Measuring the Heterogeneous Effects of Input Subsidies on Household Outcomes: Evidence from Malawi

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Authors: Christone J. Nyondo, Zephaniah B. Nyirenda, Maggie G. Munthali, Brian Dillon, Sergio Puerto

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Authors

Christone J. Nyondo, PhD
Research Fellow
MwAPATA Institute, P.O Box 30883. Capital City, Lilongwe. Malawi.

Zephaniah B. Nyirenda
Research Analyst
MwAPATA Institute, P.O Box 30883. Capital City, Lilongwe. Malawi.

Maggie G. Munthali, PhD
Research Fellow
MwAPATA Institute, P.O Box 30883. Capital City, Lilongwe. Malawi.

Brian Dillon, PhD
Assistant Professor of Development Economics and Applied Econometrics
The Charles H. Dyson School, Cornell University
Warren Hall, Cornell University, Ithaca, NY 14853 USA

Sergio Puerto
Ph.D. Student in Applied Economics and Management
The Charles H. Dyson School, Cornell University
Warren Hall, Cornell University, Ithaca, NY 14853 USA

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ABSTRACT

Countries across the south of the Sahara, including Malawi, spend vast amounts of money on agricultural subsidy programs to increase smallholder farmers' access to inputs. Such programs give local authorities significant control over the distribution of subsidized inputs. We explore the extent to which local authorities grant access to young farmers to subsidized inputs; whether access to these inputs has an impact on productivity and income; and whether those impacts are different for younger and older farmers. Using a nine-year panel survey for Malawi, for the period 2010 to 2019, we find that despite there being no age difference between coupon recipients and non-recipients, a larger share of the non-youth within the recipients' group received coupons for all the inputs offered in the program (i.e., the full program). Also, despite the share of these coupon recipients falling steadily over the review period, the fall is sharper for the non-youth, falling roughly 32%, from 47% in 2010 to 15% in 2019. For the youth, it falls roughly 28%, from 36.5% in 2010 to 9.0% in 2019. The fall coincides with governments' falling allocations to the program. Lastly, we find that, despite holding smaller landholdings, access to subsidized inputs increases the relative productivity of the youth by 34%. However, it does not have any significant effect on the incomes of both the youth and the non-youth. The productivity increase in the youth is likely driven by their ability to utilize inputs more efficiently on their smaller landholdings.

Keywords: input subsidies, household outcomes, Malawi, heterogeneous effects, bias-adjusted

JEL Classifications: O12, O13, Q12, Q18]

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ACRONYMS AND ABBREVIATIONS

AIP	Affordable Inputs Program Definition
FISP	Farm Inputs Subsidy Program
FSG	Food Security Group
IHPS	Integrated Household Panel Survey
MSU	Michigan State University
NSO	National Statistical Office
OPV	Open Pollinated Varieties
PRCI	Policy Research, Capacity, and Influence
TIP	Targeted Inputs Program
VoPPHA	Value of Production per Hectare ()
USAID	United States Agency for International Development

I. INTRODUCTION

The government of Malawi has heavily invested in agricultural input subsidies since the 2004/05 agricultural season to enable smallholder farmers to access quality inputs for maize and grain legumes production. Under the Farm Inputs Subsidy Program (FISP), smallholder farmers received 100kgs of subsidized fertilizer (50kg NPK and 50kg Urea) and improved maize seed (5kg hybrid/7kg Open Pollinated Varieties – OPV), as well as legume seeds (3kgs of either groundnut, soya beans, pigeon peas, cowpeas or sugar beans) to grow on 0.4 hectares of land. The program targeted "productive", low-income households. The age of the beneficiary was not an element in the targeting criteria but could potentially be an important consideration in future programs. The FISP was in 2020/21 agricultural season replaced with a restructured and maize-focused program, the Affordable Inputs Program – AIP - which sorely provides the same quantity of inputs for maize production.

The theoretical basis for these agricultural input subsidy programs is that they promote agricultural productivity by making investments in agricultural technologies, such as inorganic fertilizers and improved seeds more attractive to smallholder farmers (Chirwa and Dorward, 2014). Empirical evidence is mixed about the impact of subsidies on productivity and other outcomes. One strand of literature argues that subsidies, such as the FISP, have generally failed to substantially increase productivity, especially for major staples like maize, as evidenced by a lower-than-potential maize productivity growth rate over the years of the program (Burke et al., 2020; Dorward and Chirwa, 2013). Ineffective targeting, leakages, and diversion of subsidized inputs have been cited as some of the major factors contributing to the poor performance of the FISP (Dorward and Chirwa, 2013; Ricker-Gilbert et al., 2011; Ricker-Gilbert and Jayne, 2017). Another strand argues that participation in the FISP generally increases productivity and improves the food and nutrition security of households (Dorward and Chirwa, 2011; Harou, 2018; Koppmair et al., 2017).

In this paper, we investigate whether promoting the participation of the youth in the program would be one of the pathways for improving the contribution of the program to farm productivity and household income. This provides for an interesting case study because we want to understand whether disregarding the beneficiary age is a policy oversight that may need to be addressed by authorities in future. Addressing this issue is important because, first; the youth constitute the largest share of the Malawian population, constituting roughly over two-thirds of the total population (Muyanga et al., 2020). Second, the agriculture sector remains the largest and most important contributor to the national economy, and there are limited non-farm employment opportunities. Consequently, the need for generating evidence to facilitate youth engagement in productive agricultural enterprises cannot be over-emphasized.

The paper explores three guiding research questions: (i) To what extent are the youth participating in the subsidy program? (ii) What are the effects of input subsidies on household farm productivity and incomes? (ii) Are those effects different for old and young farmers? We first investigate whether the youth are less likely than the non-youth to be targeted in the FISP, conditional on observable farmer characteristics. We do this by first investigating the age distribution in the subsidy program across the 2010 to 2019 period. We subsequently measure the heterogenous effects of the program on household outcomes, such as productivity and income, conditional on the age category of the household head. We explore the nature of the association between participating in the FISP and households' productivity per hectare and income. Then again, we employ the Oster (2019) coefficient stability and unobservable selection method to estimate the causal impact of the FISP on household productivity and income, allowing for heterogeneity across participants' age distribution. Our analytical approach uses a decade-long nationally representative panel dataset from Malawi`s Integrated Household Panel Survey (IHPS), where smallholder farming households were interviewed four times between 2010 and 2020. We believe employing data from this longitudinal survey provides better dynamics for understanding the effects of the FISP on the youth and their implications for rural transformation.

The results shed some light regarding the age distribution in the FISP and the heterogenous productivity and income effects of the program by age group. The results show that there is no age difference between coupon recipients who received at least one coupon and non-recipients. This implies that there was no intentional selection of beneficiaries into the program based on age. However, among the recipients, a larger share of the non-youth received coupons for all the inputs offered in the program. This implies that while the program did not actively crowd out the youth, the youth were less likely to be given access to all the inputs offered in the program. We fail to reject the hypothesis that non-FISP beneficiaries were older than FISP beneficiaries in all four survey waves. The results also show that the share of coupon recipients falls steadily over the course of the review period. The fall is relatively sharper for the non-youth, falling roughly 32%, from 47% in 2010 to 15% in 2019. For the youth, it falls roughly 28%, from 36.5% in 2010 to 9.0% in 2019. As to why this fall is happening at these high rates, the analysis reveals that the fall is coinciding with the period government was reducing its funding allocations to the program. Lastly, we find that access to subsidized inputs increases the relative productivity of the youth more than that of the non-youth despite the youth holding smaller landholdings. It increases the relative productivity of the youth by 34% over the mean value of the excluded group, and roughly 40% over the mean for non-recipient youth. The program increases the productivity of the non-youth by about 29%. However, it does not have any impact on the incomes of both the youth or the non-youth. The productivity increase in the youth is likely driven by their ability to utilize inputs more efficiently on their smaller landholdings.

