Gendered Misallocation of Agrarian Labor*

Gabriella Fleischman† and Nicholas Errol Rahim‡

August 21, 2026

Click here for the latest version

Abstract

We test a novel explanation for disparities in agricultural output between men and women in Malawi: child-bearing as a unique shock to women's labor supply that inhibits efficient land utilization. We implement a randomized controlled trial with female farmers who are pregnant or have a child under the age of two years old. We test the impact of providing five paid days of skilled agricultural labor during the farming season. For women who are enrolled in the trial during the first two trimesters of pregnancy, the program does not substitute for household labor, and, if anything, crowds *in* hired labor. These treated women experience a 0.26 standard deviation increase in harvest yields and a 0.39 standard deviation increase in maternal food security. For women enrolled in the trial during the third trimester of pregnancy, the treatment leads farmers to substitute away from hired labor and engage more in non-agricultural income-generating activities, with no effects on yields or food security. The program has no impact among women who are non-pregnant. We interpret these results through a model where the physiological labor supply shock of pregnancy interacts non-linearly with market failures and intra-household norms to create gendered shocks to farm productivity and consumption.

*Thank you to One Acre Fund Malawi and Invest in Knowledge Initiative, without whom this project would not be possible. Special thanks to Yash Gharat, Laetitia Pham, Nandi Bwanali, Emmanuel Malata, Ojas O, Fanny Kulisewa, Flora Magaleta, and James Mkandawire, who were instrumental in the intervention design, implementation, and data collection. We are thankful for useful comments and suggestions from Sarah Baum, Emily Breza, and Margaret McConnell. We gratefully acknowledge financial support from the Weiss Fund at the University of Chicago. This study received IRB approval from Harvard University Area, the Harvard Longwood Campus, and the Malawi National Committee on Research in Social Sciences and Humanities. The experiment was pre-registered under the AEA RCT Registry (AEARCTR-0014981) and ClinicalTrials.gov (NCT06631768).

†Fleischman: University of Pittsburgh, gfleischman@pitt.edu

‡Rahim: Harvard T.H. Chan School of Public Health, nrahim@g.harvard.edu

1 Introduction

Female-managed farming plots in low- and middle-income countries (LMICs) systemically produce less than their male counterparts (Oseni et al., 2014; Udry, 1996; Pierotti et al., 2022; Bambio, 2025). Existing evidence finds that the disparity in output is driven by disproportionate allocation of resources: women receive less or worse seeds, land, fertilizer, and labor (Akram-Lodhi, 2018; UN Women, 2015; Burke and Jayne, 2021). The primary source of labor for female-managed plots is the farmer herself. However, female farmers experience a double burden of labor in which they are expected to split their time between domestic responsibilities and income-generating activities. Moreover, the reduction in labor time and intensity caused by pregnancy is not adequately replaced by the labor of male household members (Bryson et al., 2021). Does the labor productivity shock represented by pregnancy in physically intensive work contribute to low productivity of female-managed plots? Do households reallocate land and labor inputs effectively to manage this labor productivity shock?

First, we quantify the bidirectional relationship between fertility behavior and agriculture. Using Malawi Demographic and Health Survey data, we find that births are most common in the height of the agricultural season. This implies that women experience pregnancy, a physiological phenomenon that increases nutritional requirements and makes physical activity more challenging, precisely at the same time that labor demand is highest and food prices are highest. Using data from One Acre Fund Malawi (OAF), a non-profit agricultural organization, we find that women who are pregnant for most of the farming season report working 15% fewer hours per week than non-pregnant women. While prior studies in sub-Saharan Africa have explored interventions to alleviate the constraints women face in allocating time between domestic responsibilities and income-generating activities, these interventions often focus on reducing the burden of childcare and tend to target those women whose youngest child is aged 1 year or older.[1] For women who are pregnant or postpartum, it may not be optimal or possible to reduce physiological and childcare barriers to engaging in agricultural employment without causing harm to maternal and child health.

Next, we conduct a cluster-randomized controlled trial in Malawi to test if labor shortages during pregnancy contribute to low farm productivity. We partner with OAF to provide subsidized casual farm labor, sourced and trained by OAF, to pregnant women and women caring for infants (the Planting Partners program). OAF is a non-profit

[1] There is evidence from across national contexts in sub-Saharan Africa that suggests that improving access to childcare resources increases maternal employment and income (Clark et al., 2019; Donald, 2024; Bjorvatn et al., 2025; Ajayi et al., 2022). In particular, Donald (2024) find that establishing childcare centers in rural communities in the Democratic Republic of the Congo increases the probability of female participation in farming crops for sale by 11 percentage points and increases the overall household production of produce via improving the productivity of female-managed plots.

organization that provides training and agricultural inputs to farmers on credit, such as seeds and fertilizers. Consequently, this sample is land-owning farmers with access to complementary capital inputs, but who typically cultivate their land with their own labor supply. The intervention effectively resolves myriad frictions to hiring farm labor (Breza and Kaur, 2025), including credit market frictions (Feder, 1985; Eswaran and Kotwal, 1986; Karlan et al., 2014), search frictions (Foster and Rosenzweig, 2022), labor supply rationing (Breza et al., 2021; Dillon et al., 2019b; Kaur, 2019), and quality control (Frisvold, 1994; Foster and Rosenzweig, 1994).

The treatment leads to substantial effects on farm yields (0.26 SD, $p < 0.10$) and maternal food security (0.39 SD, $p < 0.05$) among women who enter the trial early in their pregnancy. Solid food consumption for the youngest child decreases by 0.24 SD ($p < 0.05$), without any increases in the frequency of breastfeeding, suggesting improvements in the quality or quantity of breast milk.[2] These women's pregnancies overlap with most of the farming season, including the most labor-intensive farming activities, but they have the ability to provide some on-farm labor for much of the season. Women who are in their third trimester at the start of the farming season do not experience any treatment effects on production or consumption. These women spend most of the agricultural season in late-term pregnancy or postpartum recovery, particularly during phases of the season where supplying labor during narrow time frames has large implications for yields, and thus are severely constrained in their own ability to supply labor. There are no treatment effects among women who are not pregnant, suggesting that the binding labor supply constraint is physiological, rather than about time dedicated to childcare. Jointly, these results suggest that the physiological constraint of pregnancy limits women's ability to efficiently supply labor to their farm. The Planting Partners program was sufficient to overcome the labor supply shock of early- and mid-term pregnancy, but not enough to overcome the labor supply shock of spending most of the agricultural season in late-term pregnancy and postpartum recovery.

We propose a conceptual framework that extends standard agricultural household models and models of separation failures to explain these results (de Janvry et al., 1991; Singh et al., 1986; Benjamin, 1992). Consistent with prior models and empirical evidence demonstrating complementarities between farm labor supply and other farm inputs (Fink et al., 2020; Feder, 1985; Eswaran and Kotwal, 1986), we allow for a non-convexity in the marginal returns on labor. We assume that households always supply enough farm labor to produce food for subsistence, even when returns are lower than off-farm wages. In a standard model with complete markets, while pregnancy leads to a reduction in total

[2] For 75% of women in this group, the youngest child is less than 6 months old, the age up until which the World Health Organization recommends exclusive breast feeding (World Health Organization, 2026). All are less than 8 months old.

household labor supply available, it should not affect the productivity of *land*. Households can reallocate on-farm and off-farm labor between household members, can hire labor to cultivate the land, or can rent land out. We test if these margins of substitution are adequately available in the face of a labor productivity shock by estimating treatment effects on land use and labor allocations.

If pregnant control women are able to effectively utilize land renters and labor substitutes for their own farm labor, the Planting Partners program should crowd out at least one of these margins of substitution. Among women in all stages of pregnancy, there is no reduction in on-farm labor supply from other household members, suggesting there are constraints to intra-household labor substitution.[3] For women who enter the trial early in pregnancy, the treatment crowds *in* hired labor, while for women who enter the trial late in pregnancy, the treatment crowds *out* hired labor. There is no effect among women who are not pregnant. We argue that women who enter the trial late in pregnancy are unable to supply enough non-Planting Partners labor to benefit from complementarities between labor and other inputs, and choose to supply enough labor for subsistence with or without Planting Partners. Consistent with this hypothesis, we observe treated women who enter the trial late in pregnancy are more likely to engage in non-agricultural income-generating activities, suggesting they reinvest savings from hired labor into more profitable non-agricultural activities. Women who enter the trial early in pregnancy are able to supply labor productively enough so that, together with Planting Partners labor inputs, they are able to access complementarities, use land efficiently, and produce greater yields.

Jointly, this evidence demonstrates that pregnancy generates a gender-specific productivity shock whose economic consequences are amplified because households are unable to adjust through labor markets, land markets, or intra-household labor reallocation. Supplying insufficient labor so as to access complementarities with other inputs further amplifies the economic consequences of this labor supply shock. Pregnancy, market failures, and gender norms dictating household members' labor supply interact to shape women's well-being and household productivity.

This paper contributes to the literature on agricultural household models and separation failures by examining how multiple market imperfections jointly limit households' ability to adjust to productivity shocks. In a neoclassical household without market failures, a reduction in the labor supply of one household member can be offset through hired labor, land rental, or intra-household reallocation (de Janvry et al., 1991; Jacoby, 1993; Singh et al., 1986). However, we find that resolving frictions to hired labor leads to impacts

[3] There is likewise no reduction in labor hours supplied by the farmer herself, but this may mask increased time acting in a supervisory role while decreasing physically intensive work that hired labor can do more efficiently than pregnant women.

on consumption and production decisions that are significantly larger among women who are pregnant during the agricultural season. These findings provide evidence on the underlying complementary market failures in land markets, labor markets, and intra-household reallocation of labor, that can give rise to nonseparable behavior (Benjamin, 1992; Dillon et al., 2019a; Jones et al., 2022; LaFave and Thomas, 2016). Furthermore, we show that pregnancy, an almost universal yet gendered household labor supply shock in agricultural societies, exacerbates the implications of this inability to reoptimize.

Second, this paper contributes to the literature on intra-household allocation and gender differences in agricultural production. Our findings demonstrate that these norms interact with pregnancy to have important consequences for maternal and child health. A large body of work shows that women face systematic constraints in agricultural settings, including limited access to inputs, labor, and decision-making authority (Doss, 2018, 2013; Doss and Morris, 2001; Doss et al., 2015; Udry, 1996). We show that the economic consequences of these limitations on intra-household substitution of agricultural inputs is exacerbated by pregnancy, a biological shock to women's effective labor productivity. At the same time, resolving labor market frictions has substantive impacts on women's food security. These findings have direct policy implications for public health, as maternal and child malnutrition continues to be a pressing public health issue in many low- and middle-income countries (LMICs), which directly impacts people's well-being, survival, and productivity (Victora et al., 2021).

Third, the paper contributes to the broader literature on gender, labor supply, and the economic consequences of childbearing. Much of the existing literature, particularly in high-income contexts, emphasizes the role of labor supply decisions, employer responses, and institutional factors in generating gender gaps following childbirth (Bertrand et al., 2010; Kleven et al., 2019a,b; Angelov et al., 2016). In contrast, we show that in settings where work is physically intensive and markets are incomplete, the biological component of pregnancy itself can generate meaningful productivity losses. These results suggest that the economic impact of childbearing depends not only on labor market institutions and norms, but also on the extent to which households can access substitute inputs when biological constraints temporarily reduce women's productivity.

In Section 2, we describe the experimental design and empirical specification. Next, in Section 3, we describe the context, and present descriptive evidence on the seasonal relationship between fertility, agricultural production, and labor demand. Section 4 presents the treatment effects of the intervention on our main downstream outcomes: farm yields, maternal food security, and child nutrition. Section 5 presents a conceptual framework of how the gendered labor productivity shock of pregnancy and incomplete markets can interact to affect agricultural household decisions; guided by the framework, Section 6 estimates treatment effects on labor and land allocations. Finally, Section 7 concludes.

2 Experimental Design

We partner with One Acre Fund Malawi, a non-profit organization that provides training and agricultural inputs on credit to farmers, to evaluate the Planting Partners program. While OAF selects household who own land, and provides access to agricultural capital inputs, its model relies on farmers being able to supply their own labor to their farms or hire farm labor when they cannot. While most farmers are likely selected on the ability to supply farm labor, pregnancy represents a common but intense physiological shock to women's labor productivity. Planting Partners was designed to fill this gap and help child-bearing female farmers mitigate adverse consequences of labor supply shocks to their farm's productivity.

Site Selection and Eligibility

We conduct the RCT across four districts in Malawi at the "site" level, the geographic unit that OAF uses to administer services such as trainings and farmer monitoring. Each site includes several villages, but is smaller than any governmental administrative units. The four district we administer the study in are Chiradzulu, Dedza, Lilongwe, and Machinga, which span both the Central and Southern regions of Malawi. There are approximately 200 OAF sites across these four districts. We randomly select 75 sites for participation in the trial, stratified at the district level to provide representativeness across multiple regions that OAF operates in.[4] From these 75 sites, 38 were randomly selected to pilot the service and the remaining 37 were control sites.

Women were eligible within these sites if they were enrolled OAF farmers, and if they were pregnant or had a child under 1 year old in their household at the time of recruitment (November 2024). Finally, up to 45 eligible women were randomly selected from each site.

Planting Partners Program Details

OAF hired between two and three casual workers per site, depending on the number of eligible women. Selected women in treatment sites were offered a voucher that they could redeem up to five times, where each voucher was for a day of agricultural work supplied by the OAF casual worker hired within that site. Per protocol, workdays were meant to consist of six hours of work and a one-hour break. Farmers were told by OAF that they must also be present at the farm when the casual worker is there to provide oversight.

Labor from casual workers provided by the program could only be used to assist with farming-related activities associated with the OAF-sponsored plot managed by each beneficiary household, in which OAF inputs were used, including seeds, fertilizer, and OAF-encouraged farming methods. These OAF-sponsored plots were primarily for the purpose

[4] The Central and Southern regions in Malawi are distinct culturally and agriculturally.

of cultivating maize, but there are instances where households intercropped these plots with soybeans. The agricultural workers who provided this labor were screened, hired, and trained ahead of time by OAF. Farmers in both treated and control sites continued receiving the standard OAF programming.

Randomization was conducted in November 2024, and implementation of the "Planting Partners" program began in December 2024. We conducted a survey to measure impacts of the intervention after the conclusion of the harvest season in August and September of 2025. Details of this trial and analysis were recorded before program conclusion on ClinicalTrials.gov (NCT06631768) and AEA RCT Registry (AEARCTR-0014981).

2.1 Data

During eligibility surveying of female members, OAF collected basic information on pregnancy status, household members and their respective sexes and ages, and reported estimated daily amount of hours and lines worked as measures of quantity and quality of productivity. Farmers were unaware of the program rollout at this time, and surveyors were blinded to treatment assignment of sites. During the endline survey, data were collected on household characteristics, household crop production, farm labor quantity and sources, fertility history, maternal and child food consumption, and social networks.

2.1.1 Outcomes

The primary outcome of interest for this trial is total harvest yield, measured in Malawi Kwacha (MWK). We construct this measure by converting the amount of each crop reported into kilograms and multiplying by the median expected price reported in control sites in each district. The total value of each crop is then winsorized at the 1st and 99th percentile and then summed across every crop. The other main outcomes are measures of maternal and child well-being in terms of nutrition. For the farmers themselves, we construct a standardized measure of food security comprised of their responses to questions regarding how many times they went to bed hungry over the past month (0 = never; 1 = a few times or more); frequency of meals the day before and two days before (0 = one or two meals; 1 = three or more meals); and the numbers of days in the past month they consumed meat, egg, *usipa* (a preserved fish foodstuff), and fish. For the youngest child, we similarly construct a standardized measure of solid food consumption comprised of the reported number of days in the past month the child had meat; fruits and vegetables; and carbohydrates such as porridge, bread, rice, pap, or pasta. Because some of the farmers in this study gave birth during the agricultural season and thus their youngest child would not be expected to have transitioned to solid food, we also measure treatment effects on average daily frequency of breastfeeding of the youngest child when recalling over the past week.

2.1.2 Sample Characteristics and Program Implementation

Data Collection Timeline

Using administrative data from 13,585 female farmers across the 75 study sites, we randomly select 1,445 farmers who we determine to be eligible based on data from OAF's records. After eligibility is assessed and farmers are selected for the program, sites were randomized to treatment and control. OAF then conducted a verification process in treated areas in November 2024, to ensure the program was only administered to eligible farmers. Four sites were dropped from the trial entirely, because there were too few eligible women for One Acre Fund to be able to logistically provide the Planting Partners intervention. Given time constraints and the need to conduct this verification prior to the program roll-out, OAF only conducted the verification process in treatment areas. They conducted a similar verification process in control areas in April 2025. We hired a third-party survey firm, Invest in Knowledge Initiative, to collect endline data in August-September 2025, before the following agricultural season.

