The Macroeconomic Impact of Agricultural Input Subsidies*

Karol Mazur[†] Laszlo Tetenyi[‡]

February 28, 2023

WORK IN PROGRESS. Click here for the most recent version.

Abstract

We quantitatively evaluate the general equilibrium effects of input subsidy programs in agriculture. First, we present cross-country evidence that staple-targeting subsidy programs improve the productivity of staples and food security, increase the relative price of cash crops and the share of land devoted to their cultivation, and increase the share of people employed in manufacturing. We confirm these findings in micro-data from Malawi. Then, we build a dynamic general equilibrium model with financial frictions, transaction costs, subsistence consumption constraints, and heterogeneous agents making an occupational choice between working as laborers in urban areas and as staple or cash crop farmers in rural areas. Quantifying the model for the case of African input subsidy programs, we show the importance of financial development and infrastructure on optimal policy.

Keywords: Occupational Choice, Macro-development, Input Subsidy Programs, Sub-Saharan Africa

JEL Codes: Q12, Q18, O11

*Our thanks for valuable input are due to Arpad Abraham, Zsofia Barany, Douglas Gollin, Albert Rodriguez-Sala, Karthik Sridhar, Chris Woodruff and conference participants in Oxford, St. Gallen, Spanish Macro Network and the Econometric Society Meetings. Karol gratefully acknowledges financial support from the British Academy under the Leverhulme Small Research Grant 2021/210492. All remaining errors are our own.

†Peking University HSBC Business School, contact: kmazur@phbs.pku.edu.cn

‡Bank of Portugal, contact: ltetenyi@bportugal.pt

1 Introduction

The "Green Revolution" in the last four decades of the 20th century dramatically improved the productivity of agriculture across Asia and South America, but less so in Sub-Saharan Africa (SSA). Because the agricultural sector is vital to unlocking robust economic growth and structural transformation, cross-country differences in the performance of agricultural sectors have attracted the interest of policymakers and academics, see, e.g., [Caselli, 2005] and [Gollin et al., 2014]. In reaction to falling behind, several African nations signed the 2003 Maputo Declaration committing resources and efforts to stimulate local agricultural sectors' productivity growth. Most participating countries implemented input subsidy programs (ISPs) supporting using fertilizers, pesticides, or modern seeds.[1] In this paper, we study the general equilibrium effects of ISPs on agricultural productivity, crop cultivation decisions, occupational choice, and market prices.

Agriculture in many developing countries functions on a small scale with limited marketing of crop output. Moreover, the lack of geographical market integration implies large gaps between consumption and producer prices, and the consumption of poor rural populations is close to subsistence levels. Therefore, developing countries' agricultural policies must balance efficiency and food security. In SSA, tensions between policies that support food production and policies that support exportable cash crops production such as cash crops such as cocoa, coffee, cotton, tobacco, or sugar, are especially relevant. Exportable cash crops may maximize the producers' production value, but they are not a good source of carbohydrates, dietary fiber, and proteins. Because staples provide valuable nutrition and are significantly cheaper when self-produced, ISPs may trigger an equity-efficiency trade-off whenever they target staples and not cash crops[2]. However, general equilibrium effects may mitigate the severity of this trade-off as whenever productivity of staples production is improved, food security concerns become less relevant, releasing more land for the cultivation of cash crops.

We evaluate the effects of agricultural policy by employing both empirical and structural methods. First, we use data from FAOstat to study these policies in the panel of SSA countries. By comparing signatories of the Maputo Declaration with the rest of region in a diff-in-diff setting, we show evidence suggesting that the yields of staples increased by around 323kg per hectare on impact of introducing ISPs, without having any effect on yields of cash crops. Consequently, we find evidence of improvements in food security, as proxied by a 11% reduction in the share of stunted children. Studying data on land allocation and market

[1] For additional details on the history of ISPs in SSA, see [Jayne et al., 2018].

[2] As is the case in all SSA countries with ISPs

prices, we find that the share of land devoted to cash crops increases by 9% and the relative price of cash crops to staples increases by 15%. When analysing intersectoral allocation of labor, we find that the subsidy programs increase mobility of people, as suggested by the 10% reduction in the share of people employed in agriculture.

In order to further evaluate ISPs at the micro level, we study the case of Malawi, where the government introduced the Farm Input Subsidy Program (FISP) in 2004, providing subsidized inputs for the cultivation of staples at the cost of approx. 3%-6% of GDP annually. First, we confirm the qualitative findings from the cross-country panel in micro-data from the 2010 wave of the Living Standards Measurement Survey-Integrated Household Survey (LSMS-IHS) for Malawi. Second, we find that the value of agricultural production of households receiving FISP-subsidized inputs tends to be 8% higher. These households devote 10% less of land to staples (and more to cash crops), and their share of crop output sold in markets increases by 5%. Overall, evidence suggests that the staples-targeting ISP policies do not trigger significant equity-efficiency trade-offs in agriculture. Instead, the policy allows households to increase the efficiency of food production and release more land to produce exportable cash crops.

Motivated by these findings and to fully account for other potential trade-offs, we develop a dynamic stochastic general equilibrium framework with an occupational choice between two sectors: agriculture in rural areas (staple or cash crop production) and wage work in urban areas. Our model includes sector-specific productivity shocks, reallocation costs, financial frictions, incomplete markets, and food security concerns. The latter enters our framework through two channels. First, households have non-homothetic preferences as they require a subsistence level of staple consumption, increasing the relative importance of staple production, especially for low levels of economic development. Second, we introduce transaction costs implying that maximizing the market value of crop output need not be the optimal strategy from the household perspective [de Janvry et al., 1991]. Finally, our framework also accounts for the general equilibrium effects induced by ISPs, which is particularly important for evaluating the market and fiscal consequences of policies implemented at scale.

We calibrate the model to the economy of Malawi in 2010 to evaluate FISP. After setting some parameters based on the literature and the institutional setup of Malawi, we identify the model's parameters using the simulated method of moments. The macro moments we match include the structural composition of the country, the urban unemployment rate, and the relative size of the government-run FISP. Furthermore, we also rely on micro evidence from LSMS-IHS on income processes in urban and rural areas, rural-urban migration rate, relative agricultural input costs of staple and cash crop producers, and differences between producer and consumer prices of agricultural products. Finally, we calibrate the severity of financial frictions using the Randomized Control Trials (RCT) evidence in [Daidone et al., 2019].

Our quantitative analysis measures the macroeconomic effects induced by FISP in Malawi. Eliminating input subsidies for staples from the calibrated model generates a 4% decrease in consumption-equivalent welfare, with large declines in output and consumption. These effects arise as households use fewer intermediate inputs, implying reduced agricultural productivity (especially for staples). The trade balance improves as fertilizer imports decline. The urban-rural gaps in wealth, income, and consumption increase while migration and the share of manufacturing households decrease. As our quantitative experiment provides an upper bound for the welfare effects of the Malawi subsidy program, we aim to provide alternative quantitative analyses in the near future.

Literature review. Our paper falls within the recent macro-development literature reviewed by [Buera et al., 2021b]. One strand of this literature has documented large cross-country disparities in the productivity of agricultural sectors ([Caselli, 2005], [Restuccia et al., 2008], [Vollrath, 2009] and [Gollin et al., 2014]), with much recent literature focusing on the reasons of these productivity gaps.[3] Our paper focuses on the region of SSA characterized by particularly low agriculture productivity and studies input subsidies as a potential development policy allowing for closing these gaps.