Nonetheless, empirical evidence is inconclusive about the role of agriculture in stimulating youth engagement in agriculture and the structural transformation of rural economies. One school of thought argues for the intentional inclusion of the youth in agricultural programming to facilitate the structural transformation of the national economy and, more specifically, the agricultural sector (see, Fox et al., 2016). This school of thought also argues for the direct involvement of the youth in agriculture programs to sustain social stability (Fox et al., 2016). It is not clear whether this school of thought is consistent with the context of Malawi considering its current stage of development. Yet, another school of thought argues that the agriculture sector is not a panacea for youth employment challenges given that productivity growth has limited employment creation potential for the youth relative to the non-farm sector and for driving structural transformation in rural areas (Liu et al., 2020). The non-farm sector removes the need for land and associated inputs required for a successful agricultural enterprise (Liu et al., 2020). Additionally, agriculture may not be expected to have overwhelming prospects for the youth as the young people may be looking to avoid some of the risks associated with farming by moving into other employment sectors.

Yet again, alternative evidence suggests that in predominantly agrarian economies such as Malawi, the rural exodus of the youth from the farm to off-farm employment upsurges only when economic prospects outside agriculture improve (Kafle et al., 2018). Else, the agriculture sector continues to dominate because inter-sectoral movements involve transaction costs that the youth may not be willing to bear (Kafle et al., 2018). Considering the existence of limited non-farm employment opportunities and the limitations transaction costs impose on the ability of the youth to migrate to off-farm sectors, it is possible that, in the context of Malawi, the sector has prospects for the youth. The sector will likely remain critical to the country's economy for the foreseeable future.

Our findings contribute to two threads of literature on subsidies as follows: on the impact of subsidies on farm-level productivity; and on the profitability and impact of subsidies on household incomes. Regarding these threads, empirical evidence suggests that previous studies have focused on assessing the productivity impact (see, Burke et al., 2020; Dorward and Chirwa, 2013; Ricker-Gilbert et al., 2011; Ricker-Gilbert and Jayne, 2017) or profitability of fertilizer and/or income effect (see, Burke et al., 2017; Dorward and Chirwa, 2013; Ricker-Gilbert et al., 2011; Ricker-Gilbert and Jayne, 2017; Xu et al., 2009) without regarding the age category of the household head. While empirical evidence is inconclusive regarding the productivity impacts, evidence suggests negligible impacts of subsidies on the profitability of fertilizer use and household incomes We build on these two strands showing the heterogeneous productivity effects of subsidies based on the age group of a household head. By doing so, we incorporate an element of inclusive participation and its potential effects on the outcomes of beneficiaries (e.g., Lindsjö et al., 2021; Kafle et al., 2018; Liu et al., 2020; Susilowati, 2014). This also helps us understand whether the direct involvement of the youth in a subsidy program is a potential pathway for improving farm productivity and the general impacts of the program.

The paper is structured as follows: section 2 presents a contextual framework and the questions considered in the study; Section 3 presents the empirical strategy; section 4 discusses the data and sample selection issues. The analytical results are presented in section 5; followed by the discussion of the results and their policy implications in Section 6.

II. CONTEXT AND RESEARCH QUESTIONS

THE YOUTH AND THE AGRICULTURAL SECTOR IN MALAWI

Malawi is a young country, with a high labour force growth rate, due partly to high fertility rates (NSO, 2018). The youth constitute more than half of the population estimated at 18 million (NSO, 2018). About two-thirds of these are under 24 years of age, 45 percent under 15 (Muyanga et al., 2020). Malawi has limited employment opportunities in the formal sector, implying that the sheer numbers of youth entering the job market cannot be absorbed by the non-agricultural wage jobs let alone the non-youth who are on the job market ((Mangani et al., 2020). The Malawian youth face many entry hurdles into the agriculture sector, including limited access to farm inputs, prime agricultural land, credit, viable output markets and extension services (Chinsinga and Chasukwa, 2012). Also, Malawi is yet to significantly urbanize, implying that the majority of the youth, who live in rural and peri-urban areas, are unlikely to meet their income aspirations because of low formal employment opportunities (Fox et al., 2016). These factors suggest potential scope for stimulating rural transformation through deliberate youth inclusion in subsidy programs if there is adequate supporting evidence.

Notwithstanding the critical role the agriculture sector plays in the country's economy, agricultural production and correspondingly, the factors of production are principally controlled by the non-youth. The empirical literature on the generational perspectives and labour distribution in agriculture shows that despite some evidence that a large share of the Malawian population is young[1], the youth have lower access to factors of production (Lindsjö et al., 2021). Consistent with the 'social capital theory (see, Edwards and Foley, 1998; Putnam, 2001, 2015), this should be expected as the non-youth are normally more connected in society and have better access to resources. The non-youth,[2] though relatively limited in terms of the physical labour required for the "hoe" based agriculture practised in Malawi, mostly control land and other agricultural inputs (Lindsjö et al., 2021). Yet, the marginal output realized by the elderly from these productive resources is relatively lower than that realized by youth-headed households (Lindsjö et al., 2021).

Also, while the Malawian population growth rate remains high, life expectancy at birth has risen sharply since the 1970s[3] thereby increasing the proportion of older farmers in the population. Between 1970 and 1990, life expectancy at birth rose from 39.8 years to 46.1 years, before slightly falling to 45.1 years in 2000[4]. The increasing life expectancy at birth and its resultant increase in the share of the non-youth in the farmer population, the underlying high population growth rate and the dominance of the agriculture sector in development planning underscore the need for creating space

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[1] There are no universally agreed definition of the term "youth" The UN identifies those within the age-group 15 to 24, the AU Commission those within 15 – 35. According to Malawi' National Youth Policy, the term "youth" refers to anyone within the 10 -- 35 years' age group. For our context, the youth headed households are those within 18 – 35 years age-group. This is consistent with the definition used in Lindsjö et al., 2021.

[2] Similarly, in the Malawian context, the term elderly refers to those aged 65 and over (GoM, 2017a).

[3] Life expectancy at birth indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life

[4] htt*ps://data.worldbank.org/indicator/SP.DYN.LE00.IN?contextual=default&locations=MW*

for the youth in agricultural programming. Lastly, we have not come across any study that investigated the heterogenous effects of FISPs on household outcomes

INPUT SUBSIDY PROGRAMS IN MALAWI

Input subsidy programs (ISPs) in Malawi have significantly evolved since their inception. From 1971 to 1994, subsidized inputs were universally made available to smallholder farmers through farmer clubs. This approach was changed in 1994 when the government introduced an "inputs for work" program, where smallholder farmers were paid in kind with farm inputs. Later, the government introduced a free inputs distribution program "the Starter Pack Program", where around 2.8m farmers were given free packs of inputs for maize and legume production (i.e., 15kgs of fertilizer, 2kgs of maize seed and 1kg of legume seed) (Levy, 2005). The program was subsequently "Targeted Inputs Program" (TIP), in 1999, and scaled down to only target the poorest smallholder farmers with the same input packs. The program was further rescaled in 2000, and between 2001-02 to only targeted 1.5m and 1m 'poorest smallholder farmer households, respectively. The fertilizer component was scaled down to 10kgs per pack (Levy, 2005). The TIP was replaced by the Farm Inputs Subsidy Program (FISP), in 2005, which provided 100kgs of fertilizer (50kg NPK and 50kg Urea) and improved maize seed (5kg hybrid/7kg Open Pollinated Varieties – OPV), and a variation of legume seeds (3kgs of either groundnut, soya beans, pigeon peas, cowpeas or sugar beans) to cover roughly 0.4 hectares of land.