Analytical Sample Criteria

The verification process may have created a differential selection process for the endline survey, since verification surveys were conducted after treatment status was assigned, and at different times in treatment and control areas. To mitigate concerns about differential selection, we restrict our analytical sample to farmers whose eligibility is determined by a third-party survey firm that collected endline data. In the endline survey, households report the ages of each household member, the date of the last time they gave birth, and if they have had a miscarriage since November 2024. These variables allow us to impute eligibility (pregnancy or having a household member under 2 years old) in November 2024. This restriction drops 134 households, non-differentially between treatment and control.

We drop another 46 households (16 control and 30 treated) whose name did not match our originally recorded sample from the administrative data we used to determine eligibility. In some cases, these are situations where a treated respondent transferred the Planting Partners vouchers to somebody else. In other cases, in both treatment and control areas, farmers registered with OAF under a family member's name. While the second case does not create issues of differential selection across treated and control areas, we remove all households where the names do not align to be as conservative as possible and eliminate all threats to treatment imbalance. Ultimately, we drop 16% of control respondents and 20% of treated respondents. Our final analytical sample consists of 440 farmers in the treated group and 368 farmers in the control group.

The final sample is balanced overall between treated and control groups ($p = 0.176$ for

Table 1: Balance of characteristics between treated and controlled group

Characteristic	Control Farmers (N = 359)	Treated Farmers (N = 433)	p-value	N	Clusters
Proportion reported pregnant at time trial start in OAF data	0.53 (0.03)	0.48 (0.02)	0.319	792	71
Reported household size at trial start	4.53 (0.09)	4.96 (0.08)	0.013	792	71
Reported lines worked per day	22.36 (0.79)	25.86 (0.69)	0.445	792	71
Reported hours worked per day	4.22 (0.10)	4.10 (0.06)	0.559	792	71
Married and living together	0.82 (0.02)	0.83 (0.02)	0.837	792	71
Number of prior births	3.38 (0.09)	3.27 (0.09)	0.516	792	71
Age	32.63 (0.34)	32.83 (0.37)	0.376	792	71
Proportion reported pregnant during trial in research data	0.47 (0.03)	0.41 (0.02)	0.104	792	71
Total acres owned	1.65 (0.06)	1.83 (0.06)	0.214	791	71
F-test of joint significance (F-stat)		1.47	0.176	791	71

Note: Results presented as mean (standard error). p-values calculated via simple linear regression models with district-level fixed effects and standard errors clustered at the One Acre Fund site-level. Lines worked, hours worked, and household size winsorized at the 1st and 99th percentiles.

joint test, Table 1). That being said, there is a slight imbalance between the two groups in regard to household size reported in administrative data. Treated households are slightly larger, with 4.96 versus 4.54 household members ($p = 0.013$).

Program Implementation

Of the 440 farmers who were selected to receive the treatment and were confirmed to be eligible, 354 (80.45%) made use of the Planting Partners program (Table A.6). Farmers who opted to participate in the program utilized an average of 13.59 hours of casual laborers' time, with each workday with the casual worker being roughly three hours. While this is a shorter span of time than what was initially stipulated, feedback from both farmers and casual workers conveyed that six hours was too long to be actively working on the farm. This is supported by the average number of hours reported by farmers in the control group. Generally, beneficiary farmers rated the casual laborer assigned to them as better-skilled than the average farmer.

2.2 Empirical Specification

2.2.1 Intention-to-treat effects and effect heterogeneity

We estimate the effect of assignment to treatment using the following linear regression model specification:

$$Y_{ids} = \beta_0 + \beta_1 T_s + X_i\beta + \delta_d + \epsilon_{ids}, \tag{1}$$

where T_s indicates whether farmer i is in a treated site, and δ_d are district fixed effects. We include vector X_i containing variables that are unbalanced in either the main sample or within pregnancy groups and whether the participant gave birth during the trial in order to improve efficiency and correct for residual imbalance.[5] Standard errors are clustered at the site level.

We pre-specified our hypothesis that giving birth during the agricultural season would be a greater negative shock to self-sourced labor supply, relative to having a youngest child aged between 1 and 2 years. As such, we evaluate whether a labor subsidy would have a greater effect among those who were pregnant at the time of program start by estimating the following model:

$$\begin{aligned} Y_{ids} &= \beta_0 + \beta_1 T_s + \beta_2 \mathbb{I}(P_i = 1) + \beta_3 \mathbb{I}(P_i = 2) \\ &\quad + \beta_4 \mathbb{I}(P_i = 1) \times T_s + \beta_5 \mathbb{I}(P_i = 2) \times T_s + X_i \beta + \delta_d + \epsilon_{ids}. \end{aligned} \tag{2}$$

Here, P_i is a categorical variable for pregnancy status at the time of recruitment, where 0 indicates non-pregnant (62% of participants), 1 indicates first or second trimester (21% of participants), and 2 indicates third trimester (17% of participants).[6] We pool women who were in the first two trimesters of pregnancy because there are very few women who were in their first trimester of pregnancy during recruitment, likely because they were not aware of or unwilling to disclose their pregnancy status at the time (45 women in trimester 1, compared with 108 women in trimester 2). X_i are the same covariates as Equation 1 along with interactions between P_i and variables that are unbalanced across treatment and control within any of the sub-samples selected via double-selection Lasso method (Belloni et al., 2014). Data were analyzed using Stata version 18.0 (StataCorp, College Station, TX).

2.2.2 Treatment-on-the-treated effects

Treatment take-up is imperfect, with 20% of treated households never utilizing Planting Partners. Among households who *did* utilize Planting Partners, the hours of Planting Partner time on the farm ranged from 1 to 40 hours (mean = 13.5 hours, median = 12 hours).[7] To estimate the impacts of Planting Partners support on the farm, we estimate

[5]The unbalanced variables are the number of acres owned by the household, and a continuous measure of household size as measured in the administrative data collected before treatment assignment, a binary indicator for whether the participant is a married and cohabitating with partner, and a continuous measure of age in years (Tables A.3 - A.5)

[6]Because our estimations of pregnancy beginnings are based on dates of child birth, we omit this categorization for women who experienced a miscarriage during the agricultural season

[7]Planting Partners hours on the farm is winsorized at the first and ninety-ninth percentiles.

treatment-on-the-treated (TOT) effects:

$$Y_i = \beta_0 + \beta_1 \hat{Z}_i + X_i\beta + \delta_d + \epsilon_{ids} \tag{3}$$

$$Z_i = \beta_0 + \beta_1 T_s + X_i\beta + \delta_d + \epsilon_{ids}, \tag{4}$$

where Z_i is treatment take-up, and all other variables are as in Equation 1. In our main tables, Z_i is a variable that takes the value of 1 for treated households who used any amount of Planting Partners support on the farm, and takes the value of 0 for control households and treated households who never utilized Planting Partners.[8]

To evaluate TOT effects heterogeneously, we estimate Equations 3 and 4 separately in the three sub-samples among whom we evaluate ITT effect heterogeneity: women who were not pregnant at the time of recruitment, women who were in the first or second trimester at the time of recruitment, and women in the third trimester.

3 Background: Agriculture and Fertility

3.1 Maternal Malnutrition and Female Farming

Globally, 8% of adolescent girls and 10% of women are considered underweight, with 68% of underweight women and girls living in South Asia and sub-Saharan Africa (UNICEF, 2022). Beyond female malnutrition's direct contribution to the gender gap via the reduction in learning and work potential, maternal malnutrition is associated with increased risks of many adverse health outcomes (de Souza et al., 2011; Talebi et al., 2024; Allen et al., 2025; Lechtig et al., 1978; Dolati et al., 2025).[9] The issue of maternal malnutrition is further exacerbated in settings in which subsistence farming is prevalent. At a time when it might be optimal to conserve their labor due to the physiological constraints of pregnancy symptoms and increased nutritional needs, pregnant women must conduct strenuous physical labor during the agricultural season to improve food security in the harvesting period (Talebi et al., 2024; Khammarnia et al., 2024; Marshall et al., 2022; Rao et al., 2003). Bryson et al. (2021) show qualitatively that this tradeoff prompts female farmers to attempt to time their pregnancies around the harvest season in order to both overlap with the time of greatest food availability and least intensive labor requirements. Even so, this is not always possible even with accessible family planning services available and full bodily autonomy.

At the same time, female-managed plots have systematically lower productivity relative to male-managed plots. The underdevelopment of female-managed plots both directly

[8] There were no cases of Control farmers who were able to access Planting Partners farm labor.

[9] For example: low birthweight, reduced child development, gestational hypertension, gestational diabetes, and infant mortality.

limits total household income for households primarily engaged in subsistence farming and undermines women's ability to influence household decisions, including fertility timing (Bernard et al., 2020; Doss, 2013). Given women's propensity to spend on food and healthcare when they have more financial power, this has implications for the well-being of all household members (Duflo, 2003; Kevane, 2012; Lufuke and Tian, 2024).

Located in southern Africa, Malawi is an ideal setting to explore this tension. Its economy strongly relies on farming, with approximately 80% of households engaged in agricultural activities (Akram-Lodhi, 2018). A majority of agricultural activity is small-scale for the purpose of providing food and income to the household. There is also a gendered dynamic to the types of crops grown by women and men, with women tending to cultivate food crops like maize, soybeans, and pigeon peas, and men tending to cultivate cash crops like tobacco and cotton (Zimba et al., 2025; Perelli et al., 2024). Similar to other countries in this region, there is a 28% gap in productivity between male-managed and female-managed plots (Akram-Lodhi, 2018; UN Women, 2015; Burke and Jayne, 2021).

While women in Malawi are actively engaged in farm labor, they also are very frequently pregnant or postpartum. In a cross-sectional representative survey, forty percent of women in rural Malawi aged 18–35 years are pregnant or have a child aged less than two years, and an additional 11% want to have another child in the next two years (National Statistical Office (NSO) et al., 2024).

3.2 Seasonality of Fertility and Agriculture

3.2.1 Data and Empirical Specification

Using data from both the OAF administrative survey and the endline survey, we can measure the differences in agricultural behavior by pregnancy status to better expand the empirical evidence base for reduced investment into farming due to pregnancy and postpartum. We restrict our sample to data collected in control sites and estimate the differences in land renting; land usage; productivity toward the beginning of the agricultural season measured in hours and lines worked per day; productivity measured during endline when recalling the average number of hours worked per week; engagement in non-agricultural income generating activities; and total harvest yield, measured in Malawi Kwacha (MWK). Land usage is defined as the proportion of land that is owned or rented by the household that is cultivated during the agricultural season under observation. Similarly, we describe the differences in food security during the post-harvest period by pregnancy status among farmers in control sites.

Data from the Malawi 2024 Demographic and Health Survey (MDHS 2024) and the endline survey can be used to show how natality trends correlate with the agricultural season. We formally explore whether there is monthly and quarterly seasonality in these trends using the following two models:

$$\text{NumBirths}_t = \beta_0 + \beta_1 \text{Time}_t + \beta_2 \text{Month}_t + \epsilon_t, \tag{5}$$

$$\text{NumBirths}_t = \beta_0 + \beta_1 \text{Time}_t + \beta_2 \text{Quarter}_t + \epsilon_t. \tag{6}$$

These are two OLS regressions estimated using time-series data of the total number of birth events per month t in the MDHS 2024 from January 2013 to December 2023, with Time_t being a continuous measure of time in months. Month_t and Quarter_t are categorical variables for the month of the year and the quarter of the year, respectively. Standard errors are estimated using the Newey-West estimator, which is robust to temporal autocorrelation.

3.2.2 Descriptive Evidence

Agricultural behavior by pregnancy status

Table 2 shows the means and standard errors of measures of agricultural engagement by pregnancy status group among farmers in the control group. Differences between groups were assessed for statistical significance using OLS models with the agricultural measure regressed on binary indicators for pregnancy status with district-level fixed effects and standard errors adjusted for clustering at the site level. Due to the low number of clusters, p-values for the joint test of the coefficients against the null were derived using wild cluster bootstrapping with 999 replications.

There is no difference in amount of land rented by pregnancy status ($p = 0.874$). Similarly, land usage does not vary significantly by pregnancy status ($p = 0.891$), with each subgroup cultivating upwards of 95% of available land. The number of lines and hours worked each day on average toward the start of the agricultural season did not vary ($p = 0.4494$ and $p = 0.366$). However, there is a more observable difference in the weekly average number of hours worked when recalling over the entire agricultural season ($p = 0.111$). Farmers enrolled while not pregnant reported 22.72 hours per week, while farmers enrolled in their first/second trimesters and third trimester reported 19.24 hours and 21.05 hours per week respectively.

There is slightly stronger evidence that pregnancy status at baseline may be correlated with productivity when recalling over the entire agricultural season as compared to productivity toward the beginning. There are two possible explanations for this. First, the strenuous nature of farming activity changes throughout the agricultural season. The start of the agriculture season with land preparation in August and planting in November are high-effort activities, but both are still less intensive than weeding that occurs sometime between December and March. It may be the case that one's pregnancy status

Table 2: Agricultural Behavior by Pregnancy Status

Measure	(1) Non-Pregnant (N=190)	(2) Enrolled 1st/2nd trimester (N=75)	(3) Enrolled 3rd trimester (N=60)	p-value
Acres rented by the household for use	0.35 (0.04)	0.36 (0.07)	0.32 (0.09)	0.882
Proportion of household land cultivated	0.95 (0.01)	0.96 (0.01)	0.96 (0.02)	0.891
Whether the household rents out land	0.08 (0.02)	0.04 (0.02)	0.02 (0.02)	0.109
Reported lines worked per day	22.98 (1.11)	22.79 (1.64)	21.15 (2.01)	0.460
Reported hours worked per day	4.34 (0.13)	3.85 (0.21)	4.25 (0.25)	0.411
Average hours of labor per week from self	22.72 (0.76)	18.84 (1.35)	21.05 (1.53)	0.067
Whether the farmer engages in non-agricultural income generating activities	0.67 (0.03)	0.60 (0.06)	0.58 (0.06)	0.308
Total agricultural yield (MWK)	1432714.78 (105130.91)	1197653.80 (126103.21)	1238048.90 (144538.00)	0.212

Note: Results presented as mean (standard error). p-values calculated via simple linear regression of each measure regressed upon pregnancy status binary indicators with district-level fixed effects. Final p-values estimated with wild cluster bootstrap jointly testing indicators against null hypotheses that they equal zero, with clustering at the site-level. Average hours of labor per week recalling over the whole agricultural season winsorized at the 1st and 99th percentiles.

does not hinder labor output as much below a certain intensity level. Second, unlike the earlier collected OAF administrative data, the endline measure of productivity takes into account the shock of childbirth and the subsequent recovery period. This difference in labor is further corroborated by the lower agricultural yields of both pregnancy groups, with the gap in yields between the non-pregnant group and the early pregnancy group being larger (1,432,714.78 MWK *vs.* 1,188,342.57).

Table 3: Food Security by Pregnancy Status

Measure	(1) Non-Pregnant (N=190)	(2) Enrolled 1st/2nd trimester (N=76)	(3) Enrolled 3rd trimester (N=60)	p-value
Whether the farmer went to bed hungry a few or more times in the past month	0.27 (0.03)	0.39 (0.06)	0.35 (0.06)	0.137
Whether farmer had three meals yesterday	0.41 (0.04)	0.29 (0.05)	0.28 (0.06)	0.030
Whether farmer had three meals the day before	0.42 (0.04)	0.26 (0.05)	0.23 (0.06)	0.003
Days of maternal meat consumption in the past month	2.18 (0.21)	2.03 (0.38)	1.95 (0.35)	0.692
Days of maternal egg consumption in the past month	2.56 (0.27)	2.13 (0.41)	2.05 (0.40)	0.479
Days of maternal usipa consumption in the past month	4.11 (0.42)	3.66 (0.63)	3.78 (0.69)	0.720
Days of maternal fish consumption in the past month	3.99 (0.33)	4.51 (0.56)	2.78 (0.46)	0.124

Note: Results presented as mean (standard error). p-values calculated via simple linear regression of each measure regressed upon pregnancy status binary indicators with district-level fixed effects. Final p-values estimated with wild cluster bootstrap jointly testing indicators against null hypotheses that they equal zero, with clustering at the site-level.

