (0.619)	1.059** (0.457)	-1.892*** (0.524)	2.838*** (0.658)	-2.671*** (0.750)
Number of household members	0.397 (0.243)	0.307 (0.254)	0.444*** (0.163)	0.166 (0.272)	0.319* (0.169)	0.519 (0.415)
Age of household head (years)	0.024 (0.118)	0.011 (0.124)	0.013 (0.073)	0.092 (0.111)	0.015 (0.072)	-0.045 (0.139)
Education of household head (years)	0.334*** (0.086)	0.277*** (0.087)	-0.038 (0.051)	0.034 (0.081)	0.360** (0.087)	0.523*** (0.101)
Land owned (ha)	-0.191 (0.132)	0.097 (0.130)	-0.020 (0.052)	-0.041 (0.112)	-0.006 (0.032)	0.141 (0.102)
Asset value(log)	0.087 (0.267)	0.585* (0.353)	-0.625** (0.309)	-0.306 (0.396)	-0.176 (0.212)	0.006 (0.402)
Tropical Livestock Units	-0.040 (0.068)	-0.066 (0.112)	-0.092 (0.060)	0.092 (0.311)	0.009 (0.054)	-0.403** (0.159)
Extension access (1/0)	0.759 (0.872)	0.831 (1.026)	-0.917 (0.589)	1.460 (0.894)	0.595 (0.703)	0.866 (1.223)
Credit access (1/0)	-1.319 (3.527)	0.526 (8.577)	-1.170 (1.881)	4.563 (2.929)	4.097 (5.734)	-7.124 (4.920)
Maize (1/0)	-1.200 (1.032)	-2.183** (1.062)	1.117*** (0.367)	2.841*** (0.554)	0.085 (0.726)	-2.833** (1.346)
Rice (1/0)	0.048	-0.271	-0.171	0.782	-0.734	-0.039
Beans (1/0)	-2.559*** (0.666)	-1.503** (0.663)	-0.401 (0.389)	-0.225 (0.642)	-0.026 (0.529)	-1.527* (0.828)
Year-region interaction	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,444	2,444	2,444	2,444	2,444	2,444

Notes: OLS coefficient estimates of association between instruments and labor outcomes, and robust standard errors clustered at the household level are in parentheses. * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A5.5: Agricultural technologies and crop commercialization

	Full sample	No technology	IS	IF	IS+IF	IS+IF+AT	IS+IF+T
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Commercialization (0-1)	0.38	0.21	0.27	0.22	0.44***	0.54***	0.56***
	(0.39)	(0.29)	(0.30)	(0.30)	(0.38)	(0.38)	(0.41)
Observations	2,444	1,076	242	374	291	307	154

Notes: Commercialization is measured as the share of the value of produce sold. Mean values of commercialization are shown with standard deviations in parentheses. Data are pooled for the two survey rounds. Mean difference tests are carried out for the other technologies in comparison to the no technology category. No technology refers to where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization).