The FISP has been targeting "productive" poor smallholder farmers – that is, households who own and cultivate a particular piece of land – with subsidized inputs. It also included households headed by vulnerable people (e.g., physically disabled persons) and their guardians, as well as female-, orphan, or child-headed households as beneficiaries. The age or sex of the recipient was never part of the targeting criteria. In principle, only one beneficiary, the household head, was eligible for the program. In practice, this principle was rarely adhered to as evidence suggests that some of the households had more than one beneficiary in the program. The FISP targeted between 0.9 to 1.6 million smallholder farmer households, countrywide, across the 2010 to 2020 period. The salient features of the program, for the period 2010 to 2020, are presented in Appendix A.

The FISP inputs were administered through a paper voucher that defined allotted entitlement and controlled access to that entitlement (Chirwa & Dorward, 2013). However, it effectively failed to eliminate the diversion and leakage of inputs (Chirwa & Dorward, 2013). The vouchers (i.e., coupons) came in three types: fertilizer coupons (for redeeming NPK and Urea fertilizers); maize seed coupons (for redeeming hybrid or open-pollinated varieties); and a Flexi coupon for redeeming preferred legume seed, either groundnut, soya beans, pigeon peas, cowpeas or sugar beans seed. The FISP was replaced with the Affordable Inputs Program (AIP) in the 2020/21 agricultural season, by the new government, to address the targeting challenges and expand access to productive inputs. The AIP relaxed the targeting criteria of the FISP and universalized the program to the population of smallholder farmers (i.e., about 3.7 million farmers). This was a significant change in terms of beneficiary coverage and the composition of the input package. The AIP has so far exclusively focused on inputs for maize and other cereals' production (i.e., chemical fertilizers, and improved seed for maize, sorghum and rice) at 24% and 33% of market value, respectively, using a biometric (i.e., National IDs), instead of a paper voucher system (Chilundu, 2020).

RESEARCH QUESTIONS

This study answers two research questions: (i) to what extent are the youth participating in the subsidy program? and (ii) what are the effects of the program on productivity and income, and are those effects different for old and young farmers?

III. EMPIRICAL STRATEGY

CONCEPTUAL STRATEGY

To understand the heterogeneous effects of the FISP on farm productivity and household income by age group, we first frame the impact of FISP on the gross unit value of household production (VoPPHA). The VoPPHA is a composite indicator of farm productivity based on household crop enterprises, such as maize, groundnuts, soybeans, beans, pigeon peas and cowpeas, that were supported under the FISP, prior to the introduction of the AIP in the 2020/21 agricultural season. The gross VoPPHA aggregates crop income as a ratio of a standardized area under cultivation (e.g., hectare) to proxy household land productivity. In the context of this study, VoPPHA is measured in Malawi Kwacha per hectare (MK/ha). This proxy metric facilitates circumventing additive challenges associated with dealing with multiple crop yields for households producing several crops in a particular season (Abay, et.al., 2021).

Conceptually, as is the case with most African countries, rural households in Malawi typically derive their incomes from the production and sale of a basket of crops, on-farm labour wages (e.g., ganyu) and other off-farm income streams (see also. (Sheahan et al., 2013). We create a composite indicator of household income by aggregating household incomes from all income streams available to a household. Our supposition is that if FISPs are having positive impacts on households, then beneficiary households should, in principle, have better land productivity and overall incomes owing, in part, to the share of income from crop enterprises, *ceteris paribus*.

Also, in our analysis, we assume households are rational enterprises optimizing their scarce resources subject to several constraints (including access to production-enhancing inputs such as improved seeds and chemical fertilizers). Therefore, the role of the FISP is to relax the constraint, for the beneficiaries, of inadequate access to improved seeds and fertilizers. We compare the impact of FISPs on VoPPHA and household incomes, respectively, on youth and non-youth farmers, *ceteris paribus*. The comparison is critical because older farmers are believed to have disproportionately greater access to and control over productive assets as they are believed to have a relatively larger social capital than the youth (Lindsjö et al., 2021; Putnam, 2001, 2015).

REGRESSION SPECIFICATIONS

The relationship between FISP and farm productivity or household income, by the age of the farmer, is first framed in a Fixed Effects model to, first: measure the nature of the correlation between the FISP and outcome variables (see details in Appendix B). The coefficient estimates on β_1 provides the average effect of the FISP on productivity or income, irrespective of the age of the farmer, assuming the interaction coefficient β_3 is not significantly different from zero. A positive β_1 indicates positive correlation, while a negative β_1 indicates negative correlation. Coefficient estimates on β_2 give the productivity or income correlation after controlling for age. A positive and significant β_2 denotes that participation in FISP enhances youth productivity or income. The average productivity effect of FISP participation for the youth is given by β_3 (i.e., β_1 + β_2). The FISP increases the productivity of the youth if β_3 is positive (or decreases if negative) and significant, else it does not play any role in respective cases.

IDENTIFICATION STRATEGY

Given that our analysis is based on observational data, it would be misleading to interpret the correlation between FISP participation and farm productivity or household income as causal in nature without accounting for the potential effect of unobserved bias emanating from the covariates that affect the outcomes but may not have been included in the regression. First, it is incredibly difficult to generate a credible counterfactual to net out the relative effect of unobservables on outcome variables in the absence of data from a natural experiment. Second, it is incredibly difficult to explicitly account for unobservables in an empirical model in the absence of good instruments. However, the twin challenges can be effectively surmounted by applying the Oster (2019) approach to explicitly account for the extent of unobserved variable bias in parameter estimates and/or the importance of unobservables, relative to observables. Intuitively, the Oster (2019) approach identifies the share of variance in the dependent variable that can be jointly explained by the proportional effect of observed and unobserved variables that are correlated with it. The framework relies on identifying a maximum R-Squared (R_Max) statistic and the degree of selection on unobservables relative to observables (i.e., delta, δ) that would explain away the effect (i.e., make β=0) if the model had no omitted variables (i.e., hypothesized full model). One can follow Oster (2019) and set $\delta = 1$ and $R_{max} = 1.3\tilde{R}$ (See Appendix B) to explicitly account for both coefficient and R-squared movements (as opposed to traditional approaches that only account for coefficient movement) after the inclusion of relevant control variables. Therefore, with the Oster (2019) coefficient stability framework we can adjust the correlations estimated in the preceding step for the unobservable bias and give our results a causal interpretation (Oster, 2019) (see details in Appendix B). That is, we can only identify the causal impact of the program and test the robustness of our results after adjusting our coefficient estimates for any unobserved bias.

DESCRIPTIVE ANALYSIS

We begin by conducting a detailed descriptive analysis of FISP participation across the 2010 to 2019 period, by the age group of the household head. We categorize FISP participants into youth or non-youth groups depending on their age. The youth are defined as those within the 10 – 35 years age group. The non-youth are those above 35 years old. This initial step helps us deepen our understanding of the underlying sociodemographic and socio-economic characteristics of the program. It also helps us build a solid foundation for understanding and interpreting our regression results.

DATA AND SAMPLE SELECTION

This study makes use of the nationally-representative Integrated Household Panel Survey (IHPS) for Malawi, in which smallholder farming households were interviewed four times over a decade - in 2010/2011, 2012/13, 2016/2017 and 2019/2020. These datasets were collected by the National Statistical Office (NSO) of Malawi in collaboration with the World Bank. The IHPS collected comprehensive information on household composition, agricultural production, and other demographic attributes in all panel survey rounds.

A sample of over 3000 households from 204 enumeration areas (EAs), from all districts in Malawi, were randomly selected for interviews in 2010. These households were re-interviewed every 3 years up to 2019. The number of households in the sample varies over time because some could not be traced after 2010 due to either death or attrition and some were added to the original sample due to the splitting of original households of fresh recruitment. Table 1 shows the number of households per survey wave, accounting for splits, survey exits, and replacements/recruitment of new households.