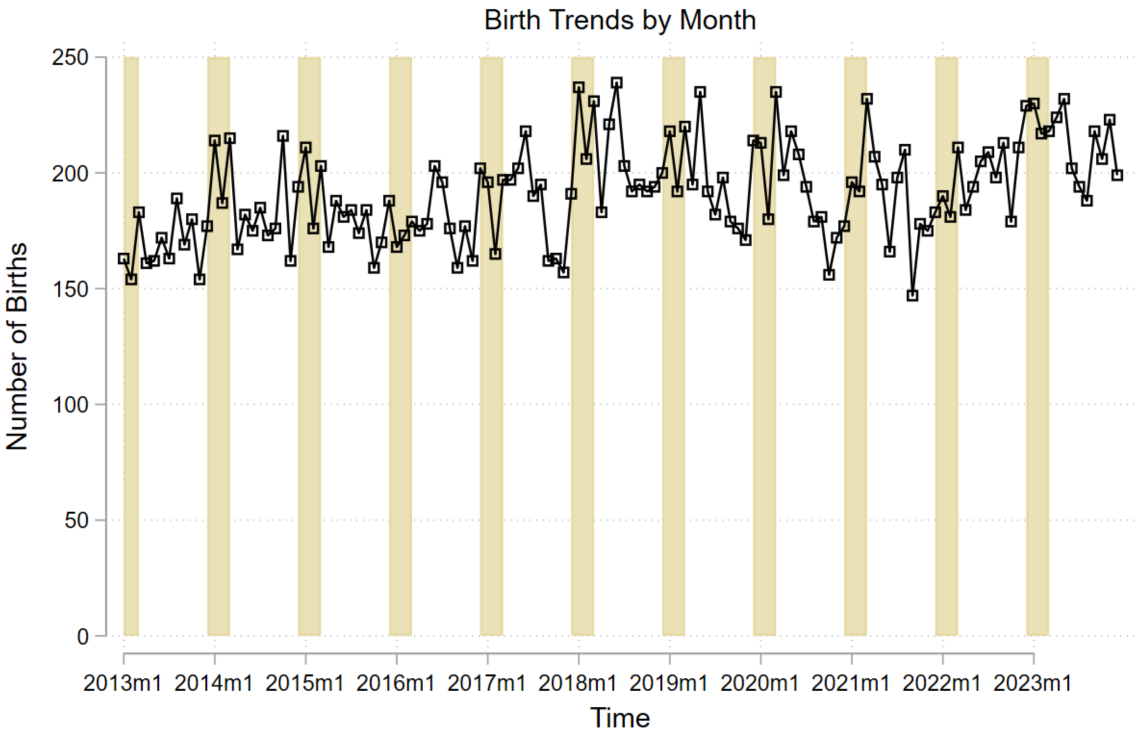
Food security by pregnancy status

We present differences in food security in Table 3. Measures of statistical significance are calculated the same as Table 2. We find differences in terms of frequency of food consumption. Farmers in both pregnancy groups were more likely to report going to bed hungry a few or more times in the preceding month (35% and 39% *vs.* 27%; $p = 0.137$). Additionally, both pregnancy groups are more than 10 percentage points (pp) less likely to report having at least two meals the day before or two days before ($p = 0.030$ and $p = 0.003$). There is less of a difference in diet quality as proxied by frequency of protein consumption.

Fertility Trends in Malawi

We illustrate the monthly trends in childbirth events from January 2013 through December 2023 in Malawi using the birth history module of the MDHS 2024 in Figure 1. There is evidence of modest seasonality, with birth events at their lowest between September and November and reaching their peak in the first quarter, specifically January and March (Table 4). This peak in natality coincides with the majority of the lean season and the peak in rural labor demand in December and January when farmers are engaging in planting and weeding activities (De Weerdt et al., 2024; Famine Early Warning Systems Network and USAID, 2024). The hypothesis that these birth trends are influenced by the agricultural calendar is further supported when the data are disaggregated by rurality, with these trends becoming more pronounced in rural areas and disappearing in urban areas (Figures A.1 and A.2, Tables A.1 and A.2).

Figure 1: Seasonality in birth events in Malawi



Note: Point estimates represent unweighted total number of birth events that occur in each month in Malawi Demographic health Survey 2024. Blue shading indicates lean season (December through March). Data restricted to January 2013 to December 2023.

Under the assumption that households have total agency over birth timing, these trends suggest suboptimal fertility behavior where the third trimester and childbirth overlap with a period in which calories are both scarcer due to limited food supply and in even greater demand as a result of higher workload. This is even more contradictory if we also consider that ensuring sufficient calorie intake becomes even more important for the health of both the mother and child during the third trimester and early postpartum.

Table 4: Models of seasonality of birth events in Malawi

(1)

Month	Estimate (SE)
January	28.43*** (7.91)
February	8.82 (5.64)
March	35.93*** (6.98)
April	11.68** (5.42)
May	24.79*** (6.53)
June	20.35** (8.06)
July	14.37** (5.56)
August	11.76* (6.49)
September	3.41 (4.76)
October	3.07 (7.17)
November	REF
December	18.20** (5.94)

(2)

Quarter	Estimate (SE)
First Quarter	17.31*** (4.61)
Second Quarter	11.85** (4.70)
Third Quarter	2.76 (2.87)
Fourth Quarter	REF

Note: OLS regressions of total number of birth events per month in model (1) and quarter in model (2), with a continuous measure of time in months. Results presented as point estimates (standard error), with Newey-West standard errors allowing for temporal autocorrelation between time periods, with optimized lags (a lag of 9 time periods in model (1) and 11 in model (2)). ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

An explanation for why we might be observing these trends is that some combination of the malnutrition caused by food scarcity and strenuous labor influences birth timing by inducing women to give birth prematurely (Dole et al., 2003; Bonell et al., 2022). When restricting to the same time range as the time-series models, we see in Table 3 that the prevalence of birth events that end in preterm birth is highest in January (11.27%), March (11.45%), and May (11.60%). If we assume that these premature births were accelerated by roughly a month, then it could be that a greater portion of households were planning the birth and the subsequent postpartum period to overlap with the early and middle stages of the harvest season when food is most available. Given that this would be the point at which the maternal consumption requirements are highest, this would be indicative of a fertility pattern that aims to optimally match the demand and supply of calories (Kominiarek and Rajan, 2016). However, the differences in preterm prevalence rates by month are not large enough to explain away all of the excess bulk of childbirths in the first quarter. Alternatively, it may not be a question of fertility timing, but the presence of conducive factors for conception. Assuming an average gestation period of nine months, these births occurring in the first quarter would have concluded pregnancies beginning in the harvest period. The reduced stress from lower labor demand and increased food availability during the harvest period would jointly serve to support higher fertility rates, resulting in more births in the first quarter (Lewinski and Brzozowska, 2023; Gaskins and Chavarro, 2018).

Regardless, the fact that there is an increase in births occurring when the demand for rural labor is highest, and that we present evidence that the third trimester and early postpartum limits labor supply, underscores that there is need for an intervention to support pregnant and postpartum female farmers to maximize their food supply.

3.3 Rural Labor Markets in Malawi

Participation in Malawi's rural casual labor markets is prevalent, with roughly 75% of farming households engaging in short-term labor, known locally as *ganyu* (Benson and De Weerdt, 2023). Similar to its peers, Malawian labor markets are characterized by liquidity constraints in which there is a lack of funds and credit readily available to purchase short-term labor, even in situations where a small investment in labor would yield better returns during harvest (Ambler et al., 2018; Fink et al., 2020). While there is evidence that *ganyu* are locally sourced from the same village or nearby villages to the employing farm, there is still the possibility for search costs of finding *ganyu* when worker quality is not perfectly observable (Ambler et al., 2018; Benson and De Weerdt, 2023; Breza and Kaur, 2025).

We can again leverage data collected during our study procedures to describe behaviors around labor consumption in this demographic of households with access to farmable land. We stratify by treatment groups and by farming activity. The farming activities included are planting (November - December), fertilizer application (November - January), weeding (December - February), harvesting (March - July), and land clearing/burning (June - August). In line with prior research on rural labor in this context, demand for labor is highest during the weeding period (Figure 2). Among farmers in control sites, 34% hired at least one casual worker for weeding activities, while the next highest rate of market engagement was during harvest (19%). Farmers in control sites hired an average of 55 hours labor, with approximately half of this labor allocated toward weeding. Average wages for casual labor were relatively stable throughout the agricultural season, though there is a slight dip during harvest activities. This may be due to the increased intensity of the resource constraints households face at the tail-end of the lean season. Despite the gap in self-sourced labor between pregnant and non-pregnant farmers shown in Section 2.2.2, pregnant farmers do not compensate for this deficit with hired labor, either in terms of market participation or total number of hours.

4 Results: Main Outcomes

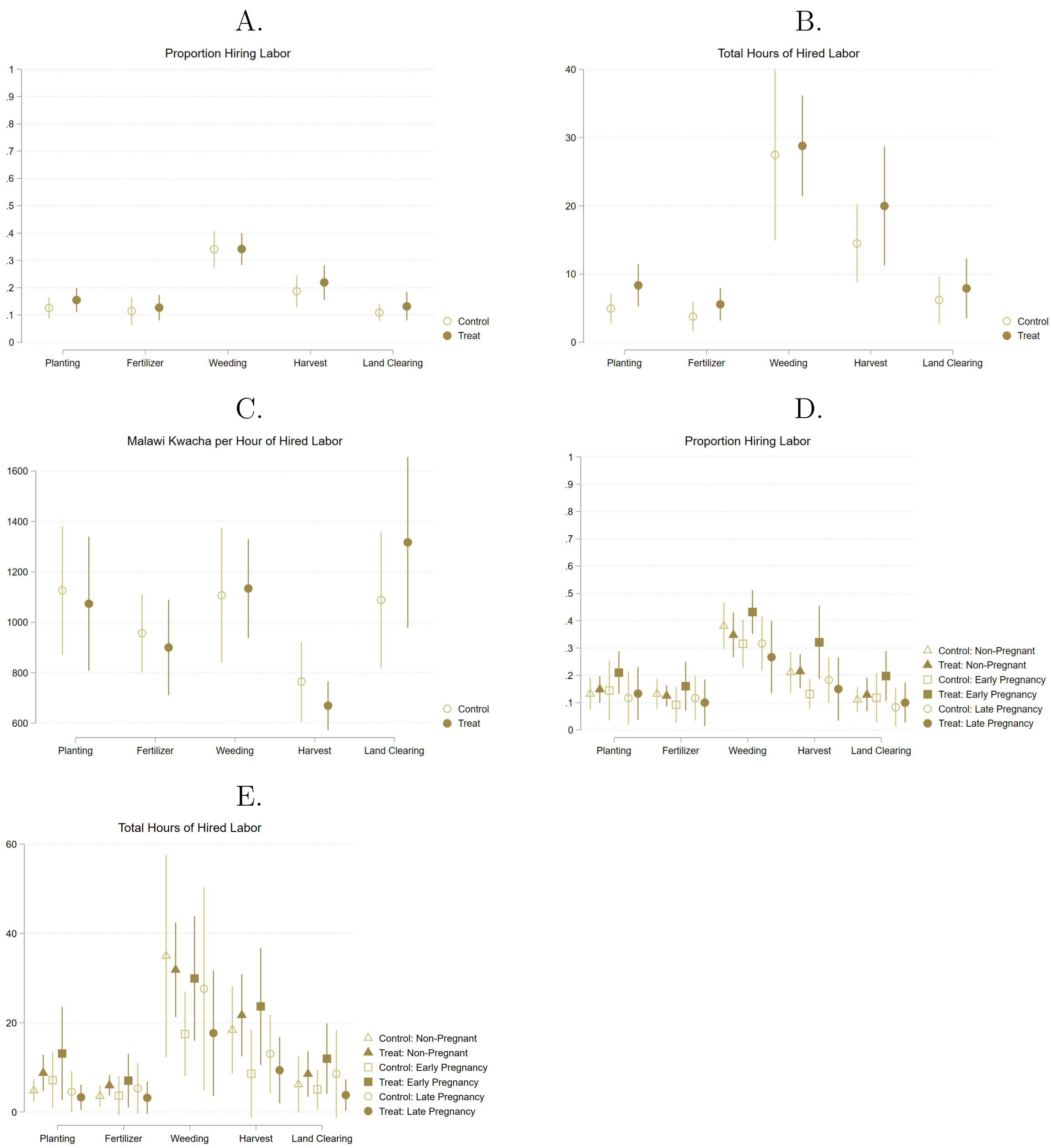
4.1 ITT and TOT effects on main outcomes

In this section we show treatment effects on our main outcomes: yields, maternal food security, child solid food consumption, and breastfeeding frequency. Table 5 reports estimated effects of being assigned to treatment. First, we find a notable increase in the value of the households' harvest, equivalent to approximately a 10% increase in output when compared to the control farmers. When disaggregating production results by crop, we see the largest increase in maize, followed by a relatively large increase in soybeans (Table A.7). There is some reduction in millet, pigeon pea, and beans yield, possibly indicating that the provision of a labor subsidy earmarked for maize cultivation implicitly disincentivizes the cultivation of other staple crops. While our estimate of the effect on total yield is noisy, the fact that the increases in crop production are primarily concentrated in the two crops most directly related to the intervention is reassuring.

In terms of effects on maternal health, we find a 0.08 standard deviation (SD) increase in food security. However, we do not see similar reinvestments of increased productivity toward child food consumption. There is essentially no effect on solid food consumption and a slight reduction in the frequency of breastfeeding. Table 6 shows TOT effects on main outcomes.

With these results in mind, it is important to situate the magnitude of the treatment. As stated previously, farmers who made use of the program redeemed an average of 13.5

Figure 2: Casual Labor Consumption



Note: Error bars represent 95% confidence intervals. Standard errors calculated via wild cluster bootstrapping.

hours of labor from the program. While this may seem neglible when dividing up across the agricultural season, one must keep in mind that the agricultural season is comprised of a series of 'lumpy' activities that require prompt, high-intensity labor. This is particularly true for fertilizer application and weeding, where delays in labor can cause substantial reductions in yield (OAF, 2016; Mosisa et al., 2022). Gantoli et al. (2013) experimentally show in Benin that variation in weeding timing and intensity can cause yield losses for maize ranging between 38 - 65%. Moreover, based on data from farmers in control sites, the provision of 13.5 hours equates to over 20% of the total amount of labor a household would hire overall.

Table 5: Intention to treat effects on main outcomes

Outcome	Estimate (SE)	Control Mean (SE)	N	Clusters
Total agricultural yield (MWK)	124122.83 (107526.14)	1314419.35 (67802.30)	791	71
Maternal food security	0.08 (0.09)	0.00 (0.05)	791	71
Child solid food consumption	-0.01 (0.05)	0.00 (0.05)	791	71
Average daily frequency of breastfeeding	-0.54 (0.37)	7.67 (0.29)	785	70

Note: OLS models adjusted for whether the farmer gave birth during the trial, total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 6: Treatment on the treated effects on main outcomes

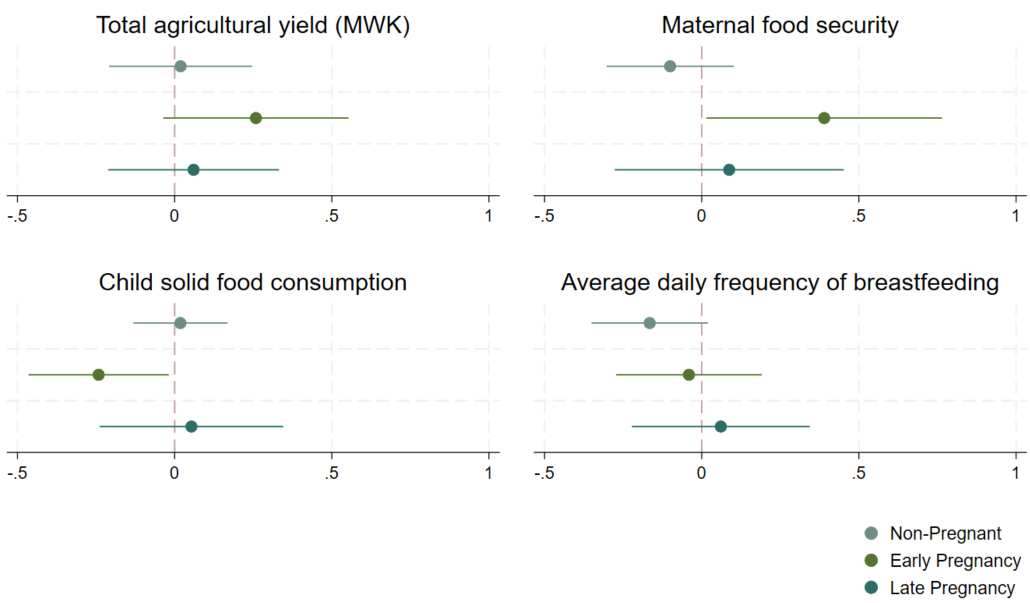
Outcome	Estimate (SE)	Control Mean (SE)	N	Clusters
Total agricultural yield (MWK)	151926.43 (130086.21)	1314419.35 (67802.30)	791	71
Maternal food security	0.09 (0.11)	0.00 (0.05)	791	71
Child solid food consumption	-0.02 (0.06)	0.00 (0.05)	791	71
Average daily frequency of breastfeeding	-0.65 (0.45)	7.67 (0.29)	785	70

Note: Models estimated via 2SLS and adjusted for whether the farmer gave birth during the trial, total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

4.2 Effect heterogeneity by pregnancy status at program start

Because we hypothesized that limitations on self-sourced labor would vary across the stages of pregnancy, childbirth, and postpartum, we estimated flexible models to explore whether treatment effects were heterogeneous by pregnancy status at the time of program rollout. To reiterate, we categorized pregnancy status as non-pregnant, first or second trimester, and third trimester. Those who were in their first or second trimester at the start would have begun their third trimester sometime between November and May, overlapping with the start of planting and weeding, and subsequently given birth between January and July, overlapping with the end of weeding and the harvest. Those who were in their third trimester would have given birth between November and January. We show results from this analysis in Table A.10. To facilitate the comparison of effect estimates across select outcomes, we illustrate effects on variables standardized by the mean and standard deviation from the control sites in Figure 3.