Table A5.6: Effect of technologies on family labor

	Total family labor (1)	Women family labor (2)	Men family labor (3)
IS	30.633	10.754	20.235***
	(25.612)	(31.286)	(7.497)
IF	-20.354	-14.527	0.686
	(20.192)	(16.747)	(9.958)
IS+IF	-39.623	-40.252	12.593
	(33.071)	(30.880)	(9.333)
IS+IF+AT	-80.352***	-25.124	-10.027*
	(17.010)	(15.913)	(5.517)
IS+IF+T	-83.231***	-55.041***	-28.040***
	(26.505)	(17.929)	(6.505)
Female-headed household (1/0)	36.215	80.184***	-43.179***
	(22.565)	(22.286)	(4.716)
Number of household members	8.337	6.621	1.370
	(6.076)	(5.601)	(1.934)
Age of household head (years)	3.353	3.283	0.193
	(2.604)	(2.551)	(0.764)
Education of household head (years)	3.945*	3.463*	0.380
	(2.130)	(2.058)	(0.578)
Land owned (ha)	-4.203**	-1.673	-2.773**
	(2.115)	(1.261)	(1.189)
Asset value(log)	0.239	0.747	-0.374
	(5.425)	(4.568)	(2.075)
Tropical Livestock Units	2.111	2.487	-0.336
	(2.072)	(1.641)	(0.973)
Extension service access (1/0)	-4.341	-9.041	2.458
	(16.266)	(15.076)	(6.058)
Credit access (1/0)	-159.988	-59.444	-99.024*
	(124.360)	(80.777)	(57.084)
Maize (1/0)	-85.530**	-92.663**	1.123
	(42.900)	(43.100)	(7.499)
Rice (1/0)	-48.632***	-47.069***	-4.219
	(18.488)	(18.129)	(4.562)
Beans (1/0)	44.391***	28.284**	18.408***
	(14.961)	(14.131)	(4.314)
Mundlak controls	Yes	Yes	Yes
Year-region interaction	2,444	2,444	2,444

Notes: This table shows the coefficient estimates of the second stage of Multinomial Endogenous Treat- ment Effect (METE) regressions with the Mundlak approach, and robust standard errors clustered at the household level are in parentheses. Family labor is measured by the number of person-days of labor per hectare. No technology is the base category, which refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A5.7: Effect of technologies on hired labor

	Total hired labor	Women hired labor	Men hired labor
	(1)	(2)	(3)
IS	0.337	-0.774	0.729
	(0.944)	(0.914)	(1.000)
IF	-0.729	-1.321	1.838**
	(1.732)	(1.271)	(0.772)
IS+IF	6.083***	3.178**	3.803***
	(2.122)	(1.422)	(1.309)
IS+IF+AT	0.868	0.733	3.478***
	(4.970)	(1.246)	(1.110)
IS+IF+T	4.359*	1.844	5.020***
	(2.572)	(1.366)	(1.240)
Female-headed household (1/0)	1.759	0.142	1.088*
	(1.177)	(0.727)	(0.590)
Number of household members	-0.278	-0.358	-0.440**
	(0.490)	(0.339)	(0.209)
Age of household head (years)	-0.291	0.088	-0.047
	(0.282)	(0.129)	(0.110)
Education of household head (years)	0.656***	0.269***	0.256***
	(0.219)	(0.102)	(0.092)
Land owned (ha)	-0.221	-0.190	-0.118
	(0.340)	(0.116)	(0.075)
Asset value(log)	1.020	0.058	0.406**
	(0.628)	(0.432)	(0.202)
Tropical Livestock	-0.704	-0.184	0.080
	(0.849)	(0.199)	(0.120)
Extension service access (1/0)	3.203*	2.804**	-0.900
	(1.836)	(1.295)	(0.911)
Credit access (1/0)	15.386	9.120	8.856
	(14.599)	(12.360)	(6.761)
Maize (1/0)	1.498	1.055	0.212
	(1.823)	(1.166)	(1.233)
Rice (1/0)	-1.915	0.171	-0.652
	(1.864)	(0.916)	(0.555)
Beans (1/0)	-2.788***	-1.165	-1.189**
	(1.065)	(0.714)	(0.533)
Mundlak controls	Yes	Yes	Yes
Year-region interaction	2,444	2,444	2,444

Notes: This table shows the coefficient estimates of the second stage of Multinomial Endogenous Treat- ment Effect (METE) regressions with the Mundlak approach, and robust standard errors clustered at the household level are in parentheses. Hired labor is measured by the number of person-days of labor per hectare. No technology is the base category, which refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.