Our work also relates to papers deploying general equilibrium models with occupational choice and financial frictions. [Buera et al., 2011], [Midrigan and Xu, 2014], [Moll, 2014] and [Tetenyi, 2019] show how financial constraints reduce aggregate productivity and efficiency of intersectoral allocations. [Buera et al., 2021a] study macroeconomic consequences of microcredit programs. In the context of Indian agriculture, [Donovan, 2021] investigates the implications of uninsured consumption risk for input adoption, productivity, and welfare. In this paper, we provide an extension of this class of models by the feature of transaction costs and apply it to the economy of Malawi.

Transaction costs have been long recognized as important determinants of agricultural choices ([de Janvry et al., 1991], [Fafchamps, 1992], [Omamo, 1998], [Adamopoulos, 2011] and [Gollin and Rogerson, 2014]). Leveraging our general equilibrium framework, we contribute to this literature with a general equilibrium analysis of transaction costs' interaction with financial constraints and their impact on occupational decisions and optimal agricultural policy.

Seminal work of [Kaboski and Townesend, 2011] estimates a structural framework on RCT data to show the importance of considering heterogeneous impacts of rural interven-

[3] See e.g. work of [Herrendorf and Schoellman, 2015], [Lagakos and Waugh, 2013], [Restuccia and Santaeulalia-Llopis, 2017], [Restuccia et al., 2020] and [Donovan, 2021].

tions for drawing policy conclusions. In this paper, we similarly leverage the RCT evidence in [Daidone et al., 2019] to discipline our quantitative model and shed light on the heterogeneous impact of input subsidy programs.[4] Consequently, we complement the purely empirical literature studying ISPs [Jayne et al., 2018] with a structural approach accounting for general equilibrium consequences of these programs in terms of food security, agricultural productivity, occupational choice, and welfare.

2 Empirical Evidence

In this Section we first discuss our cross-country data sources from the Food and Agriculture Organization (FAO) and micro-data from the 2010 Integrated Household Survey (Living Standards Measurement Survey) for Malawi. Using it, we show that ISPs are associated with improvements in productivity of staples and in food security.

2.1 Data Description

We first construct a cross-country panel using the richness of data available in FAOstat. In particular, we collect data from all SSA countries on crop yields — which we divide into cash- and staple crops, percent of children stunting, cultivated land area devoted to cash- and staple crops, and relative prices of crops. Most of the data is available directly from FAO. The exception is the price data, which we derive as price $= \frac{\text{value}}{\text{quantity}}$ combining the series on (i) value of cash- and staple crops output, and (ii) quantities produced. Furthermore, we group countries into control and treatment groups based on the introduction of ISP. Table 1 presents summary statistics, details on selection of countries into the two groups and composition of cash and staple crops.

In case of the IHS 2010 data for Malawi, we mostly follow [De Magalhaes and Santaeulalia-Llopis, 2018]. All quantities are computed at annual values. First, we use consumption both in our empirical evidence and calibration. We measure it as the sum of both purchased, self-farmed or received value of food and non-food nondurable expenditures, including clothing, health, education, utilities, housing and transportation. Additional details about the data construction are provided in appendix B.

Second, we use a measure of agricultural harvest, which amounts to the household-level aggregate of crop- and plot-specific output for whole year, both sold and unsold. Initially we evaluate both food consumption and agricultural production using consumption prices,

[4] [Harou et al., 2017] presents further RCT evidence on the effects of fertilizer on returns to agriculture in Malawi.

Variable	Control group	Treatment group
Number of countries	36	10
Log yields of staples	9.18	9.32
Log yields of cash crops	10.07	9.97
Share of population stunting	33.56%	36.20%
Share of rural population	69%	75%

Table 1: Summary statistics of FAO cross-country data

Note: Yields are expressed in 2014-2016 International Dollars per hectare. Staples are composed of "cereals" in FAOStat (maize, millet, rice, sorghum, wheat, fonio, barley, oats, buckwheat, rye, quinoa, canary seed, triticale), and cash crops - of cocoa, coffee, cotton, groundnuts, sugar cane, tea, tobacco. Countries in the treatment group include (with the year of introducing ISPs in brackets): Burkina Faso (2008), Ethiopia (2009), Ghana (2008), Kenya (2007), Malawi (2005), Mali (2008), Nigeria (1999), Senegal (2008), Tanzania (2008), Zambia (2002). Countries in the control group include: Angola, Benin, Botswana, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Democratic Republic of Congo, Djibouti, Eritrea, Eswatini, Gabon, Gambia, Guinea , Gunea-Bissau, Lesotho, Madagascar, Mauritania, Mauritius, Mozambique, Namibia, Niger, Reunion, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, South Africa, Sudan, Togo, Uganda, Zimbabwe.

but we also make use of prices-at-the-gate to derive transaction costs for the purposes of calibration.

Third, for our calibration we also need measures of net income and wealth, for both rural and urban residents. We define income as the net agricultural income, including other income sources, such as livestock sales and production, land income, equipment sales. We subtract all costs stemming from using intermediate inputs, rental of land and capital, hired labor, and transportation costs. Further sources of household income include labor income, either from main, secondary and informal occupations, net business income, net interest income, pension income, rental of property and durables, asset sales, and inheritance, and net transfers. Furthermore, wealth is measured as the value of housing, land, livestock, agricultural equipment and structures, and other durables, minus debt owed. We show the summary statistics in Table 2.

2.2 Cross-Country Evidence

We first show the macroeconomic cross-country evidence on effects of ISPs in SSA. Figure 1 presents evolution of the share of agricultural land devoted to staples, agricultural yields and food insecurity in countries that introduced ISP policies compared to the rest of SSA. This comparison suggests that the policies subsidizing input use for production of staples might have been quite effective in both improving productivity of staples and reducing food insecurity. While ISPs seem to not improve the productivity of cash crops (which are not

Variable	Average	Std. Dev.
Number of households	12,015	-
Household size in rural/urban areas	4.59/4.46	-
Cons. in rural/urban areas	1,318/2,951	-
Income in rural/urban areas	1,142/2,795	-
Wealth in rural/urban areas	1,309/3,976	-
% of population in rural areas	82%	-
Size of total household land	1.97	23.01
% of HHs cultivating only maize/cash crops	41%/6%	-
% of staple harvest self-consumed	84% (92%)	0.23 (0.16)

Table 2: Summary statistics of LSMS 2010 data for Malawi

Note: Consumption, income and wealth are expressed in 2010 US dollars at the household level. Land size is in acres.

targeted by the policy), the improved food security allows farmers to devote more land to cultivating cash crops. The effect on land allocation is further strengthened by response of the relative crop price: as productivity of staples increases and food security is more easily attained, the relative price of staples decreases, creating additional market incentives for cultivating cash crops.

We confirm these results in a formal diff-in-diff settings, dividing the countries into treatment and control groups as above, and with treatments being introduced at heterogeneous points of time as described below Figure 1. Table 1 presents results of this exercise.

Introduction of ISP is associated with a statistically significant increase of 96 tonnes of fertilizer used, and of staples' yields equivalent to 323 kg per hectare. Arguably because the subsidy programs in SSA target production of staples, we do not find any significant effect on the productivity of cash crops. As the staple sector becomes more productive, the policy also improves food security, as seen by a 3.7 p.p. (11%) reduction in percentage of stunted children under 5 years of age. As a market consequence of the previous observations, we observe an 18% increase in the relative price of cash to staple crops upon introduction of ISPs. All those effects lead farmers in countries with ISPs to devote more land to cultivating higher-value cash crops, as evinced by a 6 p.p. (9%) reduction in share of land devoted to staples. Finally, we find that the the programs accelerate structural change as proxied by a 10% decrease in the share of population employed in agriculture.