Figure 3: ITT effects on main outcomes by pregnancy group

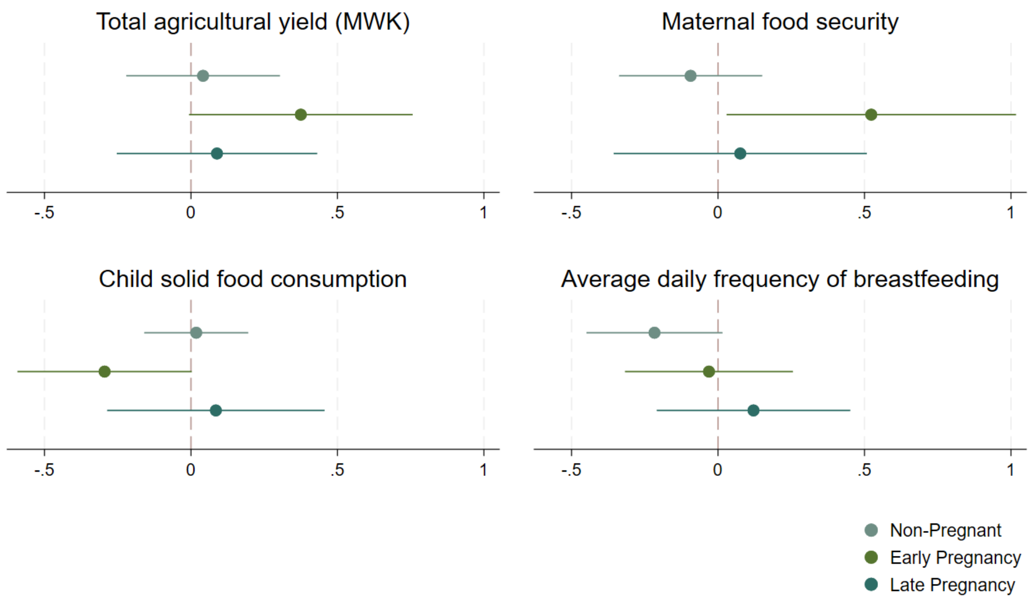


Note: Point estimates represent the ITT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized.

There is no effect on total yields in the non-pregnant group and a negligible, non-significant change in the late pregnancy group (0.06 SD). In contrast, the effect of treatment assignment increases on yields is much more pronounced for those in their first or second trimester at the start of the agricultural season (0.26 SD, $p < 0.10$). This indicates that a labor subsidy intervention such as Planting Partners is most effective for those farmers who both spent the most time pregnant during the agricultural season and whose peak labor constraints from the third trimester and childbirth coincided with the most physically intense farming activity. In line with the prior result, we also find that treatment assignment increased maternal food security by 0.39 SD ($p < 0.05$) among farmers in the early pregnancy group.

Two unexpected findings from this analysis are estimated reductions in child solid food consumption among the early pregnancy group (-0.24 SD, $p < 0.05$) and breastfeeding frequency among the non-pregnant group (-0.17 SD, $p < 0.10$). Both treatment effects are likely artefacts of the feeding natures of the youngest children for both of these groups. For the early pregnancy group, more than 90% of households in treatment and control sites report currently breastfeeding and few of the children born to this group during the trial are old enough to transition to a solid food-based diet (World Health Organization, 2026). Thus, we interpret reductions in solid food consumption as beneficial for child health in this group. Improvements in maternal food consumption directly affect child nutrition via increased quality and/or quantity of breast milk, which is aligned with evidence in public health.[10] Reductions in breast-freeding frequencey among treated women in the non-pregnant group also may indicate improvements in behaviors recommended for child health. Because their youngest children are aged between 1 and 2 years, solid food intake plays a much larger role in ensuring healthy child development (WHO, 2023). While we do not observe changes in the frequency of consumption of solid foods among these children, we cannot rule out that these reductions in breastfeeding are compensated for by other adjustments like increased portion sizes.

Figure 4: TOT effects on main outcomes by pregnancy group



Note: Point estimates represent the TOT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized.

We present the TOT effects within each pregnancy group (Figure 4, Tables A.11-A.13). Among farmers in the early pregnancy group who redeemed any labor from Planting Partners, Planting Partners increased agricultural production by 0.38 SD ($p < 0.10$) and maternal food security by 0.52 SD ($p < 0.05$).

[10] An RCT in Guatemala shows that maternal nutrient supplementation increases exclusive breast-feeding (González-Cossío et al., 1998), and qualitative evidence in several African countries demonstrate that a key reason women introduce solid foods before it is recommended is due to perceived low milk supply (Ter Goon et al., 2020; Semahegn et al., 2014; de Bruyn et al., 2018).

5 Conceptual Framework: Pregnancy and Agricultural Market Failures

Why does a labor subsidy lead to changes in farm productivity and consumption disproportionately for women who spend more of the farming season pregnant? This conceptual model motivates an exploration of labor and land allocations that can arise from market failures, intra-household norms, and their interaction with pregnancy. The model highlights the land and labor market channels in a canonical agricultural household model, and how failure to substitute for women's labor through these markets can exacerbate the economic consequences of pregnancy.

We depart from standard models in two ways: we introduce pregnancy as a productivity shock to female farmers' labor, and we introduce a threshold of total on-farm labor supply above which farm productivity is increasing. While existing agricultural household models evaluate the impact of labor productivity shocks (Adhvaryu and Nyshadham, 2017; Afridi et al., 2022; Aragón et al., 2021; Dureja and Negi, 2022; Heath et al., 2022; Kochar, 1999, 1995), and non-convexity in the marginal product of on-farm labor (Eswaran and Kotwal, 1986; Feder, 1985; Fink et al., 2020), our paper is the first, to our knowledge, to jointly incorporate both features.

5.1 Setup

A household produces agricultural output using land and labor. Household members choose labor allocations, land use, hired labor, and leisure. They consume all of their income:

$$\begin{aligned}
\max_{z_w, z_o, L_w, \ell_w, L_o, \ell_o, L_h, A_c, A_r} \; & U(c, z_w, z_o), \qquad \text{subject to} \\
\text{farm production} \quad & Y = F(A_c, \phi_f(P)L_w + L_o + L_h + L_{PP}), \\
\text{land use allocation} \quad & \bar{A} = A_c + A_r + A_f \\
\text{the budget constraint} \quad & c = pY + w\phi_{of}(P)\ell_w + w\ell_o + rA_r - wL_h, \\
\text{time constraints} \quad & L_w + \ell_w + z_w \leq \bar{T}_w \qquad \text{and} \qquad L_o + \ell_o + z_o \leq \bar{T}_o, \\
\text{subsistence constraint} \quad & F(A_c, L) \geq \underline{F}
\end{aligned}$$

Utility depends on consumption c, women's leisure z_w, and other household members' leisure z_o, where $U(c, z_w, z_o)$ is strictly increasing, continuously differentiable, and concave. Pregnancy exposure during the agricultural season is denoted by P, and modifies women's farm productivity by $\phi_f(P)$ and off-farm productivity by $\phi_{of}(P)$. $\phi_f(P)L_w$ is women's pregnancy-adjusted effective on-farm labor supply, given farm labor hours L_w and the productivity shock given by $\phi_f(P)$. Farm production Y depends on cultivated land A_c, women's effective farm labor supply $\phi_f(P)L_w$, other household member's farm labor supply L_o, hired labor L_h, and labor supplied by the Planting Partners program L_{PP}. For simplicity, we model these sources of labor as (1) additive and (2) as perfect substitutes except when women are pregnant. Households own land $\bar{A}$, which they choose to allocate towards cultivation A_c or renting out A_r, and they let fallow the remaining land A_f. Women can also allocate labor to off-farm activities and earn $w\phi_{of}(P)\ell_w$, where ℓ_w is women's off-farm labor and w is the prevailing wage.[11] Households face a subsistence constraint, and will always allocate enough labor and land to the farm to produce subsistence consumption $\underline{F}$.

Household consumption c is determined by the budget constraint, where p is the per-unit price of farm yields, ℓ_o is other household members' off-farm labor, and r is the return on rented-out land. Planting Partners labor L_{PP}, which is provided to households for free, does not enter the budget constraint. The household faces time constraints $\bar{T}_w$ and $\bar{T}_o$.

Assumption 5.1. *The productivity shock of pregnancy makes it profitable to substitute for women's farm labor.*

(a) ***Productivity:*** *Pregnancy reduces women's farm productivity. Pregnancy may also affect off-farm productivity to a lesser extent:*

$$\phi_f'(P) < 0, \qquad \phi_{of}'(P) \leq 0, \qquad |\phi_f'(P)| > |\phi_{of}'(P)|.$$

(b) ***Profitability of Farm Production Relative to Outside Options****: There exists a range of total effective on-farm labor $\underline{L} < L = \phi_f(P)L_w + L_o + L_h < \bar{L}$ where farm labor is more profitable than fallowing. We assume that $F(A_c, L)$ is continuously differentiable, increasing, and concave in both arguments on $(\underline{L}, \bar{L})$:*

$$p \cdot \left. \frac{\partial F(A_c, L)}{\partial L} \right|_{\underline{L} < L < \bar{L}} > w$$

(c) ***Profitability of Renting Out Relative to Farm Production****: There exists a high level of pregnancy exposure $\bar{P}$ such that it is more profitable to rent out land than cultivate land without help:*

$$r > p \cdot \left. \frac{\partial F(A_c, L)}{\partial A_c} \right|_{L = \phi_f(\bar{P})L_w}$$

Together, these assumptions imply that, at sufficiently high pregnancy exposure, women's own farm labor is not the optimal marginal input. It is strictly more profitable for the

[11] For simplicity, we assume that off-farm wages that women and other household members can earn is the same, and that this wage is equal to the wages paid to hired farm labor.

household to substitute through hired labor, other household labor, or land rental, rather than for pregnant women to continue cultivating.[12]

Assumption 5.2. *Low levels of labor are unproductive, but can still produce subsistence.*

(a) ***Profitability of Farm Production Relative to Outside Options when Labor Inputs are Constrained****: Below $\underline{L}$, labor is not supplied in high enough quantities to use complementary inputs efficiently (fertilizers cannot be useful unless they are applied with labor, for example), and fallowing is more profitable than farm labor:*

$$p \cdot \frac{\partial F(A_c, L)}{\partial L}\bigg|_{L \leq \underline{L}} < w$$

(b) ***Labor Requirements to Produce Subsistence****: Given that the choice of cultivated land is greater than a minimal amount required, $A_c^* > \underline{A_c}$, for some level of total effective on-farm labor $L^*(A_c^*) < \underline{L}$, $F(A_c^*, L^*(A_c^*)) = \underline{F}$. That is, even unproductive labor can still produce subsistence.*

5.2 Incomplete Markets and Pregnancy

Given Assumption 5.1, with complete markets, women should shift time into leisure or less-physically-exacting off-farm work when they are pregnant during the farming season. With frictionless markets, households can adjust to a reduction in women's farm productivity by: (i) hiring labor, (ii) reallocating farm and off-farm labor within the household, or (iii) renting out land. If any of these markets function properly, households can rely on that market to offset women's reduced farm labor supply. However, if all of these markets are simultaneously incomplete, then pregnancy reduces effective labor on cultivated land and limits the household's ability to reallocate labor efficiently across activities.

We introduce three constraints that are the result of 'incomplete markets' for land and labor reallocation. For consistency in terminology, we refer to the inability to substitute farm labor between household members as an incomplete market for intra-household labor

[12] We focus on household profits for simplicity, but note that pregnancy likely also increases the marginal utility of 'leisure' time through increased returns to activities such as rest and doctor's visits. If we allow the marginal utility of leisure to depend positively on pregnancy, then the optimal point of substituting out women's farm labor happens earlier, weakening how strong Assumption 5.1 has to be.

substitution, even if it is driven by norms:[13]

$$L_h \leq \bar{L}_h, \qquad A_r \leq \bar{A}_r, \qquad \text{and} \qquad L_o \leq \bar{L}_o^N$$

Households face constraints on access to hired labor $\bar{L}_h$, constraints on access to land renters $\bar{A}_r$, and limits to intra-household labor substitution due to norms or bargaining denoted by $\bar{L}_o^N$. We do not take a stance on where these three market imperfections can arise from; for example, constraints on hired labor $\bar{L}_h$ can arise from labor rationing and true quantity shortages, or *effective* quantity shortages due to search frictions or incomplete credit markets.[14] Furthermore, because of Assumption 5.2(a), it is possible that the labor constraints bind even if households utilize less labor than $\bar{L}_h$ and $\bar{L}_o^N$.[15]

5.2.1 Predictions with Market Frictions

Table 7 summarizes tests for market frictions that are motivated by the model (Appendix Section B describes these tests in detail). Figure 5 demonstrates a stylized depiction of household labor allocation decisions, with and without the Planting Partners labor supply shock, across varying conditions.[16] Panel (a) represents a case with frictionless markets, where the Planting Partners labor supply shock has no effect on total labor supply on the farm, but it does crowd-out labor that would have been supplied otherwise.[17] Panels (b) and (c) represent labor allocations in constrained labor markets (for simplicity, we omit land markets from the illustration). Panel (b) depicts optimal labor allocation decisions for a household whose effective on-farm labor is severely constrained by high pregnancy exposure, while Panel (c) depicts optimal labor allocation decisions for a household whose effective on-farm labor is moderately constrained by pregnancy exposure.[18]

Note that households should never choose total farm labor supply between $L^*(A_c^*)$ and

[13]While other work such as Afridi et al. (2022) look specifically at gendered responses to household labor productivity shocks, it is notable that the labor supply shock itself that we look at is *definitionally* gendered. Furthermore, unlike illness or weather, the time and extent of the labor productivity shock of pregnancy are predictable, implying that substituting women's labor supply should be easy to achieve in the absence of frictions (Fink et al., 2020; Rosenzweig and Udry, 2014). Given this context, we model the gender norms that prevent substitution between male and female household labor as a market friction on par with incomplete credit, land, and hired labor markets.

[14]While labor supply may be readily available, credit market frictions and liquidity constraints can make it impossible for a farmer to pay more than $w\bar{L}_h$ for hired labor, limiting the effective labor available to $\bar{L}_h$.

[15]For example, if a household is $\bar{L}_h + \epsilon$ below $\underline{L}$, she will choose to purchase no hired labor, even if she is able to purchase up to $\bar{L}_h$.

[16]The upper panels of Figure 5 plot household effective on-farm labor against the marginal value of on-farm labor. Figure B.2 in Appendix Section B plots household effective on-farm labor against farm productivity $F(A_c, L)$.

[17]Graphically, we show a reduction in hired labor, but this need not substitute away from hired labor rather than women's labor or other household member's labor.

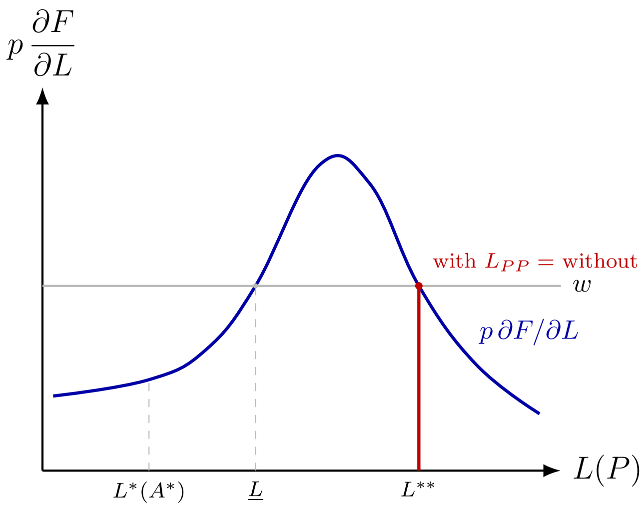
[18]Appendix Figure B.1 visually demonstrates the relationship between pregnancy exposure, the Planting Partners interventions, and total effective on-farm labor.

