Smallholder Livestock Commercialization and Dietary Diversity: Panel Data Evidence from Zambia[1]

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Abstract

Livestock represents rural wealth and economic prosperity, and their commercialization could have immense welfare, economic, nutritional, and socio-environmental benefits but little work considers these important dimensions. We investigate the relationship between livestock commercialization and dietary diversity by examining the six food groups of the Zambian food based dietary guidelines (FBDGs) in Zambia. Relying on a nationally representative rich panel dataset and employing different estimation strategies, we show that livestock commercialization is associated with dietary diversity. The consumption of fruits, vegetables, legumes, pulses and nuts as well as cereals, starchy roots and tubers respond more to livestock sales. In terms of which livestock contributes more to dietary diversity, we show that dietary diversity responds more to the sale of cattle and pigs at the extensive level of commercialization while poultry sales matter more at the intensive level. Exploring what may explain the relationship between livestock commercialization and dietary diversity, we identify three possible pathways - livestock income, off-farm income, and crop production diversity. From a gender perspective, we find similar gains for households where women and men share decision making and control, but the effects are more pronounced when females are overseeing decision making of the household. Additionally, we show that income, off-farm income, farm production diversity and gendered decision making are also associated with dietary diversity, further strengthening the identified pathways. These insights point to the importance of livestock commercialization as an important entry and leveraging point for improving dietary diversity.

Keywords: Livestock; production; commercialization; income; diets; nutrition; Zambia
JEL codes: I38; O12 ; Q12; Q13

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1. Introduction

In this paper, we investigate the association between smallholder livestock commercialization and household dietary diversity. Our measurement of dietary diversity relies on the six food groups specified in the Zambian Food Based Dietary Guidelines (FBDGs) as well as the standard household dietary diversity scores (FAO, 2021). These are six food groups that are locally available and grounded on contextual realities such as cereals, starchy roots, and tubers; vegetables; fruits; fish, insects, and animal-source foods; dairy; legumes, pulses, and nuts (FAO, 2021). These food groups are accessible, affordable, equitable and culturally acceptable with minimal environmental pressure (FAO and WHO, 2019). We also consider the 12 food groups of the standard and highly used dietary diversity scores (Swindale and Bilinsky, 2006). We examine livestock commercialization at both the extensive and intensive margins, where the extensive margin refers to whether households sell livestock, and the intensive margin refers to the actual number of livestock sold. To have a better sense of the degree of commercialization, we also use the livestock commercialization index which defines livestock commercialization as a ratio of total livestock sold to total livestock owned[2]. To enable comparison between livestock and hinge this on efficient measurements, we convert livestock resources to Tropical Livestock Units (TLUs) since different livestock offer unique contributions.[3]

In the interest of understanding which livestock contributes more to dietary diversity and adherence to Zambian FBDGs, we perform some heterogeneity analysis across five livestock portfolios: cattle, pigs, small ruminants (sheep and goats), and poultry. Related to this, we also look at how the six different food groups respond to livestock commercialization. To further enhance our analysis, we incorporate a gender dimension to understand how gendered decision-making matters. Different studies have shown differential access and control over decisions in households – including livestock production and sales. Our interest is in examining whether these gender dynamics matter for dietary diversity. We differentiate between households where men are the primary decision-makers and those where women play this role besides the standard differentiation by male and female headed households. Beyond this, we also estimate the

[2] The use of this outcome captures some effects that may be going through livestock ownership – specifically through the consumption of animal sourced foods.

[3] One TLU is equivalent to 250 kg live animal weight. We use the standard conversion factors to compute TLUs from the Food and Agriculture Organization (FAO) of the United Nation (see Jahnke and Jahnke, 1982). Full conversion table is in the supplementary information.

association between gendered decision making and dietary diversity. Additionally, we consider the implications of livestock commercialization on income, off-farm income and farm production diversity, with the aim of demonstrating associations between livestock commercialization and these pathways as well as with dietary diversity.