Table 1: Re-interview rates across the 2010 - 2019 panel survey period

	2010	**2013**	**2016**	**2019**
Original household in 2010	1,619			
Re-interviewed households		1,359 (83.94%)	1,205 (74.43%)	1,054 (65.10%)
Relative to original households				
Untraced households		260 (16.06%)	414 (25.57%)	565 (34.90%)
New households		631 (38.97%)	1,303 (80.48%)	2,124 (131.19%)
Overall households in the sample	1,619 (100%)	1,990 (122.92%)	2,508 (154.91%)	3,178 (196.29%)

Source: Authors' computations based on IHPS data for the period 2010 to 2019.

Notes:

- We could not disaggregate households based on the nature in which they existed the survey, whether by death or attrition, due to the lack of that clarity in the database

IV. ANALYTICAL RESULTS

Descriptive analysis

Household characteristics and FISP participation by age-group

The general characteristics of the households in the FISP are presented in Table 2. The overall share of households receiving coupons for all the inputs in the program (i.e., full package) declined roughly by 30% from 2010 to 2019. However, the overall coupon redemption rates were high in all periods, ranging between 88% and 98% (see, upper section of *Table 2*).

An analysis of coupon receipt by the age category of the household head shows that a larger share of the non-youth, rather than the youth, received coupons for all inputs in the program for all four survey waves. The analysis also shows that despite the share of beneficiaries receiving the full program falling for both the youth and the non-youth across the four survey years, the fall was sharper for the non-youth. The share of the non-youth receiving the full program fell roughly by 32% from roughly 47% in 2010 to roughly 15% in 2019, while that for the youth fell roughly by 28% from 36.5% in 2010 to 9.0% in 2019 (see middle section of Table 2). The fall coincided with governments' falling allocations to the program (see Table 2 in the appendix).

Further analysis reveals that conditional on receiving any coupons, more than half (52.7%) of the recipients between 2010 and 2019 were male-headed and the majority of the households received fertilizer coupons (i.e., NPK and UREA). In households that received the full program, the share that received maize coupons rarely surpassed the 50% mark, and the share that received Flexi coupons ranged between 6 and 35%. Lastly, the redemption rates (not shown here) were low for maize seed (less than 50%), and even lower for grain legumes, ranging between 4% and 25%. Clearly, maize and flexi-coupons were not as widely received by beneficiaries as fertilizer coupons.

Regarding the marital status of household heads in the FISP, the analysis shows that the program targeted households in some sort of marital union or those that were widowed. Specifically, a relatively higher proportion of coupon recipients were in monogamous unions, followed by those who were widowed or polygamously married. A negligible share of those that had never been married participated in the program across the survey years. This suggests a strong influence of social connection regarding who local leaders decided to include in the program.

On the question "to what extent are the youth participating in the subsidy program, we examined the age distribution in the FISP in two stages. First, we examined the mean age distribution for household heads as coupon recipients/redeemers across survey years. Second, we examined the proportion of households receiving coupons by different age brackets. Our analysis shows that the mean overall age of household heads in the program ranged between 44 and 50 years. Our analysis also shows that except for 2013, there was little intra-survey variation in recipient age across survey years. The mean intra-survey age variation ranged between 43 and 50 years. As for 2013, the survey variation ranged between 27 and 48 years. It is not clear why there was this wide difference in the mean age of beneficiaries in 2013 (see Appendix C).

Table 2: Characteristics of households in the FISP

Variable	Survey years				
	2010	**2013**	**2016**	**2019**	**All**
Share of households that received coupons	42.3	33	24.7	12.4	25.3
Share of households that redeemed coupon	97.8	95	91.8	87.6	93.7
Coupon receipt by age-category					
Share of the youth that received coupons	36.5	23.9	17.9	9.0	19.7
Share of the non-youth that received coupons	47.2	39.8	29.4	14.9	29.5
Conditional on receiving any coupons:					
Sex of coupon recipient					
Female	47.3	50.2	49.8	55.3	50.1
Male	52.7	49.8	50.2	44.7	49.9
Share of households that received NPK coupon	71.8	77.6	79.2	75.4	76
Share of households that received UREA coupon	74.6	80	79.6	74.9	77.5
Share of households that received Maize coupon	32.8	52.4	46.0	43.8	43.6
Share of households that received Flexi-coupon	5.8	34.5	28.4	31.4	24.0
Age group of coupon recipient					
Marital status of coupon recipient in the household					
Monogamous, married or non-formal union	72.9	72.2	67.2	74.3	71.5
Polygamous, married or non-formal union	5.3	4.4	5.7	2.3	4.6
Separated	4.9	3.7	7.4	3.1	4.9
Divorced	4.4	5	3.7	7.6	4.9
Widowed or widower	11.8	14.1	11.4	11.2	12.2
Never married	0.7	0.6	4.7	1.5	1.9

Source: Authors' computations based on IHPS data for the period 2010 to 2019.

Notes:

- The first part of the table shows the overall share of coupon recipients and redeemers across the survey years
- The second (middle) part of the table presents the same information disaggregated by age
- The last part presents the overall sociodynamics structure of the sample conditional on receiving the coupon
- The fertilizer coupon is a composite coupon that gave farmers access to NPK and UREA fertilizer.
- The maize and Flexi-coupons were separate coupons for accessing subsidized seed for improved maize varieties and grain legumes seed, respectively.

To understand whether there is age difference between coupon recipients/redeemers and the average age of household heads in the FISP, we examined the kernel distributions of the mean ages of household heads relative to the mean age of those that redeemed their coupons during the 2010 to 2019 period. The results show that there was no age difference between household heads and coupon recipients/redeemers (Appendix D).

To formalize this analysis, we applied a Kolmogorov–Smirnov two-sample test of equality of distributions for FISP and non-FISP sub-samples for the four waves of the IHPS data used in the analysis. The test of the hypothesis that non-FISP beneficiaries were younger than FISP beneficiaries is rejected in three waves of the IHPS data (2010, 2013, and 2016). We fail to reject the hypothesis only in the 2019 wave of the IHPS survey (Appendix E). We then tested whether non-FISP beneficiaries were older than FISP beneficiaries. The hypothesis is rejected in all survey waves. The combined test is not rejected.

Table 3 shows the extent of program participation by households by age, access to agricultural extension and other economic services. Regarding the extent of access to subsidized inputs, the non-youth generally had better access to productive inputs, such as land, and fertilizer (commercial + subsidized). Thus, they were able to commit more land to crop production (i.e., except for 2013), and use cumulatively more fertilizer on average (i.e., 17.5kgs) than the youth. Also, a larger share of the non-youth had greater access to agricultural extension and credit services, signifying their greater resourcefulness and possibly social connectedness. In contrast, the youths accessed larger quantities of improved maize and flexi-coupon seeds than their counterparts. Specifically, in 2019, the youth accessed significantly larger quantities of improved maize seed than the non-youth.

Regarding the total quantities of maize produced by households, our analysis shows that, overall, the non-youth harvested 161.8kgs more, on average, than the youth. This is partly because, on average, they held and allocated more land to crop production (2.6 hectares) than the youth (1.6 hectares). Surprisingly, regarding their productivity, the non-youth were relatively less productive by a significant margin, especially in 2013 and 2016, despite holding larger shares of land. Unsurprisingly, the value of crop production for the youth was approximately double that of their counterparts. Our results show that the youth zrealized roughly 22% more income than the non-youth. Further analysis suggests that the youth realized more income than the non-youth partly because their maize productivity was significantly higher than their counterparts, especially in 2013 and 2016. Considering that maize inputs (i.e., fertilizers and improved seed) constituted the most significant component of the subsidy program, the productivity difference was likely driven by the youths' ability to more efficiently utilize their subsidized inputs on the smaller landholdings that were available to them. This provides limited evidence of the inverse productivity relationship.