Table 7: Testable implications of incomplete markets, by labor regime

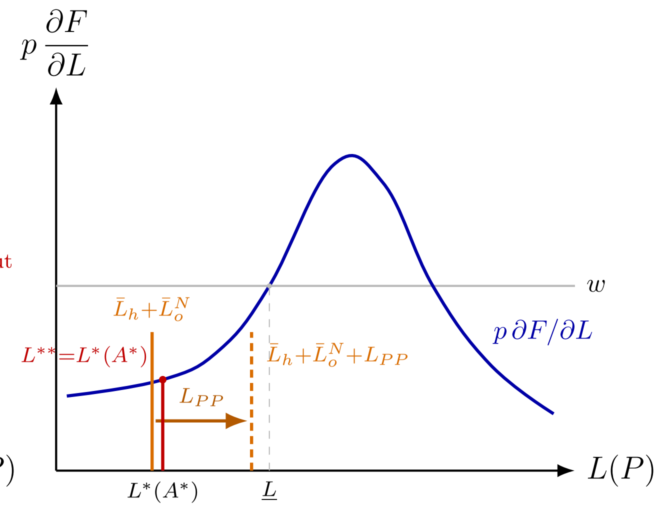
Regime	Interpretation	Testable condition	Graph
position of $L = \phi_f(P)L_w + \bar{L}_o^N + \bar{L}_h + L_{PP}$ relative to $L^*(A_c^*)$ and $\underline{L}$			
Case 1 $L^*(A_c^*) < L < \underline{L}$	Households still choose $L = L^*(A_c^*)$, but now L_{PP} frees labor (household or hired) from subsistence farming, allowing off-farm labor or leisure rise, especially at higher P. *Necessary, not sufficient* conditions for incomplete markets.	$\frac{\partial^2(\ell_w^* + z_w^* + \ell_o^* + z_o^*)}{\partial L_{PP} \partial P} > 0$ and $\frac{\partial^2(L_w^* + L_o^* + L_h^*)}{\partial L_{PP} \partial P} < 0$	Figure 5 Panel (b)
Case 2(a) $\underline{L} < L$	Land or output responds differentially to L_{PP} by pregnancy; separation fails. *Necessary and sufficient* conditions for incomplete markets.	$\frac{\partial^2(A_r^* + A_c^*)}{\partial L_{PP} \partial P} > 0$ or $\frac{\partial^2 Y}{\partial L_{PP} \partial P} > 0$	
	If no market substitutes for women's labor, none is crowded out. *Sufficient (not necessary)* for zero substitution.	$\frac{\partial^2 A_r^*}{\partial L_{PP} \partial P} \geq 0$, $\frac{\partial^2 L_h^*}{\partial L_{PP} \partial P} \geq 0$, $\frac{\partial^2 L_o^*}{\partial L_{PP} \partial P} \geq 0$	
Case 2(b) $L - L_{PP} < \underline{L} < L$	All of 2(a); *plus* crossing $\underline{L}$ raises the marginal product of on-farm labor above w. If there is slack in $\bar{L}_h$ or $\bar{L}_o^N$, on-farm labor rises.	$\frac{\partial(L_h^* + L_o^*)}{\partial L_{PP}} \geq 0$	Figure 5 Panel (c)

$\underline{L}$ — in this range, households have achieved subsistence production, but could earn more on the margin in off-farm wages. This non-convexity generates key predictions for labor allocation decisions. When households are severely constrained in their own ability to supply labor (Panel (b)), and face market constraints on hiring labor and normative constraints on intra-household labor substitution, the Planting Partners labor supply shock is not sufficient to surpass $\underline{L}$, the point where the marginal productive value of farm labor surpasses the prevailing wage. With or without Planting Partners, these households will only supply enough labor to the farm to meet subsistence $L^*(A_c^*)$. Similar to the complete markets condition, Planting Partners will substitute for hired or household farm labor. Conversely, when households are only modestly constrained in their own ability to supply labor (Panel (c)), the Planting Partners labor supply shock is sufficient to surpass $\underline{L}$. Now, it is profitable to utilize all labor available. If there is slack in either $\bar{L}_h$ or $\bar{L}_o^N$, households pushed above $\underline{L}$ by the Planting Partners intervention will *increase* hired or household member labor, which is now more profitable than off-farm wages.

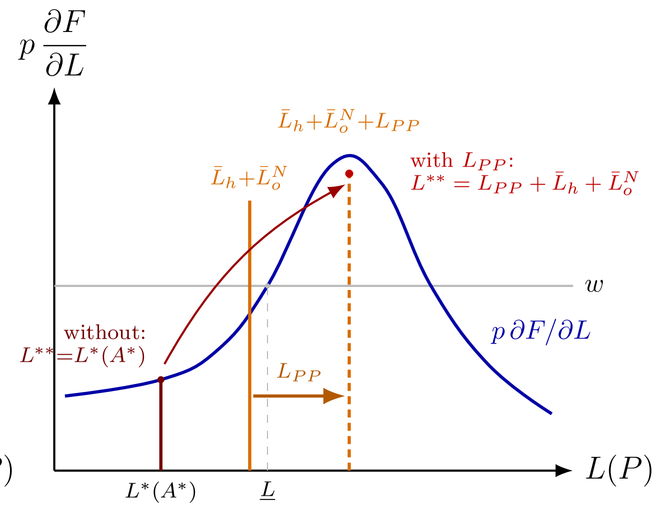
Figure 5: Labor allocations under complete and incomplete markets



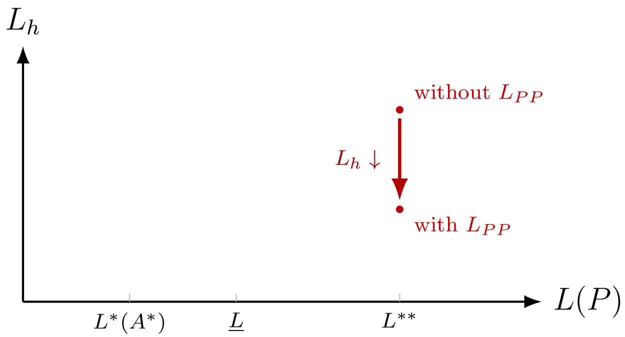
(a) Complete markets



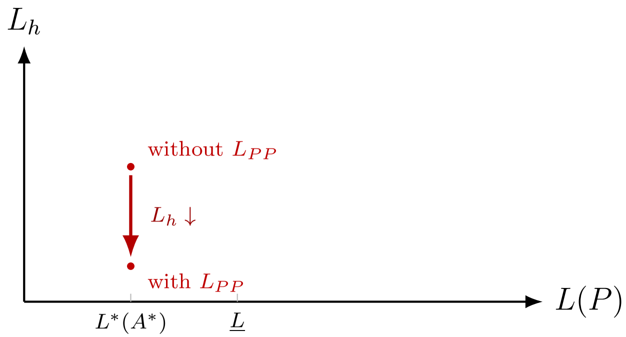
(b) Incomplete, $\bar{L}_h+\bar{L}_o^N+L_{PP} < \underline{L}$



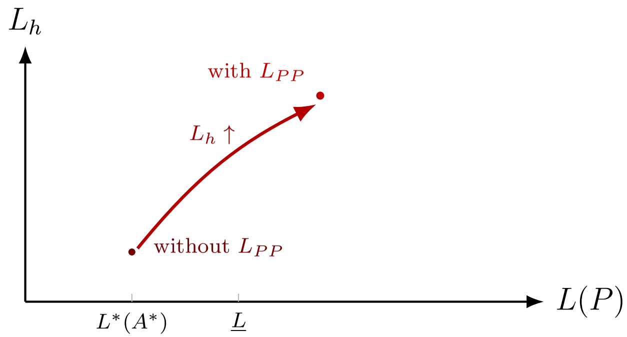
(c) Incomplete, $\bar{L}_h+\bar{L}_o^N+L_{PP} > \underline{L}$



(a) Complete markets: L_h falls
(displacement with high productivity)



(b) Incomplete markets: L_h falls
(displacement with low productivity)



(c) Incomplete markets: L_h rises

Notes: We represent pregnancy and women's own farm labor $\phi_f(P)L_w$ through where the household falls along the horizontal axis (the location of the labor constraint before L_{PP}); for clarity it is not drawn as a separate margin. Higher pregnancy exposure corresponds to a constraint located further left. The curve $p\,\partial F/\partial L$ is the marginal value product of effective on-farm labor and w is the common wage. $\underline{L}$ is the threshold above which farming becomes more profitable than off-farm work. $L^*(A^*)$ is the minimal about of labor required to meet the subsistence constraint. Columns compare complete markets (a) with incomplete markets (b, c); the L_{PP} shift is identical across (b) and (c). The bottom row plots hired labor L_h, whose response to L_{PP} flips sign from negative (a, b) to positive (c) at the threshold crossing. Parameters are illustrative.

6 Results: Labor and Land Reallocation

In this section we discuss the treatment effects of Planting Partners on households' allocation of labor and land resources by pregnancy group to better contextualize our results regarding the main outcomes.

6.1 Labor Allocations

We show the effects of treatment assignment on the number of hours of hired farming labor, the number of hours of unpaid farming labor from outside the household, the average weekly number of hours of farming labor from other household members, the average weekly number of hours of farming labor from farmer herself, and whether the farmer engages in income-generating activities unrelated to agriculture such as piece work or businesses (Figure 6 and Table A.14).[19] One concern with this intervention was that the subsidization of labor for a female-coded crop like maize would cause other household members, particularly male members, to withdraw their support. However, we do not find meaningful reductions in the provision of labor from other household members across all three pregnancy groups. Additionally, we do not observe an increase in tobacco production, which would be the most likely crop men would substitute their labor toward (Table A.7).

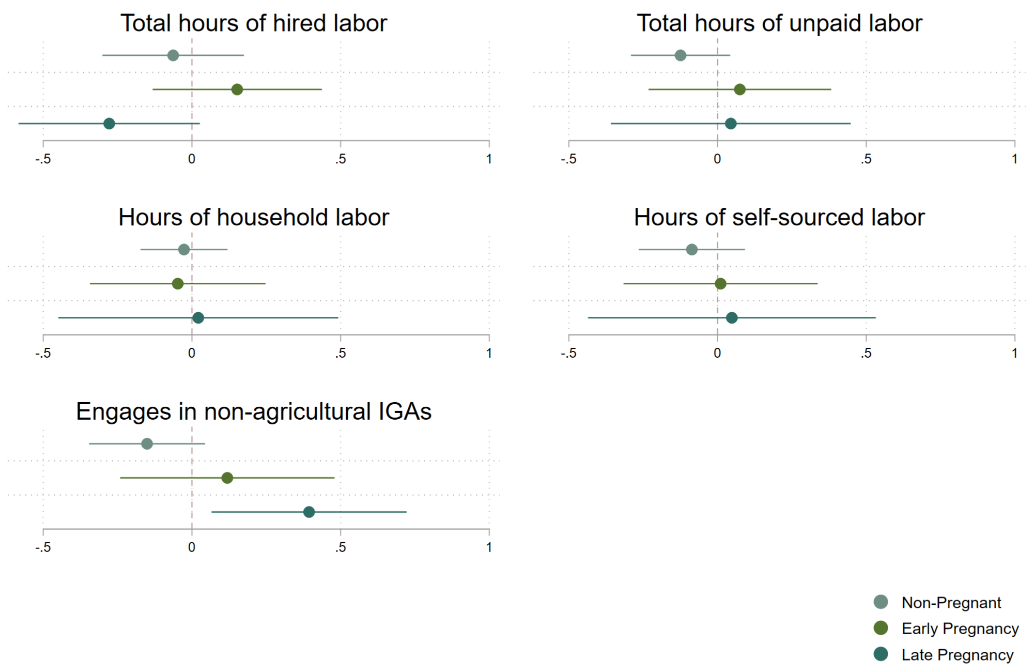
Among non-pregnant farmers, there is a noisy 8 hour reduction in the consumption of hired labor. This indicates that farmers in this subgroup were not as labor constrained during the agricultural season and were able to substitute the labor received from the program for some of the labor they would have hired otherwise. In contrast, we observe that access to Planting Partners led to a noisy 19 hour increase in hired labor for those in the early pregnancy group. This effect is driven by a 14 percentage point increase in the probability of hiring labor during the harvest, which is after the vast majority of women have already utilized Planting Partners ($p < 0.10$, Appendix Table A.15). This finding points toward a potential channel through which this program impacts yields, and subsequently food consumption. First, pregnancy creates a greater deficit in labor inputs than infant-caregiving, while liquidity or quantity constraints prevents the optimal replacement of the loss in self-labor with hired labor. Second, it is likely that there are labor-intensive activities throughout the agricultural season where productivity more closely resembles a Stone-Geary function in which there is a minimum level of labor inputs needed in order for additional labor units to be most productive (Beattie and Aradhyula, 2015). As such, the labor provided through this intervention may help farmers achieve this minimum level of labor in order for the hiring of additional labor to be profitable.

[19] All measures of labor hours refer to the entire agricultural season and are winsorized at the 1st and 99th percentiles.

There is support for this hypothesis given that, among the early pregnancy group, there is more labor hired on both the extensive and intensive margins in the treated group during the weeding period (Figure 2D and Figure 2E).

Consistent with this hypothesis, the treatment leads to a large reduction in the hours of hired labor (35 hours, $p < 0.10$) among farmers in the late pregnancy group, many of whom gave birth before the weeding period. The magnitude of this reduction exceeds the total 30 hour 'face value' of the vouchers. Moreover, we find that treatment leads to a 19 pp ($p < 0.05$) increase in the likelihood of engaging in non-agricultural income-generating activities. These two findings in conjunction suggest that, given the extreme physical limitations to engaging in agricultural labor imposed by childbirth and postpartum recovery, farmers in this group reinvest the savings on labor due to this program toward less physically strenuous employment. That being said, we do not find reductions in self-sourced labor in any subgroup. This is likely a product of one the stipulations of Planting Partners in which the recipient farmer was required to be present on their farm in a supervisory role when the OAF-provided *ganyu* was there.

Figure 6: ITT effects on labor allocations by pregnancy group



Note: Point estimates represent the ITT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized. Abbreviations: IGA = income-generating activity

6.2 Land Allocations

We show intention-to-treat effects on land allocations in Figure A.17 and Table A.17. There are no treatment effects on the likelihood of renting out land in any pregnancy subgroup, suggesting that households are unable to utilize land rental markets to earn income from their land when their labor supply is constrained. The narrative established in Section 6.1, in which we generally find that being offered a labor subsidy induces farmers in the early pregnancy group to invest more into farming while it conversely causes farmers in the late pregnancy group to invest less into farming, extends to household decisions around land allocations. For the early pregnancy group, eligibility for the program leads to a 13 pp increase in the likelihood of renting land for household use and a 0.21 acre ($p < 0.05$) increase in the amount of land rented. On the other hand, farmers in the late pregnancy group cultivate 5 pp ($p < 0.05$) less of the land available to them, without renting out the non-cultivated land.[20]

Figure 7: ITT effects on land allocations by pregnancy group

Note: Point estimates represent the ITT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized.

7 Conclusion

In this paper, we conduct a cluster-randomized trial in order to evaluate a novel intervention to alleviate the labor constraints faced by female farmers where subsistence farming

[20]These patterns suggest there may be an asymmetry in the land rental market in this setting, where it is easier to find households to rent land from than it is to find household to rent land to. Qualitatively, households describe land rental markets as functioning very informally, where individuals seeking more land to rent in simply 'ask around' and households rarely rent land out unless a potential renter approaches them directly. Twenty seven percent of the sample said someone approached them asking if they had land available to rent out, while only 5% said they searched for somebody to rent their land out to, suggesting search frictions may be an important constraint on renting land out.

is major source of household income. We find that a direct labor subsidy to women with young children or who are pregnant is most effective in increasing agricultural production for those who spend a majority of the agricultural season pregnant and enter the third and fourth trimesters during the lean season when labor demand is highest and calories are most scarce. Moreover, at least some of these returns to household income in terms of crop production is reallocated toward maternal food consumption. For those enrolled in their first or second trimester, the program alleviates some of the liquidity or quantity constraints that prevent the replacement of lost self-sourced labor, thus allowing greater investment in farming via hiring more labor and renting more land. Conversely, we find that Planting Partners induces women who entered the agricultural season to invest *less* in terms of hired labor and land, and instead reallocate resources to non-agricultural activities. This differential effect between the two pregnancy groups highlight that there is an interaction between pregnancy progression and the specific phase of the agricultural season.

A secondary contribution of this study is that we further quantify the magnitude of the shocks to farmer well-being that are associated with pregnancy status. Descriptively, among farmers in control sites, when recalling over the entire agricultural season, those who were enrolled into the program earlier in their pregnancy report working fewer hours per week. This is in part compensated for by increases in labor inputs from other household members, but there remains a persistent difference in total agricultural production. As such, it is not surprising that we also observe deficits in maternal food security.

One must keep in mind the setting of this study when interpreting these results in order to make inference on other settings. Firstly, all of the participants of this trial are members of OAF. Because of the nature of OAF as a non-profit that supports farmers with farming inputs to better promote food security, these member farmers and their families are both more likely to be trained as more productive farmers and have greater focus on staple crop cultivation. This could mean that the gendered nature of crops like maize and pigeon peas might be less pronounced for this sample and, in turn, mean that there is less of a social barrier for male household members to contribute to their cultivation. There may not be many settings in which there is a well-known and trusted third party like OAF to facilitate the selection and administration of a direct labor subsidy. Additionally, in our analyses disaggregated by pregnancy status, we highlight the fact that the non-pregnant group were still selected into study procedures because they had at least one child aged 1 year or younger. If we are to assume that domestic labor demands are overall decreasing as the youngest child ages, then our estimates of the differences in productivity based on pregnancy status are likely lower bounds if we were to instead consider the average non-pregnant female farmer as the comparison group.