We rely on a rich two-wave micro-data from Zambia and estimate different panel data restimations to control for both observed and unobserved heterogeneities. Particularly, we employ the Mundlak Chamberlain device (correlated random effects) to control for possible time invariant unobserved heterogeneity in the relationship between commercialization and dietary diversity. (Mundlak, 1978; Chamberlain, 1984). To further address possible issues of endogeneity, we employ the two-stage least squares estimation approach which relies on the specification of instrumental variables. To identify the association between livestock commercialization and dietary diversity, we use the village-level livestock commercialization level as an instrument following a rich literature on smallholder commercialization that has relied on this instrumental variable (Ogutu et al., 2020; Geffersa and Tabe-Ojong, 2024). Given some of the potential limitations with this instrument (which we discuss below), we perform some robustness checks by estimating the Kinky least squares regression as an alternative identification strategy (Kripfganz, and Kiviet, 2021).

2. Material and methods

3.1 Farm household data

Our analysis relies on data from the Rural Agricultural Livelihood survey (RALS) which is a three wave nationally representative panel survey from Zambia. It was conducted in 2012, 2015 and 2019 by the Indaba Agricultural Policy Research Institute (IAPRI) in collaboration with the Ministry of Agriculture and the Zambia Statistics Agency. It is a nationally representative survey covering all the ten provinces of the country including Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, Northern, Northwestern, Southern, and Western provinces (see IAPRI, 2020). The survey and data collection relied on a stratified two-stage sampling design where in the first stage, primary sampling units (enumeration areas) were defined. A standard household listing exercise was carried out to understand how many households were in the enumeration areas. As part of the household listing exercise, households were stratified based on the total area under crop cultivation, cultivation of some special crops and livestock ownership as well as various sources of income. Following this, there was some systematic sampling to further select 20 households

across the three strata (area under crop cultivation, cultivation of special crops and livestock ownership, and income sources) in each of the randomly selected enumeration areas.

In 2012, about 8,839 farm households were successfully surveyed and interviewed. In 2015 and 2019, 7933, and 7241 households were re-interviewed. Previous studies relying on this data have shown that attrition is not an issue with the data as it is random (Mulenga et al., 2021). The survey is quite extensive and covers information on farm production, household and livelihood dynamics, input subsidies, adoption of sustainable intensification practices, livestock production and commercialization, conservation agriculture, forestry aspects as well as dietary diversity and food consumption. However, the information on dietary diversity and consumption of various food groups was only undertaken in 2015 and 2019. Given this, we only utilized the 2015 and 2019 panel data waves for the analysis. The food consumption and dietary diversity module relied on a 24-hour recall of the various food groups that were consumed by households, alongside food expenditures. For additional insights on the sampling and survey design, confer the RALS survey report (IAPRI, 2020).

3.2 Measurement of variables

3.2.1 Measurement of commercialization

We measure livestock commercialization both at the extensive and intensive margins. At the extensive margin, we measured the sales of different livestock portfolios (cattle, pigs, sheep, goats, and poultry) as an indicator variable which takes the value of 1 for households that sell livestock and 0 otherwise. At the intensive level, we consider the number of livestock that are sold in many areas as a better measure of livestock commercialization. Given that livestock numbers may be a naïve measure of intensive commercialization because different livestock offer unique contributions, we consider the livestock units to make this more representative and enable comparison between the livestock numbers. We relied on the tropical livestock units (TLU) which attach different units to different livestock. For instance, 1 cattle is 1TLU, sheep and goats are 0.1 and poultry is 0.01 (Jahnke and Jahnke, 1982)[4]. Figure 2 shows disaggregated livestock commercialization over time.