Table 3: Characteristics of households by age-group of household head (mean)

Variable	Unit	Youth 2010	Non-Youth 2010	Youth 2013	Non-Youth 2013	Youth 2016	Non-Youth 2016	Youth 2019	Non-Youth 2019	All Youth	All Non-Youth
Amount of FISP fertilizer obtained	Kg	73.4	81.4	74.9	82.1	78.0	93.0	70.2	77.2	74.1	83.4
Amount of maize seed obtained	Kg	5.7	6.6	12.0*	7.2	5.2	5.9	5.2	5.7	7.0	6.4
Amount of flexible seed obtained	Kg	2.0	2.2	2.9	2.5	2.9	3.0	2.5**	1.9	2.6	2.4
Total fertilizer used	Kg	103.8	135.0	122.7	116.6	76.4	94.6	80.3	106.9	95.8	113.3
Total maize harvested	Kg	503.4	656.5	629.6	754.4	552.6	774.0	173.5	321.3	464.8	626.6
Total cultivated land	Ha	1.5	2.5	1.9	2.8	1.4	2.4	1.7	2.7	1.6	2.6
Total land holding	Ha	1.0	1.4	2.4	3.0	1.1	1.6	1.3	1.8	1.5	2.0
Household maize productivity	Kg/ha	1,579.0	1,660.0	2,197.40**	1,958.0	1,495.10***	1,327.0	1,476.0	1,463.0	1,717.0	1,641.0
Value of crop production	MK	17,577.00	25,518.00	83,157.00	100,965.40	108,620.50	118,476.20	90,506.00	12,184.00	89,205.00	69,222.00
Crop value productivity	MK/ha	52,147.0	62,177.0	240,985.0	22,577.0	325,297.70**	28,383.0	31,526.0	324,308.0	212,354.0	214,795.0
Household sales value	MK	10,898.00	15,706.00	32,604.00	37,462.00	57,581.00	54,835.00	46,643.00	46,577.00	48,013.90	53,985.80
Total household income	MK	90925.90**	64851.10	252,497	213,121	438,107	447,673	59,858	53354.40	301,303.00	290,724.00
Household agricultural income	MK	7,087.00	12,490.00	23,370.00	27,239.00	32,698.00	32,275.00	34,172.00	42,201.00	22,040.00	27,178.00
Households with access to agricultural extension	%	44.7	55.3	34.5	65.5	35.6	64.4	37.1	62.9	37.5	62.5
Households with access to credit	%	44.3	55.7	40.5	59.5	44.0	56.0	40.5	59.5	42.3	57.7

*** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate statistically significant at 1%, 5% and 10% level, respectively

Source: Authors' computations based on IHPS data for the period 2010 to 2019

Notes

The units Kg, Ha and Kg/ha represent kilogram, hectare and kilogram per hectare, respectively.

The unit MK represent Malawi kwacha and MK/ha represent Malawi kwacha per hectare

ECONOMETRIC RESULTS

Effect of FISP on-farm productivity

Table 4 reports the coefficients of interest from model 1 (Appendix B). In the model without controls (column 1), we find for older farmers a positive but statistically insignificant association between receiving a coupon and changes in agricultural productivity (point estimate = 11,320). For younger farmers, coupon receipt is associated with a statistically significant increase of MK20,324.85 per hectare (F-statistic = 3.72), indicated by the marginal effect in the lower part of the table. This represents an increase of roughly 16% over the mean value of productivity in the excluded group, which is MK130,665.90 (S.D. = MK189,854.60) When we add controls for household characteristics, these associations are statistically significant and larger in magnitude for both older and younger farmers (column 2). For older farmers, program participation conditional on controls is associated with a statistically significant increase in productivity of MK13,988 (11%). For younger farmers, the conditional association is an increase of MK22,790.70 (roughly 17%).

Table 4: FISP participation and agricultural productivity (2010 – 2019)

	(1) Value of output per hectare (MK/ha)	(2) Value of output per hectare (MK/ha)	(3) Bias adjusted effect, $\partial = 1$
Coupon (=1)	11,320	13,988**	37,627.35
	(7,087)	(7,106)	
Youth (=1)	-10,806	-11,204	-14,734.46
	(12,039)	(12,038)	
Coupon x Youth (=1)	9,004	8,803	7,001.21
	(12,424)	(12,358)	
Youth marginal effect (coupon + coupon x youth)	20,324.85*	22,790.70**	44,642.05
Mean dependent variable (excluded group)	130,665.90	130,665.90	130,665.90
Number of observations	6,455	6.455	6.455
R-squared	0.341	0.353	

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors clustered at household ID level)

Notes:

- All models are estimated with region and survey wave fixed effects (FEs). The standard errors are in parentheses
- The mean dependent variable is the pooled mean reference value of productivity for the non-youth-headed households that did not benefit from the program during the period under review
- Value of output per hectare is the monetary value of output in local currency units per hectare– Malawi kwacha per hectare (or MK/ha)

Finally, the coefficient on the youth dummy, which measures the difference between old and young farmers in the non-recipient group, is negative but not statistically different from zero in both regressions (with and without additional controls). Our finding that the coefficients on coupon receipt increase in magnitude after conditioning on covariates indicate that local leaders target coupons toward households that are expected to be less productive. With the negative selection of this type, the coefficient estimates in Table 4 are likely to be lower bounds on the causal effects of the program.

To credibly estimate the bounds on the treatment effects of the program, we employ the coefficient stability approach of Oster (2019). In the current case, we estimate the treatment effect of FISP, assuming delta is equal to one, so selection in unobservables is proportional to selection on observables. The bias-adjusted effects are presented in column 3 of Table 4. For the treatment effects under other selection assumptions, refer to Appendix G: . In Table 4, the bias-adjusted estimates for youth-headed households suggest that the marginal effect of the program on the productivity of the youth is even larger than estimated by the previous models (column 3). Relative to the reference group of non-recipient older households, youth-headed households that receive a coupon enjoy an increase in yields of MK44,642.05. This represents an increase of roughly 34% over the mean value of the dependent variable for the excluded group and an increase of roughly 40% over the mean for non-recipient youth. The program also has substantial impacts on older farmers, with an estimated impact on the productivity of MK37,627.35 (about 29%).

Effect of FISP on aggregate household income

Table 5 reports the coefficient estimates from model 1 with income as our outcome of interest. Again, in the model without controls (column 1), for older farmers, we find a positive but statistically insignificant association between receiving a coupon and changes in aggregate household income (point estimate = 33,785). Similarly, for young farmers, coupon receipt is also associated with a positive and statistically insignificant increase of MK49,622.60 in aggregate incomes (F-statistic = 1.49) shown by the marginal effect in the lower part of the table. That represents an increase of roughly (7%) over and above the mean aggregate income in the excluded group, which is MK675,139.2. When we add controls for household characteristics, the associations remain statistically insignificant and increase at a decreasing rate, in terms of their absolute magnitudes, for both older and younger farmers (column 2), with older farmers suffering a relatively larger decrease. For older farmers, participation in the program, conditional on household controls, is associated with a statistically insignificant decrease in aggregate income of MK28,142 (roughly 4%). For younger farmers, the conditional association is a statistically insignificant decrease in income of MK48,278.03 (7%). Lastly, the coefficient on the youth dummy which measures the difference between old and young farmers in the excluded group is negative for both models (with and without controls). It is statistically significant in the model without controls (point estimate =-102,622), but statistically insignificant in the model with controls (point estimate = -86,543). That is, the incremental effect of the program on household incomes is not significantly different between older and younger farmers despite young farmers generating relatively higher incomes.