These findings build on prior work demonstrating that supporting women's income-generating activities can improve productivity. However, we show that the fertility outcomes can impact non-domestic labor productivity even before the child is born. Thus, there is a need to develop broader programming that targets pregnant women in addition to women with young children. This is even more important because women whose labor and production is constrained by pregnancy are the very same people where ensuring sufficient nutritional intake is most important for both their own and their children's health and development.

References

Adhvaryu, Achyuta and Anant Nyshadham, "Health, Enterprise, and Labor Complementarity in the Household," *Journal of Development Economics*, 2017, *126*, 91–111.

Afridi, Farzana, Kanika Mahajan, and Nikita Sangwan, "The Gendered Effects of Droughts: Production Shocks and Labor Response in Agriculture," *Labour Economics*, 2022, *78*, 102227.

Ajayi, K. F., A. Dao, and E. Koussoubé, "The Effects of Childcare on Women and Children: Evidence from a Randomized Evaluation in Burkina Faso," Working Paper 628, Center for Global Development 2022.

Akram-Lodhi, A. H., "Factors driving the Gender Gap in Agricultural Productivity: Malawi," 2018.

Allen, L. H., S. E. Moore, G. Kac et al., "The Mothers, Infants and Lactation Quality (MILQ) Study: Introduction and Study Design," *Advances in Nutrition*, 2025, *16*, 100499.

Ambler, K., A. de Brauw, and S. Godlonton, "Rural Labor Market Responses to Large Lumpy Cash Transfers: Evidence from Malawi," Technical Report 2018-11, Department of Economics Working Paper 2018.

Angelov, Nikolay, Per Johansson, and Erica Lindahl, "Parenthood and the Gender Gap in Pay," *Journal of Labor Economics*, 2016, *34* (3), 545–579.

Aragón, Fernando M, Francisco Oteiza, and Juan Pablo Rud, "Climate Change and Agriculture: Subsistence Farmers' Response to Extreme Heat," *American Economic Journal: Economic Policy*, 2021, *13* (1), 1–35.

Bambio, Y., "Gender differences in agricultural productivity," *World Development*, 2025, *187*, 106856.

Beattie, Bruce R. and Satheesh Aradhyula, "A NOTE ON THRESHOLD FACTOR LEVEL(S) AND STONE-GEARY TECHNOLOGY," *Journal of Agricultural and Applied Economics*, November 2015, *47* (4), 482–493.

Belloni, A., V. Chernozhukov, and C. Hansen, "Inference on Treatment Effects after Selection among High-Dimensional Controls," *The Review of Economic Studies*, 2014, *81* (2), 608–650.

Benjamin, Dwayne, "Household Composition, Labor Markets, and Labor Demand: Testing for Separation in Agricultural Household Models," *Econometrica*, 1992, *60* (2), 287–322.

Benson, T. and J. De Weerdt, "Employment Options and Challenges for Rural Households in Malawi: An Agriculture and Rural Employment Analysis of the Fifth Malawi Integrated Household Survey, 2019/10," 2023.

Bernard, T., C. Doss, M. Hidrobo, J. Hoel, and C. Kieran, "Ask me why: Patterns of intrahousehold decision-making," *World Development*, 2020, *125*, 104671.

Bertrand, Marianne, Claudia Goldin, and Lawrence F. Katz, "Dynamics of the Gender Gap for Young Professionals in the Financial and Corporate Sectors," *American Economic Journal: Applied Economics*, 2010, *2* (3), 228–255.

Bjorvatn, K., D. Ferris, S. Gulesci, A. Nasgowitz, V. Somville, and L. Vandewalle, "Childcare, Labor Supply, and Business Development," *American Economic Journal: Applied Economics*, 2025, *17* (2), 75–101.

Bonell, A., B. Sonko, J. Badjie et al., "Environmental heat stress on maternal physiology and fetal blood flow in pregnant subsistence farmers in The Gambia, west Africa: An observational cohort study," *The Lancet Planetary Health*, 2022, *6* (12), e968–e976.

Breza, E., S. Kaur, and Y. Shamdasani, "Labor Rationing," *American Economic Review*, 2021, *111* (10), 3184–3224.

Breza, Emily and Supreet Kaur, "Labor Markets in Developing Countries," *Annual Review of Economics*, 2025, *17*, 747–776.

Bryson, J. M., K. Patterson, L. Berrang-Ford et al., "Seasonality, climate change, and food security during pregnancy among Indigenous and non-Indigenous women in rural Uganda," *PLOS ONE*, 2021, *16* (3), e0247198.

Burke, W. J. and T. S. Jayne, "Disparate access to quality land and fertilizers explain Malawi's gender yield gap," *Food Policy*, 2021, *100*, 102002.

Clark, S., C. W. Kabiru, S. Laszlo, and S. Muthuri, "The Impact of Childcare on Poor Urban Women's Economic Empowerment in Africa," *Demography*, 2019, *56* (4), 1247–1272.

de Bruyn, Julia, Brigitte Bagnol, Ian Darnton-Hill, Wende Maulaga, Peter C. Thomson, and Robyn Alders, "Characterising Infant and Young Child Feeding Practices and the Consumption of Poultry Products in Rural Tanzania: A Mixed Methods Approach," *Maternal & Child Nutrition*, 2018, *14* (2), e12550.

de Janvry, Alain, Marcel Fafchamps, and Elisabeth Sadoulet, "Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained," *The Economic Journal*, 1991, *101*, 1400–1417.

de Souza, A. S., F. S. Fernandes, and M. G. T. do Carmo, "Effects of maternal malnutrition and postnatal nutritional rehabilitation on brain fatty acids, learning, and memory," *Nutrition Reviews*, 2011, *69* (3), 132–144.

Dillon, Andrew, Joachim De Weerdt, and Cathal O'Donoghue, "Asymmetric Non-Separation and Rural Labor Markets," *Journal of Development Economics*, 2019, *138*, 305–323.

Dillon, Brian, Peter Brummund, and Germano Mwabu, "Asymmetric Non-Separation and Rural Labor Markets," *Journal of Development Economics*, 2019, *139*, 78–96.

Dolati, S., A. Barzegar, F. Mohammadi-Nasrabadi, M. Abdollahi, and R. Khodayari-Zarnaq, "Cash transfer program on pregnancy outcomes and infant growth in deprived pregnant and lactating mothers in Iran: a field trial," *BMC Public Health*, 2025, *25* (1), 2219.

Dole, N., D. A. Savitz, I. Hertz-Picciotto, A. M. Siega-Riz, M. J. McMahon, and P. Buekens, "Maternal stress and preterm birth," *American Journal of Epidemiology*, 2003, *157* (1), 14–24.

Donald, A., "Caring about carework: Experimental evidence on rural childcare provision," 2024.

Doss, Cheryl R., "Intrahousehold Bargaining and Resource Allocation in Developing Countries," *The World Bank Research Observer*, 2013, *28* (1), 52–78.

_ , "Women and Agricultural Productivity: Reframing the Issues," *Development Policy Review*, 2018, *36* (1), 35–50.

_ **and Michael L. Morris**, "How Does Gender Affect the Adoption of Agricultural Innovations? The Case of Improved Maize Technology in Ghana," *Agricultural Economics*, 2001, *25* (1), 27–39.

_ **, Ruth Meinzen-Dick, and Agnes R. Quisumbing**, "Women in Agriculture: Four Myths," *Global Food Security*, 2015, *4*, 69–74.

Duflo, Esther, "Grandmothers and Granddaughters: Old-Age Pensions and Intrahousehold Allocation in South Africa," *World Bank Economic Review*, 2003, *17* (1), 1–25.

Dureja, Digvijay S. and Digvijay S. Negi, "Coping with the Consequences of Short-Term Illness Shocks: The Role of Intra-Household Labor Substitution," *Health Economics*, 2022, *31* (7), 1402–1422.

Eswaran, Mukesh and Ashok Kotwal, "Access to Capital and Agrarian Production Organisation," *The Economic Journal*, 1986, *96* (382), 482–498.

Famine Early Warning Systems Network and USAID, "Seasonal calendar for typical year: Malawi," 2024.

Feder, Gershon, "The Relation between Farm Size and Farm Productivity: The Role of Family Labor, Supervision and Credit Constraints," *Journal of Development Economics*, 1985, *18* (2-3), 297–313.

Fink, G., B. K. Jack, and F. Masiye, "Seasonal Liquidity, Rural Labor Markets, and Agricultural Production," *American Economic Review*, 2020, *110* (11), 3351–3392.

Foster, Andrew D. and Mark R. Rosenzweig, "A Test for Moral Hazard in the Labor Market: Contractual Arrangements, Effort, and Health," *The Review of Economics and Statistics*, 1994, *76* (2), 213–227.

_ and _ , "Are There Too Many Farms in the World? Labor Market Transaction Costs, Machine Capacities, and Optimal Farm Size," *Journal of Political Economy*, 2022, *130* (3), 636–680.

Frisvold, George B., "Does Supervision Matter? Some Hypothesis Tests Using Indian Farm-Level Data," *Journal of Development Economics*, 1994, *43* (2), 217–238.

Gantoli, Geoffroy, Victor Rueda Ayala, and Roland Gerhards, "Determination of the Critical Period for Weed Control in Corn," 2013, *27* (1), 63–71.

Gaskins, Audrey J. and Jorge E. Chavarro, "Diet and Fertility: A Review," 2018, *218* (4), 379–389.

González-Cossío, Teresa, Jean-Pierre Habicht, Kathleen M. Rasmussen, and Hernán L. Delgado, "Impact of Food Supplementation during Lactation on Infant Breast-Milk Intake and on the Proportion of Infants Exclusively Breast-Fed," *The Journal of Nutrition*, 1998, *128* (10), 1692–1702.

Goon, Daniel Ter, Anthony Idowu Ajayi, and Oladele Vincent Adeniyi, "Reasons for the Early Introduction of Complementary Feeding to HIV-Exposed Infants in the Eastern Cape, South Africa: An Exploratory Qualitative Study," *Medicina*, 2020, *56* (12), 703.

Heath, Rachel, Ghazala Mansuri, and Bob Rijkers, "Labor Supply Responses to Health Shocks: Evidence from High-Frequency Labor Market Data from Urban Ghana," *Journal of Human Resources*, 2022, *57* (1), 143–177.

Jacoby, Hanan G., "Shadow Wages and Peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra," *Review of Economic Studies*, 1993, *60* (4), 903–921.

Jones, Kelly M., Florence Kondylis, and John Loeser, "Factor Market Failures and the Adoption of Irrigation in Rwanda," *American Economic Review*, 2022, *112* (1), 292–324.

Karlan, Dean, Robert Osei, Isaac Osei-Akoto, and Christopher Udry, "Agricultural Decisions after Relaxing Credit and Risk Constraints," *The Quarterly Journal of Economics*, 2014, *129* (2), 597–652.

Kaur, Supreet, "Nominal Wage Rigidity in Village Labor Markets," *American Economic Review*, 2019, *109* (10), 3585–3616.

Kevane, M., "Gendered production and consumption in rural Africa," *PNAS*, 2012, *109* (31), 12350–12355.

Khammarnia, M., A. Ansari-Moghaddam, F. G. Kakhki, C. C. T. Clark, and F. B. Barahouei, "Maternal macronutrient and energy intake during pregnancy: a systematic review and meta-analysis," *BMC Public Health*, 2024, *24*, 478.

Kleven, Henrik, Camille Landais, and Jakob Egholt Søgaard, "Children and Gender Inequality: Evidence from Denmark," *American Economic Journal: Applied Economics*, 2019, *11* (4), 181–209.

_ , _ , Johanna Posch, Andreas Steinhauer, and Josef Zweimüller, "Child Penalties across Countries: Evidence and Explanations," *AEA Papers and Proceedings*, 2019, *109*, 122–126.

Kochar, Anjini, "Explaining Household Vulnerability to Idiosyncratic Income Shocks," *American Economic Review*, 1995, *85* (2), 159–164.

_ , "Smoothing Consumption by Smoothing Income: Hours-of-Work Responses to Idiosyncratic Agricultural Shocks in Rural India," *The Review of Economics and Statistics*, 1999, *81* (1), 50–61.

Kominiarek, M. A. and P. Rajan, "Nutrition Recommendations in Pregnancy and Lactation," *Medical Clinics of North America*, 2016, *100* (6), 1199–1215.

LaFave, Daniel and Duncan Thomas, "Farm Profits, Prices, and Household Behavior," *Journal of Development Economics*, 2016, *118*, 105–123.

Lechtig, A., H. Delgado, R. Martorell, D. Richardson, C. Yarbrough, and R. E. Klein, "Effect of Maternal Nutrition on Infant Mortality," in W. H. Mosley, ed., *Nutrition and Human Reproduction*, Springer US, 1978, pp. 147–174.

Lewinski, Andrzej and Maria Brzozowska, "Female infertility as a result of stress-related hormonal changes," 2023, pp. 094–098.

Lufuke, M. and X. Tian, "Women's empowerment and food consumption," *Journal of Integrative Agriculture*, 2024, *23* (2), 457–467.

Marshall, N. E., B. Abrams, L. A. Barbour et al., "The importance of nutrition in pregnancy and lactation: lifelong consequences," *American Journal of Obstetrics and Gynecology*, 2022, *226* (5), 607–632.

Mosisa, Waktole, Nigussie Dechassa, Kibebew Kibret, Habtamu Zeleke, and Zelalem Bekeko, "Effects of timing and nitrogen fertilizer application rates on maize yield components and yield in eastern Ethiopia," *Agrosystems, Geosciences, & Environment*, 2022.

National Statistical Office (NSO), Utica International, and ICF, "Malawi Demographic and Health Survey 2024," 2024.

OAF, "Maize Fertilizer Timing," 2016.

Oseni, G., P. Corral, M. Goldstein et al., "Explaining Gender Differentials in Agricultural Production in Nigeria," *SSRN*, 2014. Working paper.

Perelli, C., L. Cacchiarelli, V. Peveri, and G. Branca, "Gender equality and sustainable development: A cross-country study on women's contribution to the adoption of the climate-smart agriculture in Sub-Saharan Africa," *Ecological Economics*, 2024, *219*, 108145.

Pierotti, R. S., S. Friedson-Ridenour, and O. Olayiwola, "Women farm what they can manage," *World Development*, 2022, *152*, 105800.

Rao, S., A. Kanade, B. M. Margetts et al., "Maternal activity in relation to birth size in rural India: The Pune Maternal Nutrition Study," *European Journal of Clinical Nutrition*, 2003, *57* (4), 531–542.

Rosenzweig, Mark R and Christopher Udry, "Rainfall Forecasts, Weather, and Wages over the Agricultural Production Cycle," *American Economic Review*, 2014, *104* (5), 278–283.

Semahegn, Agumasie, Gezahegn Tesfaye, and Alemayehu Bogale, "Complementary Feeding Practice of Mothers and Associated Factors in Hiwot Fana Specialized Hospital, Eastern Ethiopia," *Pan African Medical Journal*, 2014, *18*, 143.

Singh, Inderjit, Lyn Squire, and John Strauss, "A Survey of Agricultural Household Models: Recent Findings and Policy Implications," *The World Bank Economic Review*, 1986, *1*, 149–179.

Talebi, S., H. R. Kianifar, and A. Mehdizadeh, "Nutritional requirements in pregnancy and lactation," *Clinical Nutrition ESPEN*, 2024, *64*, 400–410.

Udry, Christopher, "Gender, Agricultural Production, and the Theory of the Household," *Journal of Political Economy*, 1996, *104* (5), 1010–1046.

UN Women, "The cost of the gender gap in agricultural productivity in Malawi, Tanzania and Uganda," 2015.

UNICEF, "Undernourished and Overlooked: A Global Nutrition Crisis in Adolescent Girls and Women," 2022.

Victora, C. G., P. Christian, L. P. Vidaletti, G. Gatica-Domínguez, P. Menon, and R. E. Black, "Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda," *The Lancet*, 2021, *397* (10282), 1388–1399.

Weerdt, J. De, C. Duquennois, and A. Oliveres-Mallol, "Changing rural labor markets and welfare in Malawi," 2024.

WHO, "WHO Guideline for complementary feeding of infants and young children 6-23 months of age," 2023.