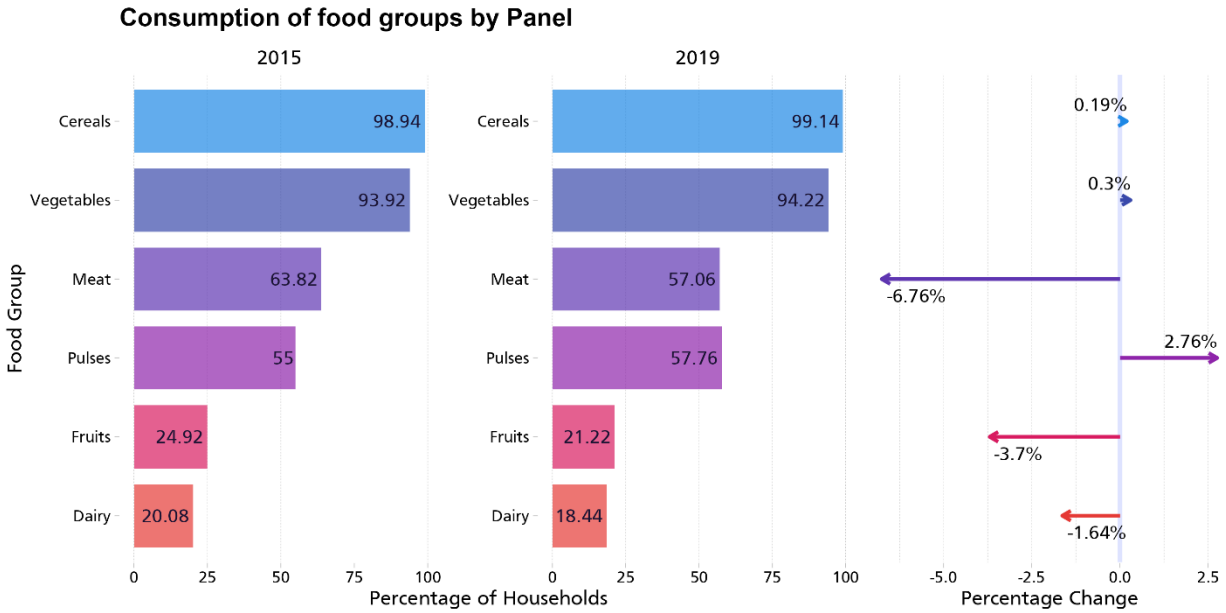
[4] Full conversion factors in Table S12 of the supplementary material.

Besides using the extensive and intensive measures of livestock commercialization, we also measure livestock commercialization using the livestock commercialization index which is a more nuanced and informative alternative than the traditional measures of commercialization (sellers vs non sellers and the number of livestock sold) which may oversimplify the complexity of commercialization. This index measures the ratio of the value of livestock sales to total livestock owned.

3.2.2 Measurement of outcomes

Our main outcome is dietary diversity based on the six food groups consumed by households in line with the Zambian FBDGs. These six food groups are cereals, starchy roots and tubers; vegetables; fruits; fish, insects and animal-source foods; dairy; legumes, pulses and nuts (FAO, 2021). These six well-integrated food groups promote different dimensions of individual health and well-being, while being accessible, affordable, equitable, and culturally acceptable (FAO and WHO, 2019). They are also locally adapted and culturally driven. Besides these, we also use the widely recognized household dietary diversity scores (HDDS) based on the consumption of 12 food groups as a robustness check (Swindale and Bilinsky, 2006). Figure 3 shows the various food groups and consumption patterns over time.

Figure 3 Dietary diversity in Zambia



3.3 Empirical strategy

Given we have panel data, we exploit the nature of the data using panel data estimations to understand the association between livestock commercialization and dietary diversity. We estimate a general regression equation of the form:

$$N_{it} = \alpha + CM_{it}\delta + \boldsymbol{X_{it}\beta} + t_t + c_{1i} + \varepsilon_{it} \quad (1)$$

Where N_{it} represents dietary diversity (FBDGs) which constitutes the six food groups consumed by households. It also includes the standard HDDS given that we perform some robustness checks on this (Swindale and Bilinsky, 2006). CM_{it} represents livestock commercialization. Our main parameter of interest is δ which measures the association between livestock commercialization and FBDGs. In all regression models, we add a set of household level controls represented as $\boldsymbol{X_i}$. ε_{it} is the stochastic error term which captures time varying unobservables and t_t refers to time fixed effects which captures changes over time. c_{1i} represents time-invariant unobserved heterogeneity and refers to variables which are time constant and hard to measure (or have not been measured) such as skills, preferences, managerial abilities, and motivation which may be driving both livestock commercialization and FBDGs.