Our finding that the coefficients on coupon receipts decrease in magnitude after conditioning on household covariates, despite not being statistically significant, suggests that local authorities target coupons at households that may already be better off and well-connected in society. These do not generate significant additional income from the program.

Table 5: FISP participation and household income (2010 – 2019)

	(1) Aggregate household income (MK)	(2) Aggregate household income (MK))	(3) Bias adjusted effect, $\partial = 1$
Coupon (=1)	33,785	28,142	-787.17
	(29,448)	(29,378)	
Youth (=1)	-102,622*	-86,543	-4,113.059
	(54,619)	(55,597)	
Coupon x Youth (=1)	15,838	20,136	42,169.95
	(49,394)	(48,867)	
Youth marginal effect (coupon + coupon x youth)	49,622.60	48,278.03	41,382.96
Mean dependent variable (excluded group)	675,139.20	67,5139.20	67,5139.20
Number of observations	6,738	6,738	6,738
R-squared	0.114	0.121	

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors clustered at household ID level)

Notes:

- All models are estimated with region and survey wave fixed effects (FEs). The standard errors are in parentheses
- The standard errors are in parentheses
- The mean dependent variable is the pooled mean reference value of productivity for the non-youth-headed households that did not benefit from the program during the period under review
- Value of output per hectare is the monetary value of output in local currency units per hectare– Malawi kwacha per hectare (or MK/ha)

This notwithstanding, we do not wish to overemphasize this type of positive selection considering that the coefficient estimates in Table 5 are not statistically significant from zero and are likely to be higher bounds on the treatment effects of the program.

To credibly estimate the bounds of the treatment effects, we again employ the coefficient stability approach of Oster (2019). The bias-adjusted effects are presented in column 3 of Table 5. The bias-adjusted estimates of youth-headed households suggest that despite the youth realizing larger additional incomes from the program, overall, this marginal income effect is actually a smaller increment on their aggregate incomes than estimated by previous models (column 3, Table 5). Relative to the reference group (i.e., excluded older farmers), the youth that receive a coupon increase their aggregate incomes by MK41,382.96 (or roughly 6%) over the mean value of the excluded group and an increase of 9% over the mean value of the excluded youth. The program reduces the income of older farmers by a negligible amount of MK787.17 (point estimate -787.17) (0.12%).

Robustness tests

To further check the consistency of our main results, we run an alternative set of regressions for equation 1 by dropping the location dummies (region) as an additional set of fixed effects (FEs) in the regression. Full model results as shown in Table 6 and Table 7 in Appendix F: The results are still consistent with our earlier findings, suggesting that FISP participation has a positive effect on youth productivity but does not have a significant effect on the incomes of both the youth and the non-youth. However, in both cases, the magnitude of effect is sensitive to the degree of selection allowed in the model (i.e., choice of delta - ∂). That is, youth marginal productivity or marginal incomes increase or decrease in the degree of selectivity allowed in the model (see Appendix G:

V. RESULTS DISCUSSION AND POLICY CONCLUSIONS

Regarding the participation of households in the subsidy program and coupon redemption rates over the four survey waves under review, the results show that the share of households receiving the program declined by roughly 30% between 2010 and 2019. Strikingly, the fall only affected the proportion receiving the full program (that is, coupons for fertilizer, maize and grain legumes seed). This suggests that while the share of households receiving the full program fell over time, the share receiving at least some program benefits is reasonably stable. Also, it is important to note that this fall happened around the time when the government was reducing budgetary allocations to the program, prior to the introduction of the Affordable Inputs Program (AIP) in the 2020/21 agricultural season, which was introduced by the successor government. The AIP significantly expanded beneficiary coverage but reduced the program package to exclusively focus on inputs for maize production.

Also, despite the decline in the proportion of households receiving the full program, the overall redemption rate remained high throughout the 2010 to 2019 period, ranging between 88% and 98%. Regarding the redemption rates of specific inputs in the program, the redemption rate of fertilizers was consistently high, ranging between 87 and 97%, during the review period. However, the redemption rate for maize seed rarely surpassed the 50% mark, and for grain legumes, ranged between 4% and 25%. This suggests that the high overall redemption rates were principally driven by the high fertilizer redemption rates. The low redemption rates for maize and legume seed does not necessarily imply the lack of reception of the program by farmers. Rather, it suggests that farmers prioritize fertilizer purchases, over other inputs, due to their limited resource envelopes. Farmers' liquidity constraints need to be mitigated to encourage high uptake of the program, reduce the recycling of grain for seed and improve the contribution of the program to household outcomes. Regarding the age distribution and extent of participation of the youth in the program, we find that there is no significant age difference between those that were recruited in the program and those that completely missed out. We also find that amongst those that eventually got recruited, a larger share of the non-youth get access to the full program (i.e., receive coupons for all the inputs offered in the program). However, the share of those receiving the full program falls steadily over time, with the share of the non-youth falling faster (roughly 32%) than the youth, from 47% in 2010 to 15% in 2019. For the youth, the share falls roughly 28%, from 36.5% in 2010 to 9.0% in 2019. The fall coincides with governments' falling allocations to the program.

As to why falling budgetary allocations seemed to be associated with a sharper decline in the allocation of the full program to the non-youth, the literature suggests that the youth were progressively getting more prominent in the program because they are more productive. According to Basurto, et al., 2020, Malawian local leaders target input subsidies to households with the potential to generate higher returns from the agricultural inputs allocated to them than on need. In our case, we find that despite the non-youth having have better access to (or better endowed with) productive resources, such as land, fertilizer, agricultural extension and agricultural credit, they generally generated lower returns per unit of input applied than the youth, on average. We also find that access to subsidized inputs increases the relative productivity of the youth by 34% over the mean value of the excluded group, and roughly 40% over the mean for non-recipient youth. The FISP increases the relative productivity of the non-youth by only about 29%. These rates of increase are achieved when the degree of selection on unobservables is assumed to be proportional to selection on observables. However, access to subsidized inputs does not have any impact on the incomes of both the youth and the non-youth. The productivity increase in the youth is likely driven by their ability to utilize inputs more efficiently on their smaller landholdings. This suggests that the youth would even be more productive if they were better resourced with necessary complementary resources (e.g., good quality land with good water sources, cash to hire labourers, adequate collateral and social capital to access the necessary inputs and financial resources for their farming enterprises).

Lastly, our results show a strong influence of social connections on the program. The program targeted those in some sort of family union, the widowed and other vulnerable groups. However, considering that local leaders were more likely to prioritize productive, than needy beneficiaries, this social targeting is likely to have had minimal marginal effects on the welfare outcomes of the beneficiaries because they are likely to have similar economic attributes as other villagers.

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Appendix A: **Summary of the salient features of the FISP for the 2019/10 to 2019/20 agricultural seasons**