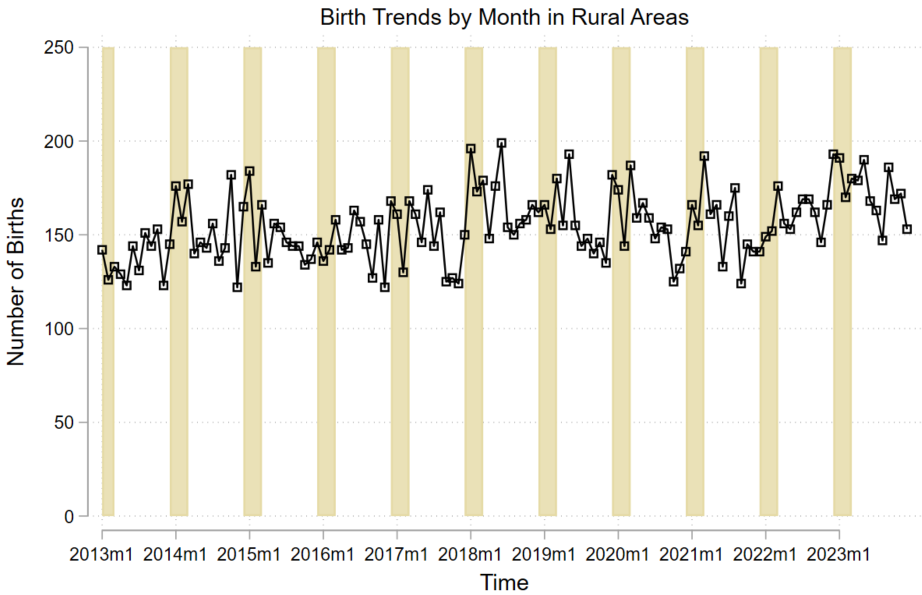
World Health Organization, "Breastfeeding," https://www.who.int/health-topics/breastfeeding#tab=tab_2 2026. Accessed: 2026-08-07.

Zimba, S., A. Dougill, C. Chanza, C. Boesch, and S. Kepinski, "Gender differential in choices of crop variety traits and climate-smart cropping systems: Insights from sorghum and millet farmers in drought-prone areas of Malawi," *Plants, People, Planet*, 2025, *7* (3), 689–703.

Online Supplementary Material

Appendix A Supplementary results

Figure A.1: Seasonality in birth events in rural Malawi



Note: Point estimates represent unweighted total number of birth events that occur in each month in Malawi Demographic health Survey 2024. Yellow shading indicates lean season (December through March). Data restricted to January 2013 to December 2023.

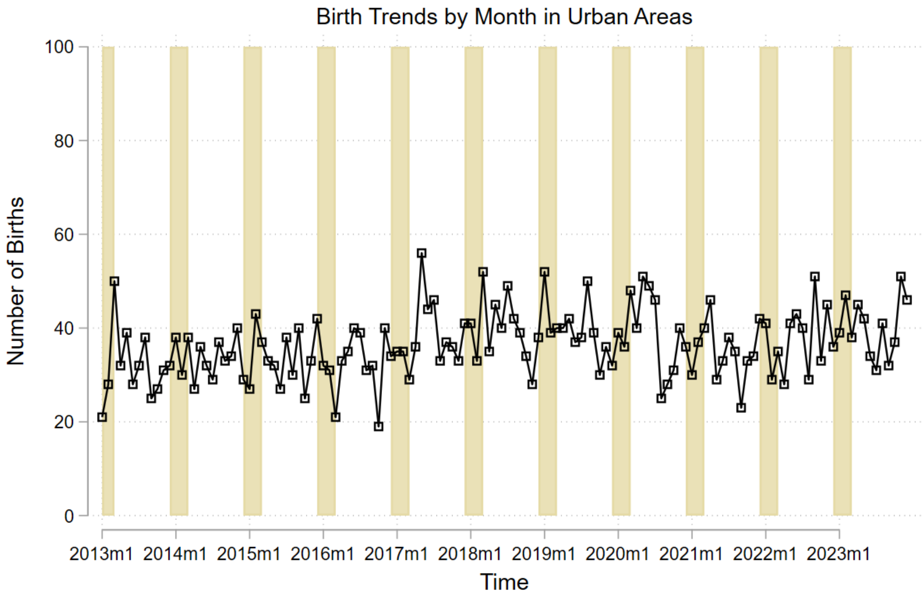
Table A.1: Models of seasonality of birth events in rural Malawi

(1)	
Month	Estimate (SE)
January	29.31*** (6.34)
February	10.39** (4.08)
March	33.92*** (5.58)
April	12.73** (4.16)
May	21.08*** (5.10)
June	20.43** (7.33)
July	12.78** (4.76)
August	13.40** (6.00)
September	6.21 (4.07)
October	9.56 (7.39)
November	REF
December	18.53** (5.52)

(2)	
Quarter	Estimate (SE)
First Quarter	15.19*** (3.55)
Second Quarter	8.72** (4.12)
Third Quarter	1.44 (2.77)
Fourth Quarter	REF

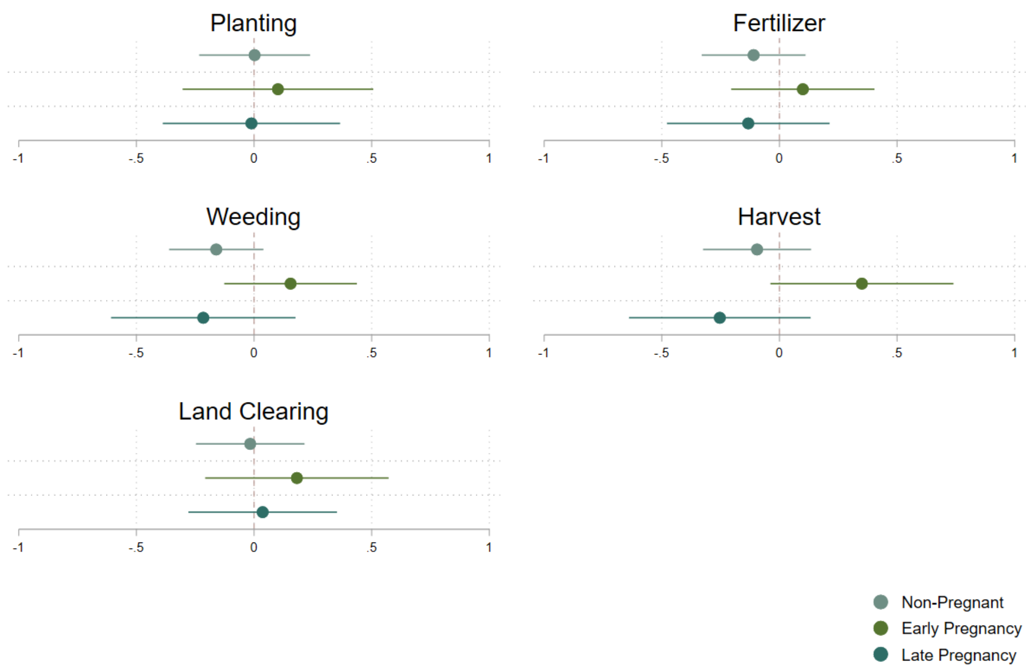
Note: OLS regressions of total number of birth events per month in model (1) and quarter in model (2), with a continuous measure of time in months. Results presented as point estimates (standard error), with Newey-West standard errors allowing for temporal autocorrelation between time periods, with optimized lags (a lag of 9 time periods in model (1) and 11 in model (2)). ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Figure A.2: Seasonality in birth events in urban Malawi



Note: Point estimates represent unweighted total number of birth events that occur in each month in Malawi Demographic health Survey 2024. Yellow shading indicates lean season (December through March). Data restricted to January 2013 to December 2023.

Figure A.3: ITT effects on likelihood of hiring labor for each activity by pregnancy group



Note: Point estimates represent the ITT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized.

Table A.2: Models of seasonality of birth events in urban Malawi

(1)	
Month	Estimate (SE)
January	-0.88 (3.41)
February	-1.57 (1.76)
March	2.00 (3.86)
April	-1.05 (2.15)
May	3.71 (3.09)
June	-0.08 (2.74)
July	1.59 (3.34)
August	-1.65 (3.24)
September	-2.79 (2.85)
October	-6.49** (2.30)
November	REF
December	-0.33 (2.14)

(2)	
Quarter	Estimate (SE)
First Quarter	2.13 (1.54)
Second Quarter	3.13* (1.72)
Third Quarter	1.32 (1.68)
Fourth Quarter	REF

Note: OLS regressions of total number of birth events per month in model (1) and quarter in model (2), with a continuous measure of time in months. Results presented as point estimates (standard error), with Newey-West standard errors allowing for temporal autocorrelation between time periods, with optimized lags (a lag of 9 time periods in model (1) and 11 in model (2)). ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.3: Balance of characteristics between treated and controlled group among non-pregnant group

Characteristic	Control Farmers (N = 190)	Treated Farmers (N = 256)	p-value	N	Clusters
Proportion reported pregnant at time trial start in OAF data	0.25 (0.03)	0.16 (0.02)	0.313	446	64
Reported household size at trial start	4.84 (0.12)	5.30 (0.10)	0.022	446	64
Reported lines worked per day	22.98 (1.11)	27.15 (0.92)	0.408	446	64
Reported hours worked per day	4.34 (0.13)	4.16 (0.08)	0.489	446	64
Married and living together	0.84 (0.03)	0.78 (0.03)	0.060	446	64
Number of prior births	3.84 (0.12)	3.77 (0.12)	0.489	446	64
Age	32.85 (0.47)	33.60 (0.50)	0.136	446	64
Proportion reported pregnant during trial in research data	0.00 (0.00)	0.00 (0.00)	.	446	64
Total acres owned	1.75 (0.09)	1.83 (0.08)	0.869	445	64
F-test of joint significance (F-stat)		2.60	0.016	445	64

Note: Results presented as mean (standard error). p-values calculated via simple linear regression models with district-level fixed effects and standard errors clustered at the One Acre Fund site-level. Lines worked, hours worked, and household size winsorized at the 1st and 99th percentiles.

Table A.4: Balance of characteristics between treated and controlled group among early pregnancy group

Characteristic	Control Farmers (N = 75)	Treated Farmers (N = 78)	p-value	N	Clusters
Proportion reported pregnant at time trial start in OAF data	0.87 (0.04)	0.99 (0.01)	0.005	153	57
Reported household size at trial start	4.20 (0.17)	4.36 (0.18)	0.504	153	57
Reported lines worked per day	22.79 (1.64)	24.15 (1.52)	0.830	153	57
Reported hours worked per day	3.85 (0.21)	3.90 (0.13)	0.970	153	57
Married and living together	0.84 (0.04)	0.95 (0.03)	0.019	153	57
Number of prior births	2.79 (0.21)	2.24 (0.18)	0.177	153	57
Age	32.17 (0.74)	30.04 (0.65)	0.029	153	57
Proportion reported pregnant during trial in research data	1.00 (0.00)	1.00 (0.00)	.	153	57
Total acres owned	1.59 (0.13)	1.80 (0.14)	0.180	153	57
F-test of joint significance (F-stat)		3.95	0.001	153	57

Note: Results presented as mean (standard error). p-values calculated via simple linear regression models with district-level fixed effects and standard errors clustered at the One Acre Fund site-level. Lines worked, hours worked, and household size winsorized at the 1st and 99th percentiles.

Table A.5: Balance of characteristics between treated and controlled group among late pregnancy group

Characteristic	Control Farmers (N = 60)	Treated Farmers (N = 60)	p-value	N	Clusters
Proportion reported pregnant at time trial start in OAF data	0.92 (0.04)	0.93 (0.03)	0.729	120	56
Reported household size at trial start	4.28 (0.21)	4.52 (0.21)	0.301	120	56
Reported lines worked per day	21.15 (2.01)	25.68 (1.92)	0.348	120	56
Reported hours worked per day	4.25 (0.25)	4.06 (0.19)	0.600	120	56
Married and living together	0.78 (0.05)	0.93 (0.03)	0.019	120	56
Number of prior births	2.73 (0.23)	2.60 (0.22)	0.681	120	56
Age	32.25 (0.83)	32.80 (0.79)	0.597	120	56
Proportion reported pregnant during trial in research data	1.00 (0.00)	1.00 (0.00)	.	120	56
Total acres owned	1.52 (0.09)	1.84 (0.16)	0.037	120	56
F-test of joint significance (F-stat)		5.10	¡ 0.001	120	56

Note: Results presented as mean (standard error). p-values calculated via simple linear regression models with district-level fixed effects and standard errors clustered at the One Acre Fund site-level. Lines worked, hours worked, and household size winsorized at the 1st and 99th percentiles.

Table A.6: Planting Partners implementation

Metric	Eligible farmers in treated sites (N = 433)
Utilized Planting Partner program	354 (80.45%)
Total hours worked for farmer	13.59 (0.46)
Perceived PP as better farmer than self	88 (24.58%)
Perceived skill of casual	
Worst	16 (4.46%)
Poor	16 (4.46%)
Average	41 (11.42%)
Good	58 (16.16%)
Best	224 (62.40%)

Note: Results presented as N (%), save for 'Total hours worked for farmer', which is presented as mean (SE).

Table A.7: Intention to treat effects on individual crop yields in Malawi Kwacha

Outcome	Estimate (SE)	Control Mean (SE)	N	Clusters
Maize	97614.03 (110079.89)	1134939.30 (60101.86)	791	71
Soybeans	27106.33* (15582.08)	36668.94 (6362.69)	791	71
Millet	-53.42 (568.55)	1044.57 (347.65)	791	71
Pigeon peas	-5009.96 (4325.22)	18336.49 (2434.42)	791	71
Groundnuts	5160.73 (27282.74)	84140.79 (13357.05)	791	71
Beans	-4522.70 (5429.03)	12701.52 (3277.43)	791	71
Tobacco	3827.82 (20439.09)	26587.74 (9806.10)	791	71

Note: OLS models adjusted for whether the farmer gave birth during the trial, total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Crop production winsorized at the 1st and 99th percentile ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.8: Intention to treat effects on food consumption

Outcome	Estimate (SE)	Control Mean (SE)	N	Clusters
Whether the farmer went to bed hungry a few or more times in the past month	-0.03 (0.04)	0.33 (0.02)	791	71
Whether farmer had three meals yesterday	0.06 (0.04)	0.35 (0.03)	791	71
Whether farmer had three meals the day before	0.05 (0.05)	0.34 (0.02)	791	71
Days of maternal meat consumption in the past month	-0.20 (0.24)	2.09 (0.16)	791	71
Days of maternal egg consumption in the past month	-0.29 (0.30)	2.24 (0.18)	791	71
Days of maternal usipa consumption in the past month	0.02 (0.53)	3.94 (0.29)	790	71
Days of maternal fish consumption in the past month	0.73* (0.37)	3.86 (0.24)	791	71
Days of child meat consumption in the past month	0.23 (0.49)	5.42 (0.34)	787	71
Days of child fruit & vegetable consumption in the past month	-0.08 (0.66)	12.08 (0.58)	787	71
Days of child carb consumption in the past month	-0.56 (0.57)	22.52 (0.59)	787	71

Note: OLS models adjusted for whether the farmer gave birth during the trial, total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.9: Treatment on the treated effects on main outcomes

Outcome	Estimate (SE)	Control Mean (SE)	N	Clusters
Total agricultural yield (MWK)	163816.44 (127401.95)	1314419.35 (67802.30)	791	.
Maternal food security	0.09 (0.11)	0.00 (0.05)	791	.
Child solid food consumption	-0.02 (0.06)	0.00 (0.05)	791	.
Average daily frequency of breastfeeding	-0.57 (0.45)	7.67 (0.29)	785	.