2.3 Micro-evidence from Malawi

Malawi is one of the five poorest countries in the world, with the 2019 GDP per capita at USD 367, almost 40% of population living below the poverty line, half of its children being

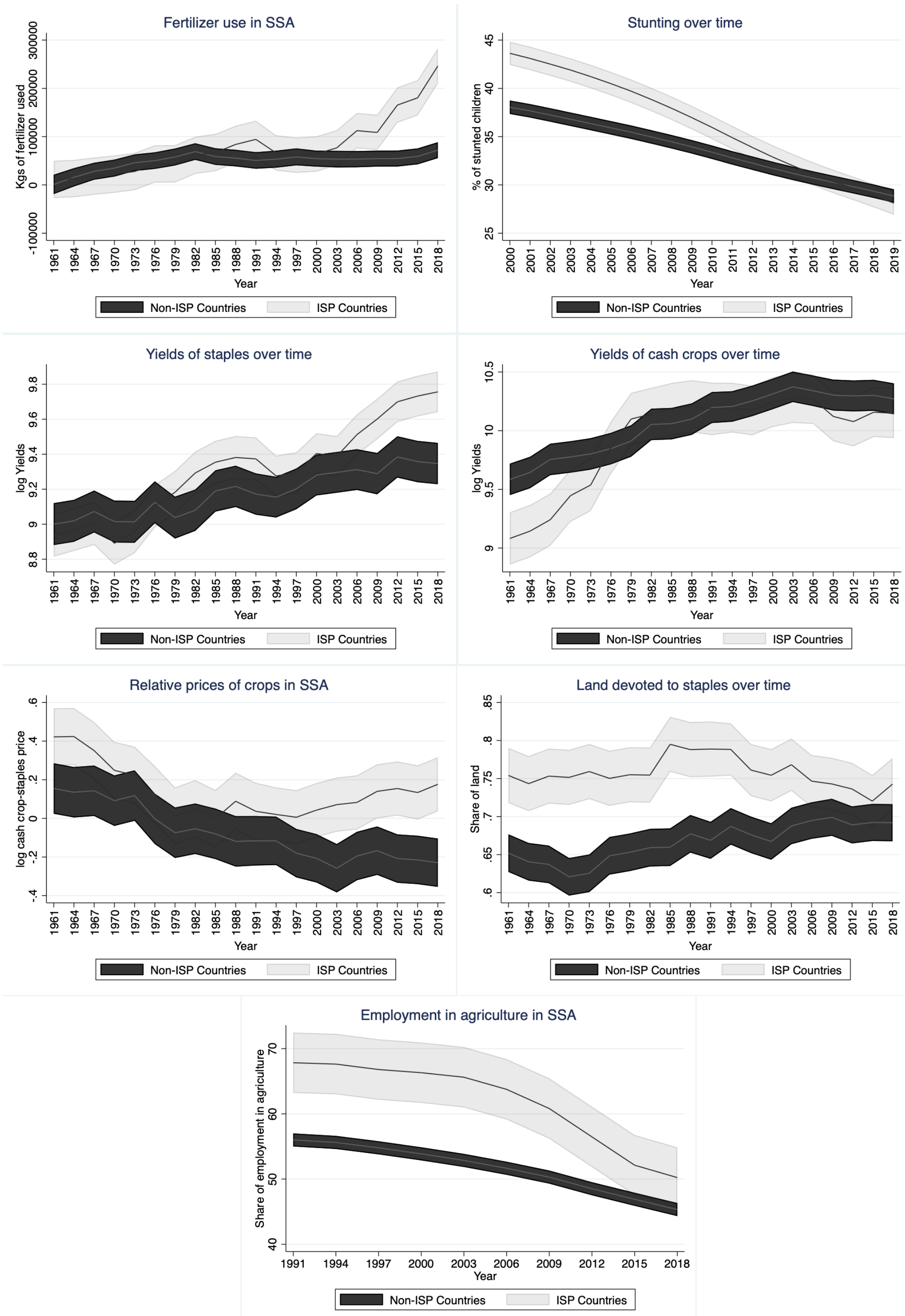

Figure 1: Economic impact of ISPs in SSA

Note: Figure presents evolution of fertilizer use, stunting (share of children stunted), log yields of staples and cash crops (in kg per ha), log relative price of cash crops to staples, land devoted to cultivation of staples and employment in agriculture in ISP and Non-ISP countries, after absorbing country and time fixed effects. Data from FAOStat.

	log Staple yields	log Cash Crop yields	Share of staples land	Relative prices	Stunting	Urbanization rate
ISP-treated	0.26***	-0.02	-0.06***	0.18***	-3.67***	-4.11***
	(0.04)	(0.04)	(0.01)	(0.03)	(0.37)	(0.58)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.17	0.33	0.09	0.16	0.74	0.48
N	2490	2490	2490	1972	900	1421

Table 3: ISP-effects in diff-in-diff regressions

Note: Table presents results of running regressions $Outcome_{i,t} = \alpha + \beta ISPCountry_i \times ISPIntroduction_{i,t} + \gamma_i + \gamma_t + \epsilon_{i,t}$, where the indicator $ISPCountry_i$ takes value of 1 for countries as listed below Figure 1, and the indicator $ISPIntroduction_{i,t}$ takes value of 1 in ISP-Countries for all the years after introduction of policy as explained below Figure 1. Data from FAOstat

stunted and a life expectancy of only 53 years. Moreover, the country is heavily reliant on agriculture with 80% of its population living in rural areas engaged in largely small-scale, non-mechanized and subsistence-based agriculture. The country's exports are mostly made of its cash crops such as groundnuts, sugar, tea and tobacco. [De Magalhaes and Santaeulalia-Llopis, 2018] studies the same IHS2010 dataset and documents very high gaps in the average levels of consumption, income and wealth between rural and urban parts of the country.[5]

Around 40% of rural households cultivate only maize (the basic source of food in the country) and around 53% produce a mix of both staples and cash crops. Importantly, most of the agricultural output is devoted for own consumption, with this pattern being strongest for households cultivating only maize (92%). Figure 3 in Appendix A (from [De Magalhaes and Santaeulalia-Llopis, 2018]) shows distributions of agricultural production value in terms of at-the-gate prices and consumption prices. While the mean value of agricultural production in at-the-gate prices is around USD 100, it would be worth around USD 490 at consumption prices. Taken together, this data constitutes evidence for presence of significant transaction costs, which households can avoid by consuming their own agricultural outputs.

In Table 4 we extend our findings from the cross-country panel to the cross-sectional data from Malawi. First we show the household-level effects of FISP-subsidies and agricultural productivity on a number of outcomes. Although we rely on regressions with a rich set of controls and village fixed effects, many of our results below are clearly subject to reverse causality. These relationships are nonetheless explicitly modeled in our theoretical framework. We first find in regression (1) that (i) being a household receiving subsidized inputs is associated with a 6 p.p. (or 10%) reduction in share of land devoted to maize; and that (ii) being a household with a 10% higher agricultural productivity, defined as *value* of agricultural output in "at-the-gate" prices per capita and per hectare, decreases the share

[5]See Figure 1 in [De Magalhaes and Santaeulalia-Llopis, 2018].