Ignoring time invariant unobserved heterogeneity may lead to biased estimates of the association between livestock commercialization and dietary diversity. To control this, we use the Mundlak Chamberlain device, also known as the correlated random effect model (Mundlak, 1978; Chamberlain, 1982). It is a perfect blend of both the household fixed effect (FE) estimator and the random effect model (RE). It relaxes the strict assumption of the RE estimator about no correlation between unobserved heterogeneity and the controls while avoiding the incidental parameters problem common with FE estimators when estimating nonlinear models (Wooldridge 2019). It can be represented as:

$$N_{it} = \alpha + CM_{it}\delta + \boldsymbol{X_{it}\beta} + \tilde{\boldsymbol{X}}_{\boldsymbol{i}}\boldsymbol{\gamma} + t_t + c_{1i} + \varepsilon_{it} \quad (2)$$

The primary distinction between equations (1) and (2) lies in the inclusion of time-averaged values for the time-varying covariates ($\tilde{\boldsymbol{X}}_{\boldsymbol{i}}$). Nevertheless, for robustness, we also conduct analyses using the household fixed effects estimator.

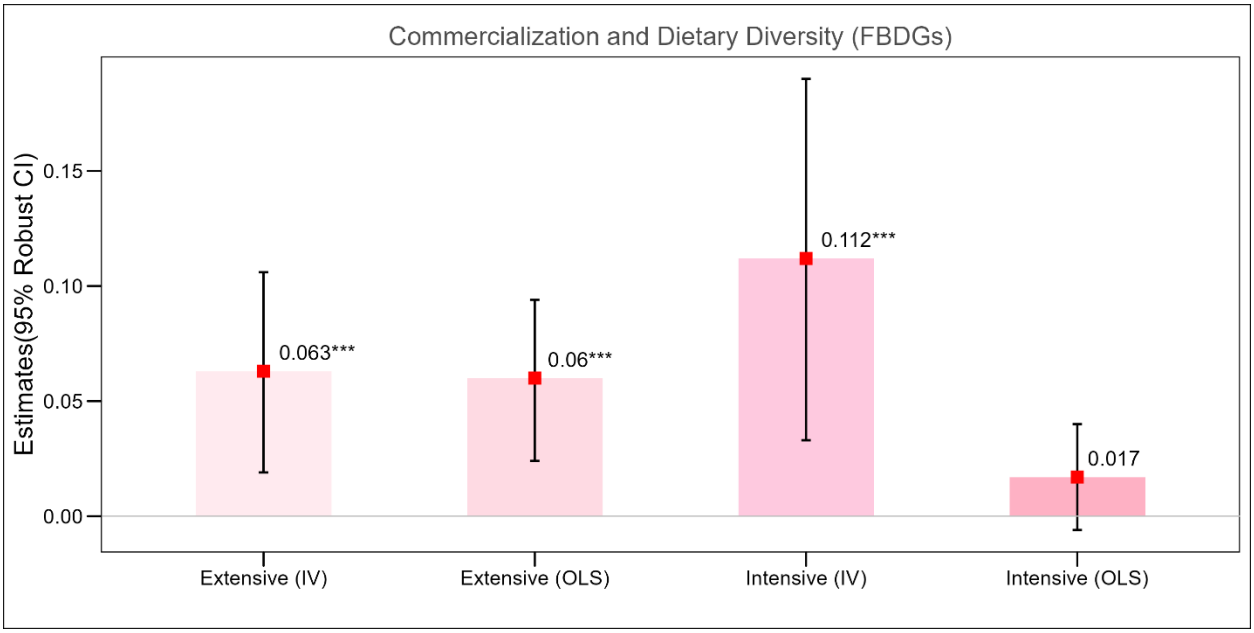
3. Results and discussion

We begin by presenting the results of the association between livestock commercialization (both at extensive and intensive margins) and dietary diversity. We then show how the different food groups in the Zambian FBDGs respond to livestock commercialization. In the third place, we highlight which livestock matters most in terms of the gains from commercialization. Going ahead, we show the pathway results on the importance of income, off-farm income, farm production diversity and gender. We then end with some robustness checks where we consider the standard 12 food groups of the household dietary diversity score and some identification checks using the Kinky least square regressions.