Note: Models estimated with a covariate balancing estimator based on Abadie's kappa and adjusted for whether the farmer gave birth during the trial, total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.10: ITT effects on main outcomes by pregnancy group

Outcome	Non-Pregnant	Early Pregnancy	Late Pregnancy	N	Clusters
Total agricultural yield (MWK)	0.02 (0.12)	0.26* (0.15)	0.06 (0.14)	718	71
Maternal food security	-0.10 (0.10)	0.39** (0.19)	0.09 (0.19)	718	71
Child solid food consumption	0.02 (0.08)	-0.24** (0.11)	0.05 (0.15)	718	71
Average daily frequency of breastfeeding	-0.17* (0.09)	-0.04 (0.12)	0.06 (0.14)	716	70

Note: OLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Interactions between these covariates and pregnancy status were additionally selected via double-selection-Lasso. All outcomes standardized. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.11: TOT effects on main outcomes among non-pregnant group

Outcome	Estimate (SE)	N	Clusters
Total agricultural yield (MWK)	0.04 (0.13)	445	64
Maternal food security	-0.09 (0.12)	445	64
Child solid food consumption	0.02 (0.09)	445	64
Average daily frequency of breastfeeding	-0.22* (0.12)	445	64

Note: 2SLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. All outcomes standardized. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.12: TOT effects on main outcomes among early pregnancy group

Outcome	Estimate (SE)	N	Clusters
Total agricultural yield (MWK)	0.38* (0.19)	153	57
Maternal food security	0.52** (0.25)	153	57
Child solid food consumption	-0.29* (0.15)	153	57
Average daily frequency of breastfeeding	-0.03 (0.15)	152	56

Note: 2SLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. All outcomes standardized. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.13: TOT effects on main outcomes among late pregnancy group

Outcome	Estimate (SE)	N	Clusters
Total agricultural yield (MWK)	0.09 (0.17)	120	56
Maternal food security	0.08 (0.22)	120	56
Child solid food consumption	0.09 (0.19)	120	56
Average daily frequency of breastfeeding	0.12 (0.17)	119	55

Note: 2SLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. All outcomes standardized. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.14: ITT effects on labor allocations by pregnancy group

Outcome	Non-Pregnant	Early Pregnancy	Late Pregnancy	N	Clusters
Total hours of hired labor	-7.86 (15.12)	18.96 (18.08)	-34.63* (19.37)	718	71
Total hours of unpaid labor	-2.30 (1.58)	1.39 (2.90)	0.83 (3.80)	718	71
Hours of household labor	-1.08 (3.03)	-1.94 (6.13)	0.87 (9.77)	718	71
Hours of self-sourced labor	-0.97 (1.03)	0.12 (1.88)	0.55 (2.79)	718	71
Engages in non-agricultural IGAs	-0.07 (0.05)	0.06 (0.09)	0.19** (0.08)	718	71

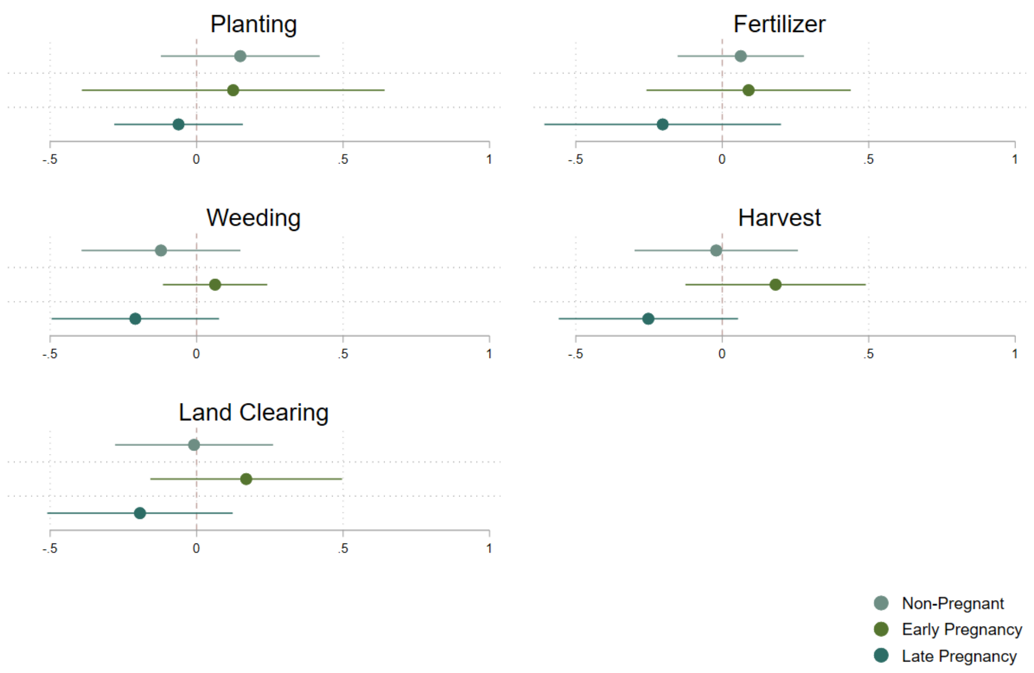
Note: OLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Interactions between these covariates and pregnancy status were additionally selected via double-selection-Lasso. Abbreviations: IGA = income-generating activity. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.15: ITT effects on likelihood of hiring labor for each activity by pregnancy group

Outcome	Non-Pregnant	Early Pregnancy	Late Pregnancy	N	Clusters
Planting	0.00 (0.04)	0.03 (0.07)	0.00 (0.06)	718	71
Fertilizer	-0.04 (0.04)	0.03 (0.05)	-0.04 (0.06)	718	71
Weeding	-0.08 (0.05)	0.07 (0.07)	-0.10 (0.09)	718	71
Harvest	-0.04 (0.05)	0.14* (0.08)	-0.10 (0.08)	718	71
Land Clearing	-0.01 (0.04)	0.06 (0.06)	0.01 (0.05)	718	71

Note: OLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Interactions between these covariates and pregnancy status were additionally selected via double-selection-Lasso. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Figure A.4: ITT effects on total hours of hired labor for each activity by pregnancy group



Note: Point estimates represent the ITT for each subgroup. Error bars represent 95% confidence intervals. Outcomes are standardized.

Table A.16: ITT effects on total hours of hired labor for each activity by pregnancy group

Outcome	Non-Pregnant	Early Pregnancy	Late Pregnancy	N	Clusters
Planting	2.78 (2.58)	2.33 (4.91)	-1.15 (2.09)	718	71
Fertilizer	1.04 (1.81)	1.48 (2.93)	-3.35 (3.39)	718	71
Weeding	-9.35 (10.64)	4.86 (6.98)	-16.08 (11.20)	718	71
Harvest	-0.86 (5.90)	7.55 (6.52)	-10.47 (6.48)	718	71
Land Clearing	-0.24 (3.79)	4.67 (4.60)	-5.33 (4.45)	718	71

Note: OLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Interactions between these covariates and pregnancy status were additionally selected via double-selection-Lasso. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.17: ITT effects on land allocations by pregnancy group

Outcome	Non-Pregnant	Early Pregnancy	Late Pregnancy	N	Clusters
Household rents out land	0.00 (0.03)	0.03 (0.04)	0.02 (0.02)	717	71
Household rents land for use	-0.04 (0.06)	0.13 (0.10)	0.05 (0.07)	718	71
Amount of land rented for use	0.00 (0.07)	0.21* (0.12)	0.06 (0.09)	718	71
Proportion of household land cultivated	-0.03* (0.02)	-0.02 (0.02)	-0.05** (0.03)	691	70

Note: OLS models adjusted for total acres owned by the household, household size, marital status, and age, with district-level fixed effects and standard error clustered at the One Acre Fund site-level. Interactions between these covariates and pregnancy status were additionally selected via double-selection-Lasso. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Appendix B Supplementary Model Exhibits

Figure B.1: Pregnancy exposure and total effective on-farm labor supply

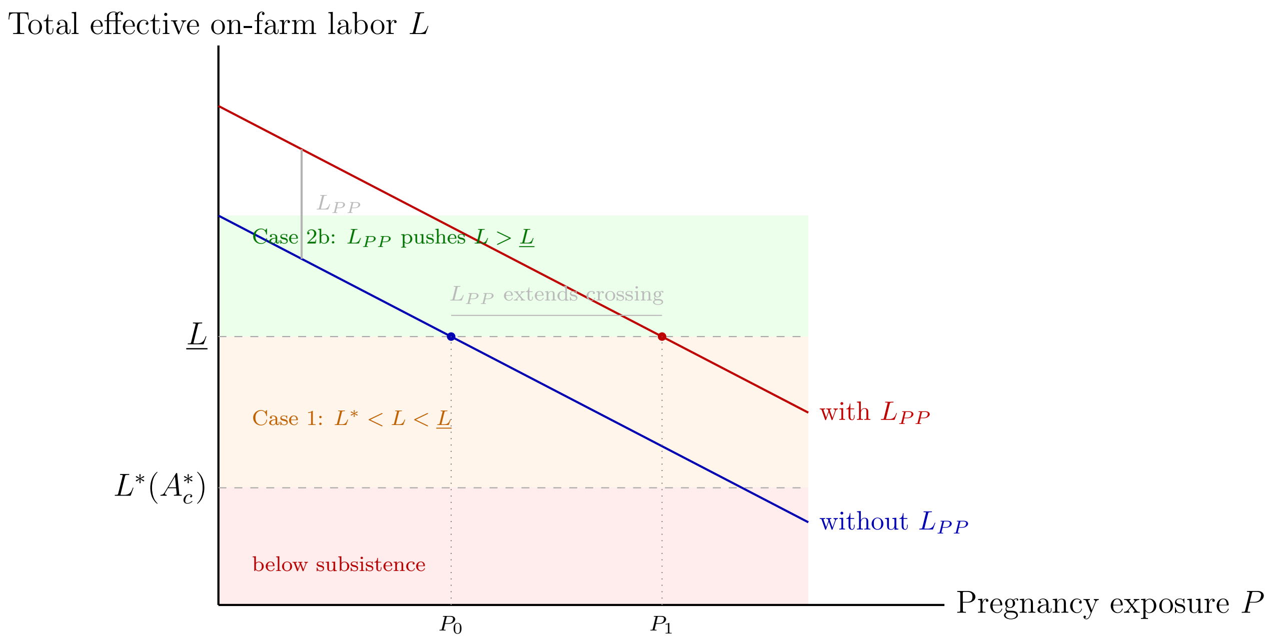
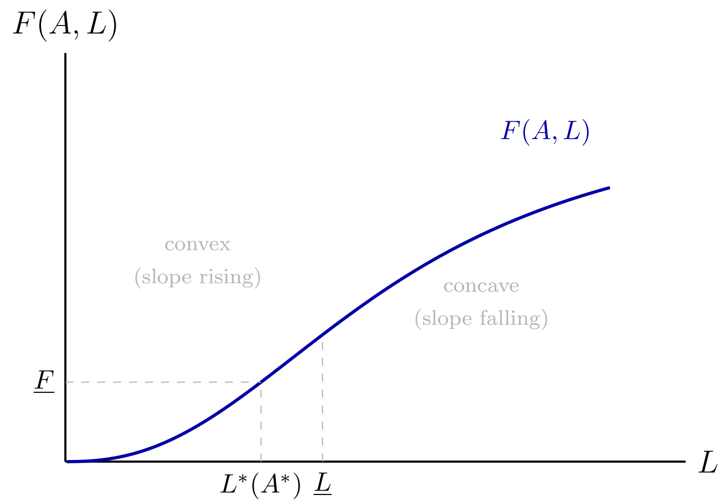
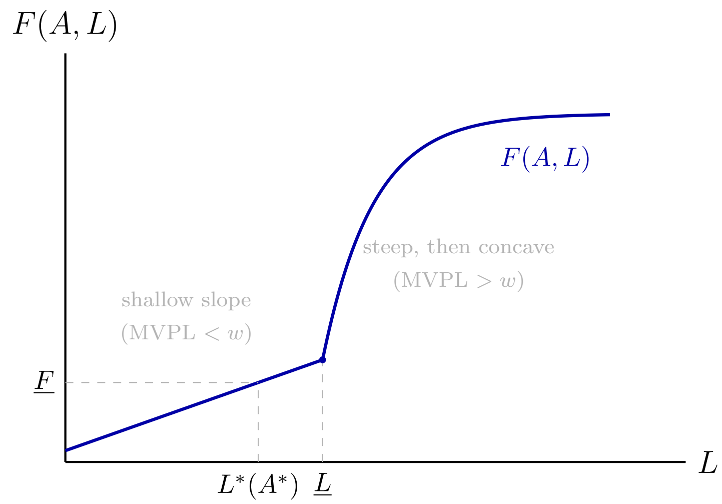


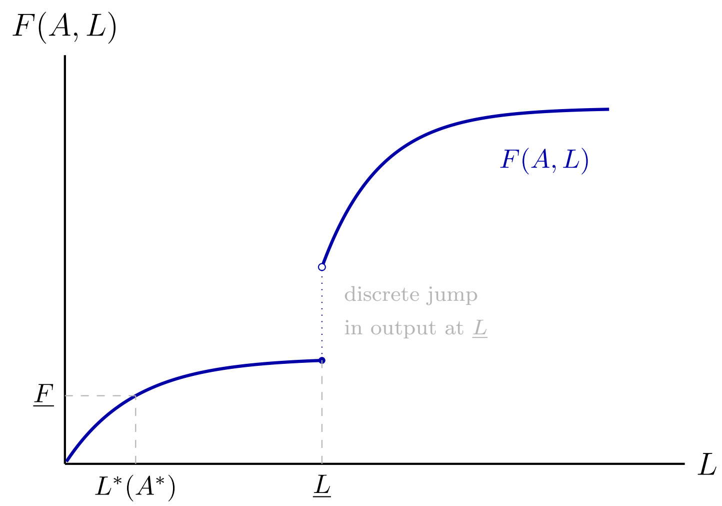
Figure B.2: Total effective on-farm labor and farm production



(1) Smooth S-shape



(2) Kinked at $\underline{L}$



(3) Discontinuous jump

B.0.1 Case 1: $L^*(A_c^*) \; < \; \phi_f(P)L_w + \bar{L}_o^N + \bar{L}_h + L_{PP} \; < \; \underline{L}$

This case is represented stylistically by Figure 5 Panel (b). Even with planting partners labor hours, the household's total effective on-farm labor is still below the threshold $\underline{L}$. However, with the planting partners labor hours, the household is above the minimal labor for subsistence consumption $L^*(A_c^*)$.

Necessary Conditions for Incomplete Markets:

$$\frac{\partial^2(\ell_w^* + z_w^* + \ell_o^* + z_o^*)}{\partial L_{PP} \partial P} > 0 \quad \text{and} \quad \frac{\partial^2(L_w^* + L_o^* + L_h^*)}{\partial L_{PP} \partial P} < 0 \tag{7}$$

When total effective farm labor supply is below the threshold $\underline{L}$, then households should only farm enough to produce subsistence production $\underline{F}$, and should dedicate their remaining labor hours off-farm. When markets are incomplete, pregnant women must still provide labor on-farm in order to ensure that the household meets subsistence. If pregnant women are differentially more likely to move labor hours off-farm when provided with L_{PP}, it implies that they are not simply substituting away from the labor that they optimally supplied to the farm (a marker of complete markets, as depicted in the lower panel of Figure 5 Panel (a)).

B.0.2 Case 2(a): $\underline{L} \; < \; \phi_f(P)L_w + \bar{L}_o^N + \bar{L}_h + L_{PP}$

With planting partners labor hours L_{PP}, the household's total effective on-farm labor is above the threshold $\underline{L}$.

Necessary and Sufficient Conditions for Incomplete Markets:

$$\frac{\partial^2(A_r^* + A_c^*)}{\partial L_{PP} \partial P} > 0 \quad \text{or} \quad \frac{\partial^2 Y}{\partial L_{PP} \partial P} > 0 \tag{8}$$

When markets are incomplete, pregnant women either must let their land fallow or attempt to supply their own labor to the farm unproductively. This slack in the amount of land that is used productively implies that a new source of labor must lead to a total increase in the amount of land that is cultivated, or the productivity of the cultivated land, more so for pregnant women than non-pregnant women (Equation 8).

Land and Labor Allocation Conditions (Sufficient but not Necessary):

$$\frac{\partial^2 A_r^*}{\partial L_{PP} \partial P} \geq 0, \quad \frac{\partial^2 L_h^*}{\partial L_{PP} \partial P} \geq 0, \quad \text{and} \quad \frac{\partial^2 L_o^*}{\partial L_{PP} \partial P} \geq 0 \tag{9}$$

If there is no scope for any amount of substitution for pregnant women's labor supply, then Planting Partners will not substitute from any existing market or intra-household solution, giving rise to all three conditions in Equation 9.[21] While this is a sufficient condition to demonstrate that none of these markets substitute for women's labor supply while they are pregnant, it is possible that women are able to use these markets for some degree of substitution (in which case not all three conditions will be met), but not enough to offset their productivity losses (implying that markets are still incomplete). Thus, the condition in Equation 9 is sufficient but not necessary.

B.0.3 Case 2(b): $\phi_f(P)L_w + \bar{L}_o^N + \bar{L}_h \; < \; \underline{L} \; < \; \phi_f(P)L_w + \bar{L}_o^N + \bar{L}_h + L_{PP}$

This case is represented stylistically by Figure 5 Panel (c). In this case, households are below the threshold $\underline{L}$ without planting partners labor, and are pushed above it through the intervention. In this case, all of the conditions in Case 2(a) still apply. However, households also experience an increase in the marginal product of labor such that it exceeds the prevailing wage w. In this regime, frictions in land markets, labor markets, and intra-household substitution lead both land *and* labor to be less productive inputs. Then, if either $L_h < \bar{L}_h$ or $L_o < \bar{L}_o^N$, we will also see an increase in on-farm labor supply:[22]

$$\frac{\partial(L_h^* + L_o^*)}{\partial L_{PP}} \geq 0$$

[21]Each second derivative condition will be greater than zero if any input is complementary to Planting Partners labor inputs, and equal to zero otherwise.

[22]Recall that it is possible that both constraints bind, but that, when total effective labor supply available is below $\underline{L}$, households choose $L_h < \bar{L}_h$ and $L_o < \bar{L}_o^N$. If a household is $\bar{L}_h + \epsilon$ below $\bar{L}$, she will choose to purchase no hired labor, even if she is able to purchase up to $\bar{L}_h$.