	(1) $share\ maize_i$	(2) $\log(value_i)$	(3) $fertilizer_i$	(4) $\%self\ consumed_i$	(5) $\frac{value\ at\ gate}{value\ at\ cons\,i}$
$FISP\ recipient_i$	-0.06***	0.08***	70.96***	-4.05***	-0.005*
$share\ maize_i$		-0.52***	24.27**	24.30***	-0.09***
$\log(value_i)$	-0.06***		37.25***	-8.26***	0.03***
Controls	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes
R^2	0.34	0.34	0.16	0.35	0.37
N	8,544	8,544	8,544	8,544	8,544

Table 4: Evidence on household-level agricultural and economic patterns in Malawi

Note: Share maize is the share of household's land devoted to maize. *Value* of crop harvested is expressed in per capita and per hectare terms, and evaluated at "at-the-gate" prices (inc. results in reg. (2)) or in "consumption" prices. *Fertilizer* is kgs of fertilizer applied per hectare. *%self consumed* is the share of total harvest's value that was not sold. Controls include household head's sex, age, marital status, religion, language, education, household size, and land controls (average soil quality, total area, total kgs of fertilizer used). Data from LSMS 2010 for Malawi.

of land with maize by 0.6 p.p. (or 1%).

This relationship is likely to go both ways, as suggested by regression (2). We find there a significant evidence suggesting that (i) receiving subsidized inputs increases value of agricultural output by 8%; and (ii) that devoting 10 p.p. less of land to maize increases the *value* by 5%.

Evidence from regression (3) suggests that FISP does indeed stimulate higher fertilizer use, and particularly so among staple producers - consistent with staple-targeting of the policy. In particular, we find that (i) being a recipient of subsidized inputs increases amount of fertilizer used by 71 kg; (ii) a 10 p.p. higher share of land devoted to maize is associated with 2.4 kgs more of fertilizer used; and that (iii) a 1% increase in agricultural productivity is associated with a 0.4 kgs more of fertilizer used.

In regression (4), we show evidence suggesting that FISP improves food security, and that cultivating maize is an important source of food for disadvantaged households. In particular: (i) being a household receiving subsidized inputs reduces share of crop output self-consumed by 4 p.p. (or 5%); (ii) a 1 p.p. higher share of land devoted to maize increases share of self consumed crops by 2.4 p.p. (or 3%); and (iii) households with a 1% higher productivity consume 8.26 p.p. (or 10%) less of their own agricultural products.

Finally, regression (5) is yet another evidence suggesting presence of significant transaction costs. Although statistically significant, being a FISP recipient does not alter by much the ratio of the agricultural output valued at the "at-the-gate" prices to this quantity at "consumption" prices. However, devoting 10 p.p. more of land to maize production is associated with this ratio being almost 1 p.p. (or 3.3%) lower. Similarly, a 10% increase in productivity is associated with a 0.3 p.p. increase in this ratio.

3 Model

The economy consists of a continuum of households that are ex-post heterogeneous due to idiosyncratic labor and agricultural productivity shocks. Households decide about living in urban areas and earning a wage, or living in the rural areas and operating own farms. Changes of occupations by households are subject to occupation-specific entry costs. Farmers decide about producing staple crops such as maize, or cash crops such as tea, tobacco or sugar, or both with an endogenous choice of the share of land being devoted to each of the crops. Moreover, agricultural production requires use of intermediate inputs such as seeds or fertilizer, that are imported from abroad at an exogenously given price. Financing of agricultural inputs is potentially limited due to a working capital constraint, farmers have to finance part of the production cost before production takes place. While both staples, cash crops and manufacturing goods are consumed by households, there is also external demand for cash crops. Household's food security are represented by Stone-Geary preferences and transaction costs for staples.

Financial markets are incomplete, with households having access only to risk-free assets that are channeled to the manufacturing sector. There is a government administering different agricultural policies such as ISP, financed through taxation of labor in urban areas and from foreign aid. All decisions are interlinked through general equilibrium effects entering through market prices.

To ease notation, we do not include individual and time subscripts in the descriptions of the model building blocks. However, we define the equilibrium along the transition path as we consider the dynamic effects of input subsidies on the economy.

3.1 Households

Households are infinitely lived and in each period they supply inelastically a unit of labor. They discount future at the rate of β and maximize the expected life-time utility $U(\mathbf{c}) = \mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t u(\mathbf{c}_t)\right]$, with the following constant elasticity of substitution (CES) per-period utility function:

$$u(\mathbf{c}) = \frac{1}{1-\sigma}\left(\psi_S (c_S - \bar{c}_S)^{\frac{\epsilon-1}{\epsilon}} + c_B^{\frac{\epsilon-1}{\epsilon}} + (1-\psi_S-\psi_C)\, c_M^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{(1-\sigma)(\epsilon-1)}{\epsilon}} \tag{1}$$

where σ is the coefficient of relative risk aversion, ϵ is the intratemporal elasticity of substitutions, and ψ_S, ψ_B, ψ_M control the share of expenditure of staples, cash crops and manufacturing goods, $\mathbf{c}$ is a vector of goods c_S, c_B, c_M and $\bar{c}_S$ introduces a subsistence food consumption constraint. Non-homothetic preferences are crucial for analyzing the welfare impact of input subsidies, since poorer household will likely be more affected by policies that support staple consumption.

We normalize the producer price of staple crops to 1. The producer price of cash crops and manufacturing goods are denoted as p_B and p_M, respectively. Households can purchase goods on centralized market, but access to staples is subject to a transaction cost. To purchase q_S amount of staples, $(1+Q_S)q_S$ must be paid. This transaction cost mimics the cost of delivering food to remote rural areas, and allows us to discuss the implications of staple subsidies on food "security" and "marketable" surplus, as households do not pay transaction cost for staples they produce for their own needs. The greater the friction generated by transaction cost, the more relevant food insecurity becomes. Notice that we restrain the economy's computational complexity by not introducing a similar transaction cost distortion in the cash crop sector. Instead, we allow for fixed costs to cash crop producers, proxying transaction costs that are independent of the scale of operations.

Expectation is taken over idiosyncratic agricultural (θ) and labor (l_z) productivity. Insurance against these shocks is imperfect, as only a non-state contingent risk-free asset a is available, without borrowing $a \geq 0$. Given the realized productivity and current asset position a, each household chooses in each period between becoming a farmer producing staple or cash crops, or moving to urban areas ($e' \in \{S, B, M\}$). Households pay entry costs F_i, $i \in \{S, B, W\}$ if they change occupations. Households that stay in rural areas earn income from production.

When households choose to move to urban areas, they earn wage w and they provide their labor endowment inelastically. Urban households face an "unemployment" risk, in which case their labor productivity drops to zero, $l_z = 0$. There are three places where workers are employed: either in a competitive manufacturing sector, by farmers that are paying for their maintenance and entry costs, and by rural households when they decide to move to urban areas and have to pay for migration services, such as housing. Workers are indifferent to their particular employer, as each of these employers offer the same competitive wage.

3.1.1 Agriculture Sector

Households in rural areas choose whether to operate as a staple producer or a cash crop producer. Staple crop farmers use the following production and total cost function, subject to a working capital constraint:

$$q_S(x_S) = \phi_S \theta x_S^{\zeta} \tag{2}$$

$$TC_S(a, x_S) = (1 + \tau_S)\, p_x x_S \leq \kappa a \tag{3}$$

where x_S denotes the amount of intermediate inputs used, purchased at price p_x and taxed/subsidized at the rate of τ_S.

To realistically model agriculture in Africa, we require the farmer's problem to be subject to a *within-period working capital constraint*. In equation 3 we require that a fraction $\frac{1}{\kappa}$ of the total taxed/subsidized cost of fertilizer inputs must be financed *within-period* from their current assets a. [Daidone et al., 2019] and [Ambler et al., 2020] show that randomized interventions among Malawian farmers disbursing cash grants generate positive responses of investment, suggesting that farmers may indeed face such financial frictions.