4.1 Livestock commercialization and dietary diversity

Figure 4 shows the association between smallholder livestock commercialization and dietary diversity. Our main estimations rely on the instrumental variable approach which we combine with the Mundlak Chamberlain device (correlated random effect model). We show a positive association between livestock commercialization at the extensive level and adherence to the FBDGs. Households who sell livestock consume more diverse and nutritious foods than their counterparts who do not sell livestock. When it comes to intensive livestock commercialization, we also observe a positive association with dietary diversity and adherence to the FBDGs.

Figure 4 Livestock commercialization and dietary diversity

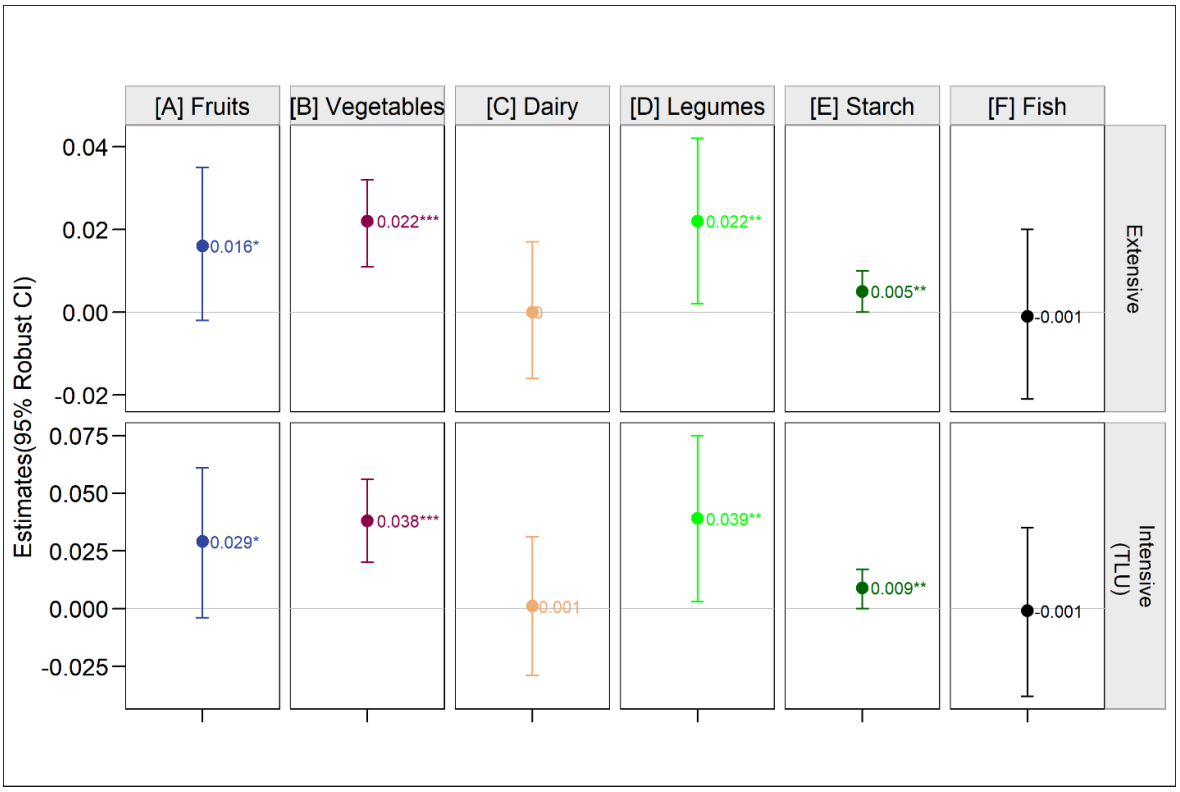


4.2 Livestock commercialization and individual food group consumption

We now examine how livestock commercialization is associated with the consumption of the six individual food groups in the FBDGs. Figure 5 shows the results for both extensive and intensive livestock commercialization and how they relate with the consumption of these food groups. We find similar insights in sign, magnitude, and direction on both extensive and intensive commercialization although intensive commercialization offers greater consumption gains. Extensive commercialization leads to commercialization of fruits, vegetables, legumes, and starch. Every additional unit (TLU) of livestock commercialized leads to a 2.9, 3.8, 3.9 and 0.9 percentage point increase in the consumption of fruits, vegetables, legumes, and starch, respectively.