Table A5.8: Effect of technologies on off-farm employment - hours worked

	Household self-employment (1)	Women self-employment (2)	Men self-employment (3)	Household wage work (4)	Women wage work (5)	Men wage work (6)
IS	-3.304	-3.619**	-1.624	-1.005	-1.644	0.252
	(3.402)	(1.549)	(1.207)	(2.261)	(4.27)	(1.902)
IF	-0.398	-4.124***	0.218	-2.941**	-2.004*	-3.730
	(2.237)	(1.769)	(1.352)	(2.391)	(1.40)	(2.351)
IS+IF	0.168	3.078**	0.129	1.604	1.117	2.907
	(2.177)	(1.341)	(1.501)	(1.126)	(1.132)	(3.062)
IS+IF+AT	1.249	3.615***	1.096	4.074*	1.293	4.692*
	(2.580)	(1.808)	(1.665)	(2.379)	(1.92)	(1.957)
IS+IF+T	5.399*	5.763**	4.743*	6.708***	2.293	7.756***
	(3.026)	(2.348)	(2.635)	(3.130)	(1.921)	(3.039)
Female-headed household (1/0)	0.561	3.236***	-2.609***	-1.839	3.237***	-5.361***
	(1.077)	(0.889)	(0.809)	(1.270)	(0.839)	(1.086)
Number of household members	0.759	0.670	-0.215	0.584	0.497	0.232
	(0.497)	(0.410)	(0.354)	(0.656)	(0.314)	(0.601)
Age of household head (years)	-0.241	-0.154	-0.278	-0.165	0.003	-0.076
	(0.251)	(0.175)	(0.190)	(0.230)	(0.133)	(0.201)
Education of household head (years)	0.331**	0.200*	0.208*	0.495***	0.208**	0.365**
	(0.153)	(0.115)	(0.116)	(0.168)	(0.096)	(0.161)
Land owned (ha)	-0.196	-0.683***	0.292	-0.206	0.039	0.077
	(0.232)	(0.222)	(0.312)	(0.283)	(0.136)	(0.285)
Asset value(log)	0.695	0.009	0.618	-1.297	-1.245***	-0.334
	(0.585)	(0.368)	(0.456)	(0.847)	(0.481)	(0.751)
Tropical Livestock Units	-0.367	-0.246	-0.116	1.592	0.146	1.367
	(0.506)	(0.237)	(0.372)	(1.371)	(0.228)	(1.306)
Extension service access (1/0)	0.463	0.494	1.056	-0.047	0.721	-0.392
	(1.754)	(1.186)	(1.321)	(1.909)	(0.930)	(1.765)
Credit access (1/0)	5.450	1.726	1.783	-5.021	0.624	-7.780
	(5.639)	(3.770)	(10.347)	(7.811)	(3.404)	(6.415)
Maize (1/0)	1.189	-0.159	-0.909	2.576	0.072	0.353
	(1.557)	(1.201)	(1.239)	(1.790)	(0.993)	(1.591)
Rice (1/0)	-1.835	0.079	-2.295**	0.348	-0.892	-0.872
	(1.314)	(1.033)	(1.044)	(1.474)	(0.745)	(1.341)
Beans (1/0)	-2.829***	-2.700***	-1.829**	-2.455**	-0.838	-1.275
	(1.073)	(0.769)	(0.807)	(1.250)	(0.646)	(1.169)
Mundlak controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-region interaction	Yes	Yes	Yes	Yes	Yes	Yes
Survey month	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,444	2,444	2,444	2,444	2,444	2,444

Notes: This table shows the coefficient estimates of the second stage of Multinomial Endogenous Treat- ment Effect (METE) regressions with the Mundlak approach, and robust standard errors clustered at the household level are in parentheses. Employment is measured by the hours worked in the last week before the survey. No technology is the base category, which refers to cases where improved seeds and inorganic fertilizers are not used, and land preparation is done manually. IS = Improved Seeds; IF = Inorganic Fertilizers; AT = Animal Traction; T = Tractors (mechanization). * denotes significance at 10%, ** denotes significance at 5%, and *** denotes significance at 1%.