If households choose to produce cash crops (denoted as occupation C), they potentially cultivate both types of crops and have to decide about their allocation of intermediate inputs and land l between production of staples (S) and cash crop (B) as follows:

$$q_S(x_{SC}) = \phi_S \theta x_{SC}^{\zeta} (1 - l)^{\rho} \tag{4}$$

$$q_B(x_{BC}) = \phi_B \theta x_{BC}^{\zeta} l^{\rho} \tag{5}$$

$$TC_C(a, x_{BC}, x_{SC}) = (1 + \tau_S)\, p_x x_S + (1 + \tau_B)\, p_x x_B \leq \kappa a \tag{6}$$

Land is in fixed supply. We make this assumption as the land markets in Malawi are virtually non-existent (see e.g. [Restuccia and Santaeulalia-Llopis, 2017]), implying that the majority of farms in Malawi are of similar size, with less than 10 hectares.[6] Furthermore, we assume that land has decreasing returns to scale $\rho < 1$, capturing all potential reasons that lead to crop diversification: insurance, heterogeneous transaction costs, differences in timing of agricultural operations, crop rotation, and associated labor smoothing. Notice that this assumption introduces motives for cash crop farmers to cultivate both cash crops and staples. Moreover, in order to generate profits from agricultural production for farmers, we also assume jointly decreasing returns to scale $\zeta + \rho \in (0, 1)$.

The comparative statics conducted over cash crop producers' optimal decisions show that:

Proposition 1. *The share of land devoted to cash crops l is (i) increasing in the staple-input tax rate τ_S, (ii) decreasing in the cash crop-input tax rate τ_B, and (iii) increasing in*

[6] This implies that the empirical variations in land holdings will be captured by our idiosyncratic productivity process.

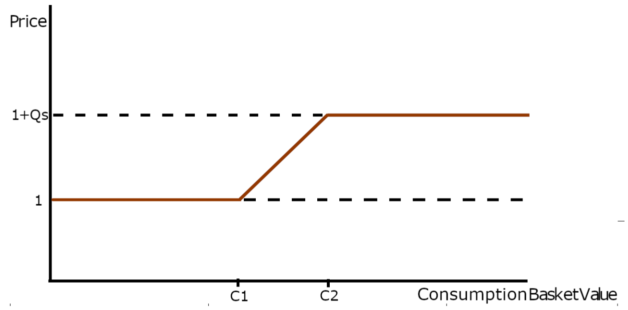

Figure 2: Shadow price of consumption in terms of the consumption bundle

the relative price $\frac{p_C}{p_S}$.

Proposition 1 confirms the importance of the general equilibrium effects in analyzing the impact of large-scale ISPs. In the partial equilibrium, ISPs push resources to the subsidized sector of agriculture. However, the equilibrium forces working through relative prices of each crop can overturn these dynamics. Our quantitative framework can therefore rationalize the empirical evidence in Figure 1 showing that ISPs lead to an increase in the share of land devoted to cash crops in SSA through the price effect.

The transaction cost for staples implies that farmer households will generally *not* maximize profits, because the internal, shadow price of staples differs from either the producer price of 1, or the consumer price of $1 + Q_S$. Rather, farmers minimize expenditures required to achieve the optimal consumption path over time, leading to the *overproduction* of staples, relative to the case without transaction costs.

The shadow price of staples, $\lambda_S \in [1, 1 + Q_S]$ measures the deviation from the profit maximizing solution. In figure 2 we show that with an increase in required consumption bundle C, farmers switch from consuming only self-produced staples ($\lambda_S = 1$, $C < C_1$) that is also profit maximizing, to first ($\lambda_S \in (1, 1 + Q_S)$, $C \in [C_1, C_2]$), overproduce staples and then ($\lambda_S = 1 + Q_S$, $C > C_2$) to purchase more and more staples on the market by paying the transaction cost.

3.1.2 Financial Markets

Households can save using a risk-free asset a', denominated in staple consumption good, at the interest rate r. The risk-free asset is pooled by a competitive financial sector lending intertemporally to the manufacturing sector. Perfect competition in the markets of intermediaries implies no profits and so that $R = r + \delta$, where r is the deposit, R is the lending rate and δ is the depreciation rate of capital. While borrowing in the risk free asset is not allowed, there is an additional, intra-period asset. This asset is interest-free, and is provided to farmers in the beginning of the period to cover a fraction of their expenditures: $a - TC_i$,

$i \in \{S, C\}$ and immediately repaid after production and realization of profits, and hence does not enter the inter-temporal budget constraint.

3.1.3 Dynamic programming

Households solve a joint occupation choice and expenditure minimization problem in Equation 7 and a dynamic problem.

$$V(z,a,e) = \max_{C,a',e',c_S,c_B,c_M,x_S,q_S,x_B,q_B,l} u(C) + \beta \mathbb{E} V(z',a',e') \tag{7}$$

$$st.: Y_{e' \in \{S,B,M\}} + a' = (1+r)a \tag{8}$$

$$\begin{aligned} Y_{e' \in \{S,B,M\}} &= c_S + p_B c_B + p_M c_M + Q_S \cdot \max((c_S - q_S), 0) \\ &- 1_{e' \in \{M\}} w - 1_{e' \in \{S\}} \pi_S(x_S, q_S) + w F_S \cdot 1_{e \in \{M\}, e' \in \{S\}} \\ &- 1_{e' \in \{B\}} \pi_B(x_S, q_S, x_B, q_B, l) + w F_B \cdot 1_{e \in \{M,S\}, e' \in \{B\}} \end{aligned} \tag{9}$$

$$st.: C = \left(\psi_S \left(c_S - \bar{c}_S\right)^{\frac{\epsilon-1}{\epsilon}} + \psi_B c_B^{\frac{\epsilon-1}{\epsilon}} + \psi_M c_M^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}} \tag{10}$$

Y denotes the potentially negative net savings of a household that is the outcome of choosing to be either a staple farmer, a cash crop producer or a worker in the urban sector. C denotes the optimal consumption bundle of a household - with the understanding, that the composition differs across occupations, wealth or productivity. Computationally, the structure of the problem can be exploited, as the occupation and consumption composition choice can be solved as a static problem. Unlike in [Tetenyi, 2019] however, occupation choice and expenditure minimization must be solved jointly and is discussed in detail both analytically and computationally in Appendix A.

3.2 Urban Sector

The labor market in the urban sector is competitive and centralized. All employers must pay the same wage per efficiency units, denoted as w, for all households living in the urban area. Demand for urban labor is comprised of two sources: households employing workers due to farm maintenance or occupation switching, and a representative manufacturing firm using it for production of manufacturing good with a standard Cobb-Douglas technology $Y_M = K^\alpha L^{1-\alpha}$. The profit maximization problem of the firm reads:

$$\pi_M = \max_{K,L} \{ p_M K^\alpha L^{1-\alpha} - (1+\tau_W) w L - RK \} \tag{11}$$

where τ_w is the wage income tax rate imposed on firms by the government.

3.3 Government

As far as concerns the fiscal implementation of the program, we consider two scenarios. First, we assume that FISP is implemented without inducing any fiscal costs. This is motivated by World Development Indicators (WDI) database of World Bank, which shows that in 2010 almost 80% of Malawian government expenses were funded by resources provided by donors and foreign aid. In the second case, we assume that the government finances the program through the taxation of labor income of urban workers.