It is important to acknowledge that all these food groups are nutritious and offer immense nutritional gains to households. While they can be purchased from markets, it could also be the case that households produce these crops themselves on their farms. This would indicate that households are engaged in mixed farming systems where they cultivate crops and rear livestock.

Figure 5 Livestock commercialization and consumption of individual food groups.



That said, it is important to highlight that higher livestock sales could also reduce household consumption of livestock products such as animal sourced foods. When a household sells more livestock, it may prioritize income generation over home consumption, potentially limiting the availability of livestock-derived products for household consumption. Additionally, the results in Figure 2 suggest a shift in consumption patterns, indicating that increased livestock commercialization is associated with a rise in the consumption of non-livestock-related products. This could mean that households invest the income from the commercialization of livestock on catering for household food demands from non-livestock products. This raises important questions about the trade-offs between income from livestock sales and household dietary diversity, particularly regarding the consumption of livestock products versus other food groups. This could possibly imply a substitution effect, where households allocate their income from livestock sales to purchase other food products rather than consuming their livestock products.

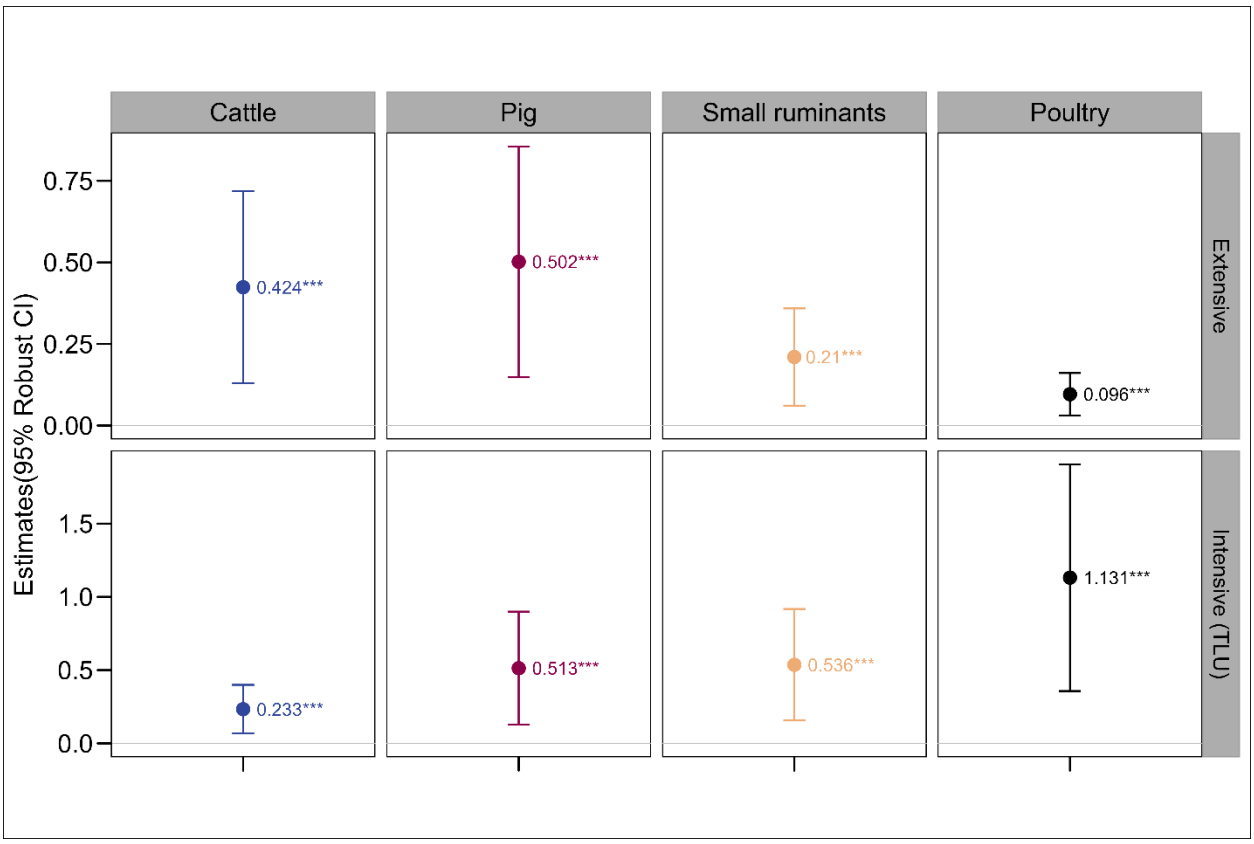
4.3 Which livestock matters most for nutrition?