	Total number of beneficiaries	Total fertilizer under ISP (MT)	Total maize seed under ISP (MT)	Hybrid maize seed (MT)	OPV maize seed (MT)	Total legume seed under ISP (MT)	Total Program cost (US$)	Unit price paid by government (US$/50kg)	Total redemption price (US$/100kgs)	Subsidy rate (%)	MoA budget share in national budget (%)	Program cost share in MoA budget (%)	Program cost share in national budget (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
2009/10	1,600,000	161,074	8,652	7,619	1,033	1550.92	150,357,819.09	51.75	8.77	95.00%	14.92%	44.74%	0.10%
2010/11	1,600,000	160,531	10,650	8,521	2,129	2,727	142,197,385.90	35.91	6.09	90.00%	11.96%	63.02%	0.35%
2011/12	1,400,000	140,000	8,245	5,643	2,602	2,562	144,082,361.43	45.34	6.70	91.85%	13.29%	52.62%	0.63%
2012/13	1,500,000	153,897	8,582	5,914	2,668	2,977	149,484,932.82	51.16	3.33	92.59%	14.68%	73.83%	1.76%
2013/14	1,500,000	149,820	8,268	6,087	2,181	3,042	140,658,572.09	48.07	2.64	96.38%	20.47%	45.62%	1.79%
2014/15	1,500,000	150,000	8,434	5,548	2,886	3,027	97,746,366.59	33.83	2.00	97.03%	17.52%	38.31%	0.35%
2015/16	1,500,000	70,000	7,135	6,207	928	2,827	94,558,295.91	21.82	12.33	79.04%	14.79%	43.99%	0.46%
2016/17	900,000	90,000	4,628	3,129	1,499	1,664	46,837,380.02	17.43	18.71	66.89%	17.56%	17.02%	0.35%
2017/18	900,000	89,380	4,352	3,786	566	1,046	48,196,528.27	28.81	19.64	65.24%	10.62%	25.54%	1.14%
2018/19	979,169	99,485	4,896	4,004	892	1,194	51,403,075.41	20.58	19.14	65.98%	10.00%	26.20%	1.50%
2019/20	898,882	89,879	4,472	3,343	1,129	1,194	45,226,319.22	20.00	18.70	65.79%	9.66%	20.28%	0.40%
Cu. avge	**1,298,005**	**123,097**	**7,119**	**5,436**	**1,683**	**2,165**	**100,977,185.16**	**34.07**	**10.73**	**82.34%**	**14.13%**	**41.02%**	**0.80%**

Source: Ministry of Agriculture (MoA) Final FISP Implementation Reports, 2009/10 to 2019/20 seasons

Notes

1. Cu. avge stands for cumulative average
2. MoA HQ operational costs are only included for 2014/15, 2015/16 and 2017/18.
3. The information on costs for printing fertilizer vouchers were only available for 2015/16

Appendix B: Description of the research methodology

The study employs a mixed methods approach to test its three research hypotheses. The first two hypotheses in sub-section 2.3**.** are tested by means of a detailed descriptive analysis of the age distribution in the FISP across the four waves of the Integrated Household Panel Survey (IHPS) covering the period 2010 to 2019. The analysis also investigated the association between the age category of the household head and productivity (VoPPHA), and income. These steps facilitated the characterization of our data, deepened our understanding of the underlying socio-economic and sociodemographic dynamics by age-group and participation status, and helped us build a solid foundation for understanding and interpreting our regression results.

The last question was tested by framing the conceptual framework in a fixed effects (FE) model with survey wave and regional FEs to measure the effect of ($FISP_{it}$ and the age of a household head ($Youth_{it}$) on productivity VoPPHA and income as shown equation (1), below:

$$\boldsymbol{Y_{it}} = \boldsymbol{\beta_0} + \boldsymbol{\beta}_1 FISP_{\boldsymbol{it}} + \boldsymbol{\beta_2 Youth_{it}} + \boldsymbol{\beta_3(FISP_{it}.Youth_{it})} + \boldsymbol{\beta_{it} X'_{it}} + \boldsymbol{\mu_i} + \boldsymbol{\varepsilon_{it}} \quad (1)$$

where Y_{it}, the outcome variable of interest is either gross value of output per hectare (VoPPHA) (as a proxy for productivity) or household income in local currency units (MK); $FISP_{it}$ is a discrete variable (=1 if a household participated in the FISP at time t, or 0 otherwise); $Youth_{it}$, is a discrete variable (=1 if farmer i is within the 10 – 35 age group); $\boldsymbol{X'_{it}}$ is a vector capturing a set of farmer characteristics (age, schooling, household size, access to agricultural extension, access to credit distance to nearest road, or ADMARC[5] depot); $FISP_{it}.Youth_{it}$ is the interaction effect of youth participation; β_{it} is a vector of coefficients associated with individual variables; μ_i is a vector of time invariant error term capturing all factors that affect productivity/income but are not captured by any variable in the model; and ε_{it} are time variant shocks that affect VoPPHA or income. Unlike estimators such as the correlated random effects (CRE) estimator proposed by Mundlak (1978) and Chamberlain (1996), the fixed effect (FE) model applied here does not account for potential endogeneity and unobserved heterogeneity to give our results a causal interpretation. If the unobserved time-invariant error term, μ_i, is not correlated with our explanatory variables, our parameter estimates are consistent but inefficient relative to estimates from the CRE model. After controlling for the observable characteristics, the proposed estimation strategy assumes that the time variant shocks, ε_{it}, that affect our outcome variables are normally distributed.

Then, we apply the Oster (2019) framework to estimate the bias-adjusted effects on productivity and income. Following Altonji, Elder and Taber (2005) and Oster (2019) one can calculate bias-adjusted coefficients using the following formula:

$$\rho^* \approx \tilde{\rho} - \delta \frac{R_{max} - \tilde{R}}{\tilde{R} - \dot{R}} (\dot{\rho} - \tilde{\rho}) \quad (2)$$

Where:

- $\dot{\rho}$ is the coefficient from the regression without any controls (except time- and other fixed effects)

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- $\dot{R}$ is the R-squared from the regression without any controls except your Fes (e.g. time and space)
- $\tilde{\rho}$ is the coefficient from regression with controls and FEs
- $\tilde{R}$ is the R-squared from regression with controls and FEs
- δ measures the importance of unobserved variables relative to observed variables.

One can follow Oster (2019) and set $\delta = 1$ and $R_{max} = 1.3\tilde{R}$. The assumption is that the closer ρ^* is to $\tilde{\rho}$, the smaller the extent of unobserved variable bias. According to Oster (2019), a coefficient can be considered as robust if the bias-adjusted coefficient has the same sign as the unadjusted coefficient. In addition, one can calculate the value for δ that would be necessary to 'explain away' the effect of the explanatory variable of interest on the outcomes of interest. That is, an estimate of how much more important the unobservables need to be than the observables.

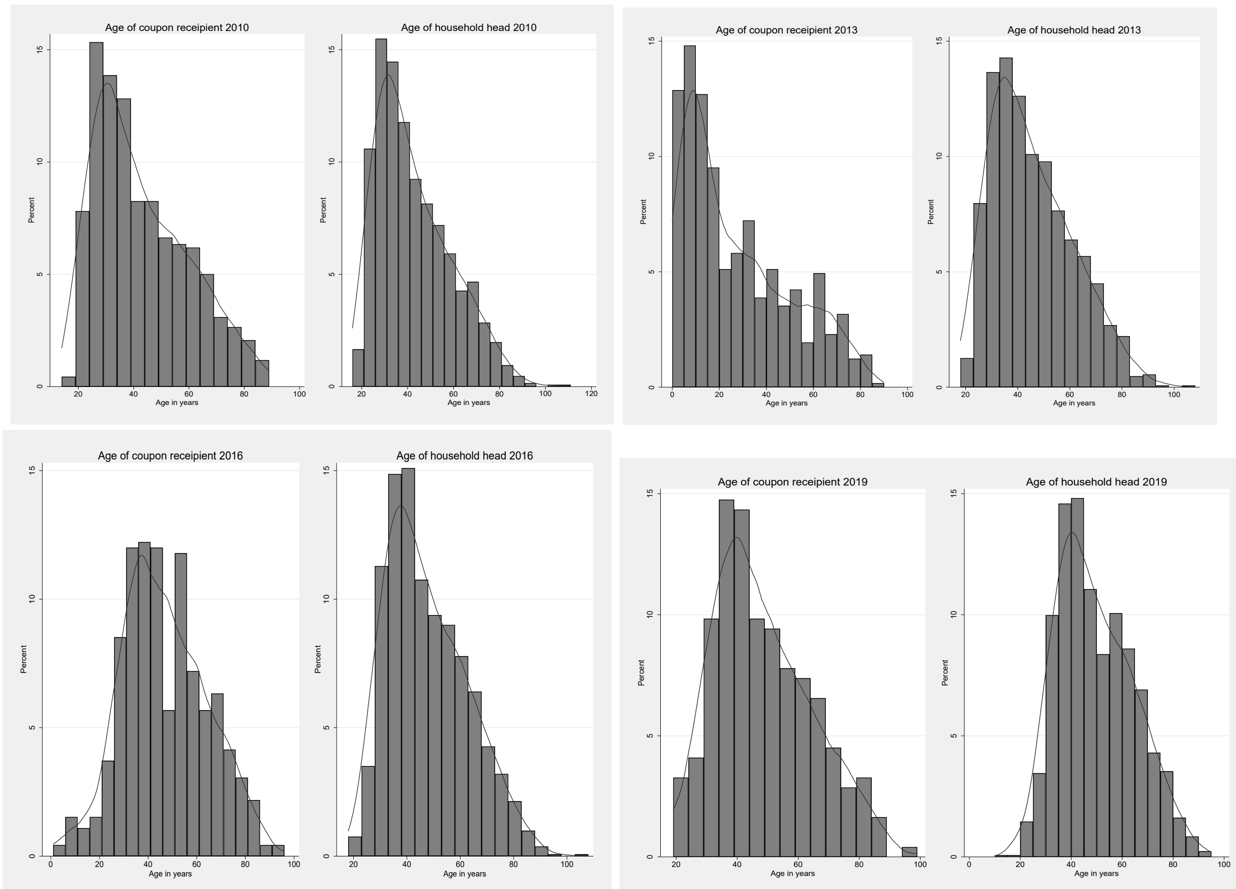
Appendix C: **Mean age distribution of households receiving/redeeming FISP coupons between 2010 and 2019.**