Denoting the distribution of households in period t as $G_t(a, \theta, e)$, the total expenditures X_G on the subsidy program are given by:

$$X_G = -p_x \int \Big((\tau_S(x_S G_{a,\theta,e'=S} + x_S G_{a,\theta,e'=B}) + \tau_B x_B G_{a,\theta,e'=B} \Big) \tag{12}$$

Therefore, the government per period budget constraint can be satisfied in both of the cases as follows:

$$\text{case } 1: X_G = NCT^X \tag{13}$$

$$\text{case } 2: X_G = \int \tau_W w \Big(G_{a,\theta,e'=M} - F_M G_{a,\theta,e'=M,e=\{S,B\}} - F_B G_{a,\theta,e'=B,e=\{S,M\}} \Big) \tag{14}$$

where NCT^T stands for total net current transfers, and NCT^X is the amount of foreign aid used to finance the program.[7]

3.4 Current account

The effect of subsidies on the country's current account is of particular concern among policy makers. The country imports intermediate inputs as there are only limited fertilizer production in Africa and so its price p_x is exogenous. The only exported good is cash crop, demanded by foreigners according to $c_B^F = a_D p_B^{b_D}$. Foreigners invest in the capital stock K^F, earning net income of RK^F. Foreigners also provide foreign aid as current transfer in the amount NCT^T. Foreign aid can be used to finance the subsidy program NCT^X, but can also be used for other reasons. In the steady state, the country's net foreign asset position cannot change and hence the current account has to equal 0:

[7] Notice that we assume that the government can only tax the manufacturing firm, and hence rural households employing laborer for covering fixed costs do no have to pay labor taxes.

$$CA = X - M - RK^F + NCT^T = 0 \tag{15}$$

$$X = p_B c_B^F = a_D p_B^{1+b_D} = p_B \int (q_B \mathbf{1}_{\{e'=B\}} - c_B) dG \tag{16}$$

$$M = p_x \Big(\int x_S G_{a,\theta,e'=S} + \int (x_S + x_B) G_{a,\theta,e'=B} \Big) \tag{17}$$

$$NCT^T = NCT^X + NCT^A \tag{18}$$

As the exports are given by export demand function and both imports and aid that is necessary to finance the subsidy program are obtained given the prices and decision rules, there are two possible ways to ensure that the current account is zero. In the first, baseline case we assume that the aid NCT^T the country receives is unchanged in the economy even if the subsidy program is abolished and the investment of the foreigners will adjust. Second we can fix the capital stock held by foreigners and change the aid the country receives.

3.5 Recursive Competitive Equilibrium

Let $G_t(a, z, e)$ be the cumulative density function for the joint distribution of households, and let $Q_t(a, z, e, a', z', e')$ the transition function. a denotes the wealth, z the joint labor and agricultural productivity and e the past employment of households. Then the distribution objects

$$\{G_t(a, z, e), Q_t(a, z, e, a', z', e')\}_{t=0}^{\infty} \tag{19}$$

the household allocations, as functions of the state variables (a, z, e):

$$\{C_t, c_S^t, c_B^t, c_M^t, a_{t+1}, e_{t+1}, x_S^t, q_S^t, x_S^t, q_B^t, x_B^t, l^t\}_{t=0}^{\infty} \tag{20}$$

the aggregate allocations $\{K_t, L_t\}_{t=0}^{\infty}$, current account variables $\{K_t^F, NCT_t^T, NCT_t^X, \}_{t=0}^{\infty}$, the prices: $\{p_B^t, p_M^t, W_t, r_t, R_t\}_{t=0}^{\infty}$ and the subsidies/taxes $\{\tau_S^t, \tau_B^t, \tau_W^t\}_{t=0}^{\infty}$ constitute an equilibrium if:

- given prices, the household allocations solve the household's dynamic consumption-saving-occupation choice problem in equation 7
- The aggregate allocations solve the manufacturing firm's problem in equation 11

- the labor market clears:

$$L_t = \int \left(\mathbf{1}_{\{e_{t+1}=M\}} l_z - \mathbf{1}_{\{e_t \in \{M,S\}, e_{t+1}=B\}} F_B - \mathbf{1}_{\{e_t \in \{S,C\}, e_{t+1}=M\}} F_M\right) dG_t \tag{21}$$

- the capital market clears:

$$K_t = \int a_t dG_t + K_t^F \tag{22}$$

- the staple, the cash crop and the manufacturing goods markets clear:

$$\int (c_S^t - q_S^t(\mathbf{1}_{\{e_{t+1}=S\}} + \mathbf{1}_{\{e_{t+1}=B\}}))(1 + Q_S \mathbf{1}_{c_S - q_S < 0}) dG_t = 0 \tag{23}$$

$$\int (c_B^t - q_B^t \mathbf{1}_{\{e_{t+1}=B\}}) dG_t - a_D p_B^{b_D} = 0 \tag{24}$$

$$\int c_M^t dG_t - A K_t^\alpha L_t^{1-\alpha} = 0 \tag{25}$$

- financial intermediaries make no profits: $R_t = r_t + \delta$,
- Government budget constraint holds, either as Equation 13 or as in Equation 14.
- The system of equations 15-18 regarding the current account clears either because K_t^F or NCT_t^T adjusts.
- Distribution evolves:

$$G_{t+1} = \int Q_t(a, z, e, a', z', e') dG_t \tag{26}$$

- $\forall\, \mathcal{S} = \{\mathcal{A}, \mathcal{Z}, \mathcal{X}\}$ measurable subset of the power set of the state space, the transition function becomes

$$Q_t(\mathcal{S}, (a', z', e')) = \mathbf{1}_{a' \in a_{t+1}(\mathcal{S})} \pi_z(\mathcal{Z}, z_{t+1}) \mathbf{1}_{e' \in e_t(\mathcal{S})} \tag{27}$$

  where π_z is defined by the productivity process of the households.

4 Calibration

We assume a yearly periodicity of our model and calibrate it using simulated method of moments in order to choose values of parameters such that the implied model dynamics match empirical facts of the Malawian economy. We associate parameters with specific moments in Table 5. In our baseline calibration, FISP is financed through foreign aid. We evaluate the model's fit together with its performance along non-targeted dimensions.

4.1 Calibration strategy

Preferences. We calibrate time preference β such that the implied capital-output ratio equals 3.84, the average for years 2000-2011 documented in [UN, 2014]. Consumption share parameter ψ_S is set to match the factor income share of the agriculture sector 30% of GDP[8] and is driving the size and cost of any agricultural policy. Cash crop spending share ψ_B is set to match the share of exported cash crops' quantity in total production, 60%. This is calculated based on the FAOstat data for Malawi in 2010, taking into account production and exports of the major export goods, tobacco, sugar and tea. We calibrate the subsistence consumption parameter $\bar{c}_S$ to match the evidence provided by IHS2010 data, such that 90% of rural households producing staples do not have any marketable surplus of production.

We estimate the demand for cash crop exports $c_B^F = a_D p_B^{b_D}$ using the panel of SSA countries from FAO data. In particular, we use the following regression:

$$\log(D_{i,t}) = A_D + b_D \cdot \log P_{i,t} + \gamma_i + \gamma_t + \epsilon_{i,t} \tag{28}$$

where γ's stand for country and year fixed effects, $D_{i,t}$ is the country i's quantity of tobacco exports in year t and $P_{i,t}$ is the export price (derived from dividing the data series of nominal value of exports by the total quantity produced). We focus on tobacco exports as this is the major export item in Malawi. We find that the associated elasticity equals $b_D = -0.2$.