After showing that livestock commercialization is positively associated with dietary diversity and nutritional adequacy, we take a deep dive to understand which type of livestock matters more for nutritional gains. We consider four different livestock portfolios: cattle, pigs, small ruminants (sheep and goats) and poultry. As shown in Figure 6, we obtain positive and statistically significant associations for all the livestock portfolios both at the extensive and intensive margins. In terms of the magnitudes, we obtain the largest magnitude for pigs and the lowest for poultry for extensive livestock commercialization. For intensive commercialization, the magnitudes increase steadily from cattle through pigs to small ruminants and poultry.

We obtain two insights from these estimates (Figure 6). First, for extensive livestock, we obtain the biggest nutritional gains from pigs, followed by cattle, small ruminants, and poultry. While this is a bit surprising because cattle usually have a high market value and offer immense income gains, this should be in order since we are considering nutrition. Households may slaughter their pigs directly, consume and increase their nutritional levels. Besides, pigs also have a high market value and can lead to income gains beyond their direct nutritional gains which could be used to purchase nutritious foods. Second, we obtain increasing magnitudes for intensive livestock commercialization from cattle to pigs, small ruminants, and poultry. This shows that although

poultry may have a low market value, their increased commercialization leads to immense nutritional gains.

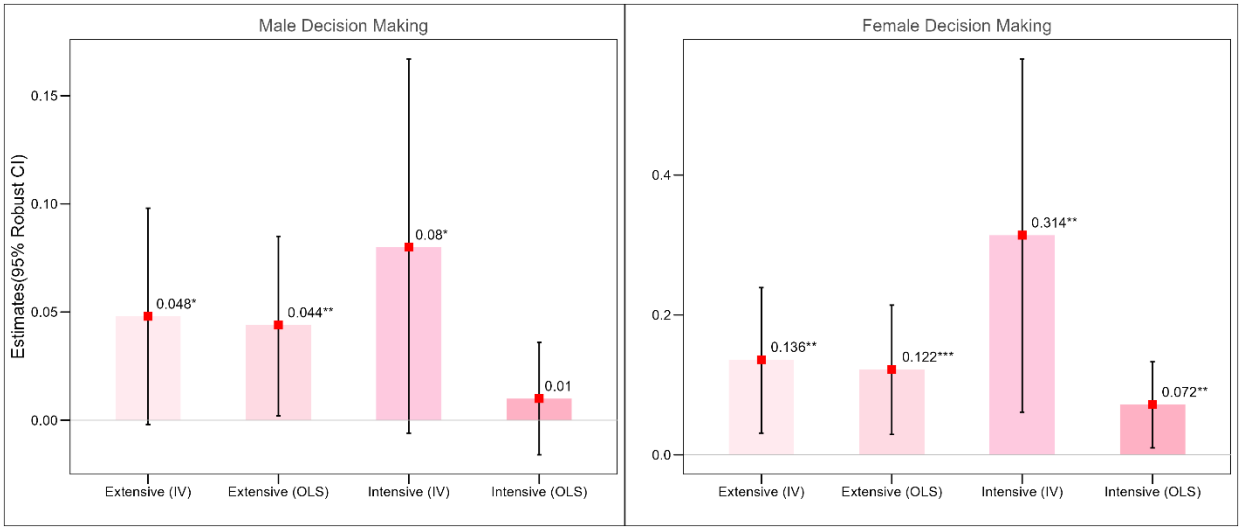
Figure 6 Disaggregated livestock commercialization and dietary diversity