Variable	**2010**		**2013**		**2016**		**2019**	
	N	**Mean**	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**
Age of coupon recipient	678	42.7	567	27.1	458	46.6	244	48.3
Age of coupon redeemer	664	42.8	536	26.6	422	46.6	219	48
Age of household head	673	43.9	567	47.9	461	49.5	245	50.4

Source: Authors' computation based on IHPS data (2010-2019)

Appendix D:

Figure 1: Age distribution for household head and coupon redeemers in the FISP, 2010 - 2019



Source: Authors' computation based on IHPS data (2010-2019)

<u>**Note**</u>:

For each of the survey years, the charts should be interpretated in terms of pairs for the age of household head/coupon recipient

Appendix E: Two-sample Kolmogorov-Smirnov tests for equality of distribution functions for FISP and non-FISP beneficiaries, 2010 to 2019

	Difference			
Smaller group	**2010**	**2013**	**2016**	**2019**
Combined K-S test	0.1246***	0.2079***	**0.1856*** **	0.1404***

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' computation based on IHPS data (2010-2019

<u>**Notes:**</u>

- The K-S tests the difference in the age distribution between non-FISP beneficiaries and FISP beneficiaries.
- The test statistic is a combined test of the age difference and the associated *p-values*

Appendix F: Tables of regression results

Table 6: FISP participation and productivity (2010 – 2019)

	(1) Value of output per hectare (MK/ha)	(2) Value of output per hectare (MK/ha)	(3) Bias adjusted effect, $\partial = 1$
Coupon (=1)	11,522	14,240**	38,564.439
	(7,070)	(7,093)	
Youth (=1)	-10,758	-11,247	-15,623.251
	(12,041)	(12,039)	
Coupon x Youth (=1)	8,721	8,496	6,482.388
	(12,419)	(12,357)	
Youth marginal effect (coupon + coupon x youth)	20,243.20*	22,735.26**	45,046.826
Mean dependent variable (excluded group)	130,665.90	130,665.90	130,665.90
Number of observations	6,455	6.455	6.455
R-squared	0.341	0.353	

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors clustered at household ID level)

Notes:

- The standard errors are in parentheses
- The mean dependent variable is the pooled mean reference value of productivity for the non-youth-headed households that did not benefit from the program during the period under review

Table 7: FISP participation and household income (2010 – 2019)

	(1) Aggregate household income (MK)	(2) Aggregate household income (MK))	(3) Bias adjusted effect, $\partial = 1$
Coupon (=1)	31,807	26,384	-656.505
	(29,547)	(29,456)	
Youth (=1)	-99,547*	-83,737	4,904.181
	(54,632)	(55,581)	
Coupon x Youth (=1)	16,750	21,161	43,155.406
	(49,445)	(48,908)	
Youth marginal effect (coupon + coupon x youth)	48,556.45	47,544.62	42,498.90
Mean dependent variable (excluded group)	675,139.2	675,139.2	
Number of observations	6,738	6,738	6,738
R-squared	0.112	0.120	

*** p<0.01, ** p<0.05, * p<0.1

Notes

- Robust standard errors in parentheses. The standard errors are clustered at household level.
- Reference for marital status of household head is monogamously married (=1 if monogamously married)

Appendix G: Value of treatment effect of FISP on productivity with different assumptions about delta

Table 8: FISP participation and agricultural productivity with region and survey wave FE and delta as 0.5, 1 or 2

	(1) Value of output per hectare (MK/ha)	(2) Value of output per hectare (MK/ha)	(3) Bias adjusted effect, $\partial = 0.5$	(4) Bias adjusted effect, $\partial = 1$	(5) Bias adjusted effect, $\partial = 2$
Coupon (=1)	11,320 (7,087)	13,988** (7,106)	25,807.67	37,627.35	61,266.70
Youth (=1)	-10,806 (12,039)	-11,204 (12,038)	-12,969.23	-14,734.46	-18,264.91
Coupon x Youth (=1)	9,004 (12,424)	8,803 (12,358)	7,902.106	7,001.21	5199.424
Youth marginal effect (coupon + coupon x youth)	20,324.85*	22,790.70**	33,716.37	44,642.05	66,493.39
Mean dependent variable (excluded group)	130,665.90	130,665.90	130,665.90	130,665.90	130,665.90
Number of observations	6,455	6.455	6.455	6.455	6.455
R-squared	0.341	0.353			

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors clustered at household ID level)

Notes

- When delta is equal to 0.5, selection in unobservables is assumed to be smaller than selection on observables
- When delta is equal to 1, selection in unobservables is assumed to be equal to selection on observables
- When delta is equal to 2, selection in unobservables is assumed to be twice as much as selection on observables

Table 9: FISP participation and household income with region and survey wave FE and delta as 0.5, 1 or 2

	(1) Aggregate household income (MK)	(2) Aggregate household income (MK)	(3) Bias adjusted effect, $\partial = 0.5$	(4) Bias adjusted effect, $\partial = 1$	(5) Bias adjusted effect, $\partial = 2$
Coupon (=1)	33,785 (29,448)	28,142 (29,378)	13,677.41	-787.17	-29,716.34
Youth (=1)	-102,622* (54,619)	-86,543 (55,597)	-45,328.03	-4,113.059	78,316.88
Coupon x Youth (=1)	15,838 (49,394)	20,136 (48,867)	31,151.98	42,169.95	64,203.90
Youth marginal effect (coupon + coupon x youth)	49,622.60	48,278.03	44,830.50	41,382.96	34,487.89
Mean dependent variable (excluded group)	675,139.20	67,5139.20	67,5139.20	675139.20	675139.20
Number of observations	6,738	6,738	6,738	6,738	6,738
R-squared	0.114	0.121			

*** p<0.01, ** p<0.05, * p<0.1 (Robust standard errors clustered at household ID level)

Notes

- When delta is equal to 0.5, selection in unobservables is assumed to be smaller than selection on observables
- When delta is equal to 1, selection in unobservables is assumed to be equal to selection on observables
- When delta is equal to 2, selection in unobservables is assumed to be twice as much as selection on observables