Production. In the agriculture sector, we set the intermediate share parameter $\zeta = 0.1$, equal to the cost share of main intermediates such as seeds and fertilizers, in gross value of crop harvest in IHS2010. Furthermore, the average productivity of staple production ϕ_S is calibrated to target the share of rural population equal to 82%, as in Table 2. We calibrate the productivity of cash crop production ϕ_C to match the data on intermediate expenses from IHS2010 showing that cash crop producers spend twice as much as staple crop producers on average. The price of agricultural inputs p_x is calibrated such that the cost of the government subsidy program (FISP) is approx. 3% of GDP, as was the case in Malawi in the year 2010 (see e.g. [Chirwa and Dorward, 2013]). As far as concerns the tax rates on intermediate inputs, they are set at the level of ($\tau_S = -0.49, \tau_B = 0$), reflecting the

[8] See World Bank database: https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=MW.

Parameter	Value	Target/Source	Data	Model
Preferences				
Time preference β	0.88	Capital-output ratio [UN, 2014]	3.84	3.84
Staple consumption share ψ_S	0.54	Agriculture share of GDP [World Bank]	30%	47%
Cash crop consumption share ψ_B	0.02	Share of cash crops exported [FAOstat]	60%	95%
Subsistence consumption $\bar{c}_S$	0.02	Share of staple producers selling output [IHS2010]	10%	98%
Export demand shifter a_D	0.16	Balanced current account (15)	0	0
Export demand elasticity b_D	-0.2	Export elasticity in reg. (28)	-0.2	-0.2
Production				
Returns to scale in farming ζ	0.1	Cost share of intermediates in value of agr. output [IHS2010]	10%	10%
Input tax rates (τ_S, τ_C)	(-0.49, 0.0)	Avg relative post-subsidy to market price of inputs [IHS2010]	51%	51%
Transaction costs Q_S	0.5	Share of producer to consumer price in Malawi relative to US	0.5	0.5
Avg productivity staples ϕ_S	1.06	Share of Malawian population in rural areas	80%	82%
Avg produtivity cash crops ϕ_C	0.6	Expenditure ratio of staple- vs cash crop [IHS2010]	2	0.8
Price of inputs p_x	0.97	Fiscal cost of FISP [Chirwa and Dorward, 2013]	3%	5%
Persistence of rural AR1 ρ_θ	0.92	Urban-rural avg consumption ratio [IHS2010]	2.2	2.2
Var of rural AR1 innovations σ_θ^2	0.15	Top10% share of wealth in rural [IHS2010]	49%	56%
Persistence of urban shocks ρ_l	0.52	Urban-rural avg wealth ratio [IHS2010]	3.0	4.87
High & low urban prod. $(\bar{l}_z, \underline{l}_z)$	(2.0,0.0)	Top10% share of wealth in urban & no UI assumed	73%	31%
Urban entry cost F_M	2.5	Rural-urban migration rate [Lagakos et al., 2020]	1%	4%
Cash crop entry cost F_B	0.38	Share of rural pop. cultivating only staples [IHS2010]	41%	8%
Working capital constraint κ	1.62	Impact of grant on crop output [Daidone et al., 2019]	7%	0.0

Table 5: Internally calibrated parameters

institutional setup in Malawi and the effective subsidy rates for staples found in IHS2010.[9]

For calibrating productivity shocks, we firstly assume that agricultural idiosyncratic process θ is a lognormal-AR(1): $log(\theta_{i,t+1}) = \rho_\theta \theta_{i,t} + \epsilon_{i,t}$ with $\epsilon_{i,t} \sim N(0, \sigma_\theta^2)$. Given this, we calibrate σ_θ such that the top 10% of rural population holds approx. 56% of wealth (from IHS2010). When calibrating persistence parameter ρ_θ, we target the urban-rural average consumption ratio (also from IHS2010). In the manufacturing sector, we assume a Markov chain with two productivity levels $(\bar{l}_z, \underline{l}_z)$ and a transition matrix $\Pi^M = \begin{cases} \rho_l & 1-\rho_l \\ 1-\rho_l & \rho_l \end{cases}$. We calibrate ρ_l such that the urban-rural average wealth ratio equals 3.0. While the low productivity level $\underline{l}_z$ is set at 0 (as there is no unemployment insurance in Malawi), the high productivity $\bar{l}_z$ is calibrated such that the top 10% of urban population holds 73% of wealth.

In order to pin down the value of transaction cost parameter Q_S, we rely on evidence in Figure 3 from [De Magalhaes and Santaeulalia-Llopis, 2018] showing that the ratio of mean value of home production evaluated at farm prices to the one evaluated at consumption prices equals 20%$(= \frac{exp(4.6)}{exp(6.3)})$. In the US agricultural census we find that this ratio for cereals equals approximately 40%, depending on the crop considered. Assuming the US as an efficient benchmark (where some transaction costs are unavoidable), we set $Q_S = 0.5$

[9] We compute the effective subsidy rate for staples as cross-sectional average subsidy rate received by households in IHS2010, weighted by the quantity of inputs received.

Parameter	Value	Target/Source
Preferences		
Risk aversion σ	1	Assumption
Elasticity of substitution ϵ	0.85	Estimates in [Herrendorf et al., 2013]
Production		
Capital share in manufacturing α	0.4	Assumption
Depreciation rate δ	0.04	

Table 6: Externally calibrated parameters

to account for the fact that some of transaction cost is unavoidable even in the relatively frictionless US economy.

Regarding fixed costs, we calibrate the entry costs to urban areas F_W such that the rural-to-urban migration rate is low and equals approx. 1%, as documented in [Lagakos et al., 2020]. In order to pin down the entry costs into cash crop production, we make use of IHS2010 where the share of rural population cultivating only staples is relatively high at 41% and choose F_B such that the model replicates this evidence.

Finally, we calibrate the working capital constraint parameter κ using the RCT evidence in [Daidone et al., 2019], who evaluated the impact of Social Cash Transfer program introduced by Malawian government. The intervention injected assets worth approx. 25% of annual consumption to poor rural households, and resulted (among others) in a 7% increase in the value of their agricultural output. In our calibration, we choose κ such that the impact on agricultural output is similar among the bottom 10% of rural population who receive an equivalent asset transfer.

Externally calibrated parameters In Table 6 we show the externally calibrated parameters. We set the elasticity of substitution between consumption goods to $\epsilon = 0.85$, following evidence in [Herrendorf et al., 2013] (also [Buera et al., 2011] choose a similarly close value of $\epsilon = 1.0$). In the manufacturing sector, we set the capital share in manufacturing to a standard value of $\alpha = 0.4$. Furthermore, we set the depreciation rate δ to a standard value of 0.04.

4.2 Calibration validation

Table 5 shows the main result of our calibration strategy. We manage to hit relatively well many of the 15 targeted moments. The current calibration struggles with some of the moments in agricultural sector.

Moment/Source	Data	Model
Share of land devoted to staples [IHS2010]	30%	66%
Urban-rural avg income ratio [IHS2010]	2.4	1.3
Top10% share of consumption [IHS2010]	34%	22%
Top10% share of income [IHS2010]	48%	24%

Table 7: Non-targeted moments and model performance

In Table 6, we present further evidence of our model's performance along a number of non-targeted moments.

5 Preview of results

In Table 8, we show the main quantitative general equilibrium effect of abolishing staple subsidy across steady states. Overall, we find that FISP generates a welfare improvement equivalent to a 4% increase in consumption on average.

As subsidies for production of staples are removed, the relative price of staples increases (which is equivalent to a decline in all other prices). Staples production decreases by 11%. Farmers are always producing staples, and hence the decline in food production happens mostly on the intensive margin - staples productivity also declines by 11%. Total cash crop production increases, even though cash crop productivity declines. The former effect arises because the relative cost of producing staples increases, generating substitution effects pushing more people to cultivate cash crops. As such, we observe a reduction of the fraction of farmers cultivating only staples from 7% to 2%.