4.4 Gendered decision making and commercialization

To further examine the role of gender in livestock commercialization, we conducted a detailed heterogeneity analysis. This involved dividing households into two distinct groups based on who holds primary decision-making authority and control: those where men lead these processes, and those where women do. By focusing on the actual locus of decision-making rather than simply the gender of the household head—a measure that can often be misleading or imprecise—we aim to gain a clearer understanding of how gender dynamics influence outcomes related to livestock commercialization. As shown in Figure 7, the nutritional gains of livestock commercialization accrue to all households, be they male headed or female controlled. However, a close look at the magnitudes and statistical significance shows that the female sample has bigger magnitudes and better statistical significance.

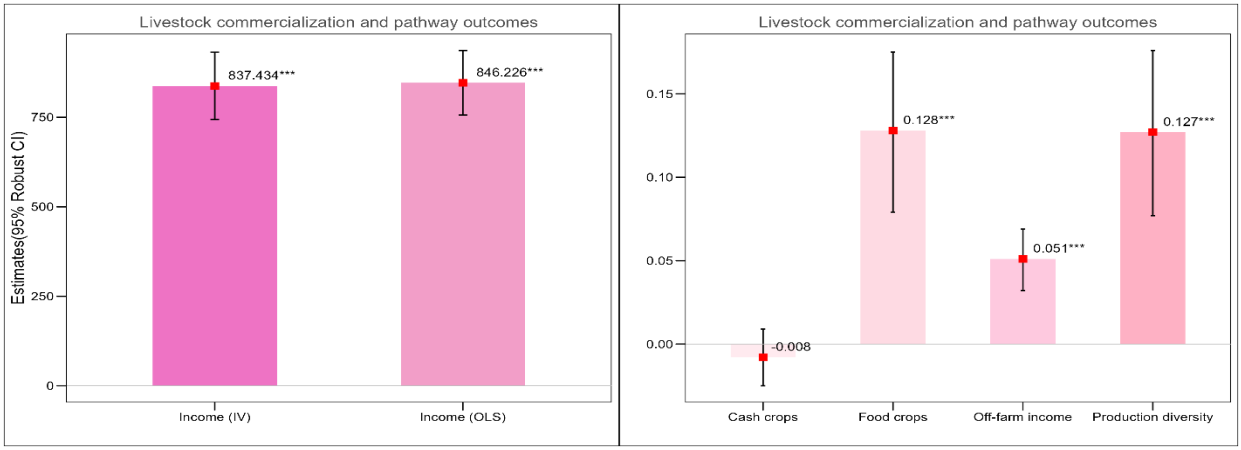
Figure 7 Gender decision making heterogeneity.



4.5 Identifying pathways of association

To understand what may be driving the relationship between livestock commercialization and nutritional adequacy, we consider three possible pathways which may explain these relationships: livestock income, off-farm income, and farm production diversity. Figure 8 shows the association of livestock commercialization with income, farm production diversity, cultivation of cash crops, food crops and off-farm income. We find that livestock commercialization is indeed positively associated with income and off-farm income. It is also positively associated with farm production diversity, especially the cultivation of food crops.

Figure 8 Pathways of impact between commercialization and dietary diversity



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