Staple subsidies are also effective in mitigating financial frictions, as without them the fraction of constrained farmers doubles from 16% to 31%. This is the main reason why the productivity of not only staple-, but also of cash crop production decreases. Marketable surplus of staples decreases, and fewer workers can afford to purchase the more expensive staples. Cash crops are still primarily exported, however due to the relative price decrease, domestic consumption increases. Aggregate output and consumption declines, while the economy spends more on transaction costs as as farmers more often have to purchase staples in the market, incurring high transaction costs. Imports of fertilizers decline while exports increase due to cheaper cash crops, resulting in an increase in the trade balance.

In the manufacturing sector, we observe slight declines in the quantity produced and the price of the good. As the fixed cost of migrating to urban areas becomes higher to finance

	Subsidy	No Subsidy
Prices		
Cash crop	100	94
Manufacturing good	100	98
Wage rate	100	98
Interest rate, %	10	9
Production		
Staple production	100	89
Staple productivity	100	89
Cash crop production	100	103
Cash crop productivity	100	95
Manufacturing production	100	96
Manufacturing productivity	100	108
Ratio of cash crop-staples input expenditures	0.49	0.51
Share of staple-only farmers, %	7	2
Share of land with staples, %	68	67
Share of financially constrained farmers, %	16	31
Aggregates		
Urbanization rate, %	18	16
Marketable staples surplus, % of GDP	17	16
Share of cash crop exported, %	94	92
Output	100	93
Consumption	100	90
Transaction cost	100	102
Trade Balance, % of GDP	14	20
Government spending, % of GDP	6	0
Welfare and Inequality		
Consumption equivalent welfare, %	0	-4
Migration rate from rural, %	4	2
Urban unemployment rate, %	31	37
Urban-rural wealth ratio	4.9	10.0
Urban-rural income ratio	1.3	1.5
Urban-rural consumption ratio	1.8	2.1
Rural: Top 10% wealth share, %	72	67
Rural: Top 1% wealth share, %	16	25
Urban: Top 10% wealth share, %	31	29
Urban: Top 1% wealth share, %	5	4
Top 10% income share, %	24	27
Top 1% income share, %	3	3
Top 10% consumption share, %	22	24
Top 1% consumption share, %	3	3

Table 8: Quantitative results of abolishing FISP in Malawi

without subsidies, the rural-urban migration rate drops from 4% down to 2%, leading to a 2 p.p. decline in the urbanization rate. The latter increases the marginal product of labor in the manufacturing sector and so leads to increased productivity there. Furthermore, urban unemployment rate increases as being a rural farmer becomes relatively less beneficial without subsidies. This implies that richer households stay in the cities longer, and therefore the urban-rural gaps increase. This is especially so in terms of wealth, where without subsidies we observe that on average urban households are 10 times wealthier than those in rural areas. As wealth is now more relevant in deciding who lives in cities, the urban inequality declines as proxied by reduction in the share of asset held by the richest urban households. Overall, all of the wealth, income and consumption inequalities increase as FISP is removed.

Overall, as we introduce FISP in our economy: (i) urbanization rate increases; (ii) productivity of staples increases most significantly; (iii) relative price of cash crops drops; (iv) the mean share of land devoted to cash crops increases; and (iv) inequalities are reduced (proxying reductions in food insecurity). Therefore, our quantitative framework is able to rationalize all the empirical cross-country evidence presented in Section 2.

6 Conclusion

Agricultural input subsidies can constitute an effective tool in mitigating different aspects of market incompleteness. We have showed empirically and theoretically that subsidizing inputs for cultivation of staples makes their production more efficient, allowing households to reduce their exposure to high transaction costs, to devote more land to producing exportable cash crops, and to migrate to cities more easily. As such, the staple-targeting ISPs in Sub-Saharan Africa do not seem to be associated with a significant equity-efficiency trade-off and lead to improvements in both agricultural productivity and food security.

Next step for us is to investigate the role of the general equilibrium effects in generating these results, and tie this back to the micro-evidence. Furthermore, we also plan to investigate consequences of replacing FISP with alternative policies, such as shifting subsidies to cash crops, introducing cash transfers (allowing for flexible choice of production patterns by households), and investments into infrastructure reducing both the cost of entering urban sector and lowering transaction costs.

References

[Adamopoulos, 2011] Adamopoulos, T. (2011). Transportation costs, agricultural productivity, and cross-country income differences. *International Economic Review*, 52:489—-521.

[Ambler et al., 2020] Ambler, K., de Brauw, A., and Godlonton, S. (2020). Cash, inputs, and information: Direct effects and complementarities in malawi. *working paper*.

[Buera et al., 2011] Buera, F., Kaboski, J., and Shin, Y. (2011). Finance and development: A tale of two sectors. *American Economic Review*, 101:1964–2002.

[Buera et al., 2021a] Buera, F., Kaboski, J., and Shin, Y. (2021a). The macroeconomics of microfinance. *Review of Economic Studies*.

[Buera et al., 2021b] Buera, F., Kaboski, J., and Townsend, R. (2021b). From micro to macro development. *Journal of Economic Literature*.

[Caselli, 2005] Caselli, F. (2005). Accounting for cross-countryincome differences. *Handbook of Economic Growth*, pages 679—-741.

[Chirwa and Dorward, 2013] Chirwa, E. and Dorward, A. (2013). Agricultural input subsidies: The recent malawi experience.

[Daidone et al., 2019] Daidone, S., Davis, B., Handa, S., and Winters, P. (2019). The household and individual-level productive impacts of cash transfer programs in sub-saharan africa. *American Journal of Agricultural Economics*, 101:1401–1431.

[de Janvry et al., 1991] de Janvry, A., Fafchamps, M., and Sadoulet, E. (1991). Peasant household behaviour with missing markets: Some paradoxes explained. *Economic Journal*, 101:1400–1417.

[De Magalhaes and Santaeulalia-Llopis, 2018] De Magalhaes, L. and Santaeulalia-Llopis, R. (2018). The consumption, income, and wealth of the poorest: An empirical analysis of economic inequality in rural and urban sub-saharan africa for macroeconomists. *Journal of Development Economics*, 134:350–371.

[Donovan, 2021] Donovan, K. (2021). The equilibrium impact of agricultural risk on intermediate inputs and aggregate productivity. *Review of Economic Studies*, 88:2275–2307.

[Fafchamps, 1992] Fafchamps, M. (1992). Cash crop production, food price volatility, and rural market integration in the third world. *American Journal of Agricultural Economics*, 74:90–99.

[Gollin et al., 2014] Gollin, D., Lagakos, D., and Waugh, M. E. (2014). The agricultural productivity gap. *The Quarterly Journal of Economics*, 129(2):939–993.

[Gollin and Rogerson, 2014] Gollin, D. and Rogerson, R. (2014). Productivity, transport costs and subsistence agriculture. *Journal of Development Economics*, 1-7:38–48.

[Harou et al., 2017] Harou, A., Liu, Y., Barrett, C., and You, L. (2017). Variable returns to fertiliser use and the geography of poverty: Experimental and simulation evidence from malawi. *Journal of African Economies*, 26:342–371.

[Herrendorf et al., 2013] Herrendorf, B., Rogerson, R., and Valentinyi, A. (2013). Two perspectives on preferences and structural transformation. *American Economic Review*, 103:2752–2789.

[Herrendorf and Schoellman, 2015] Herrendorf, B. and Schoellman, T. (2015). Why is measured productivity so low in agriculture? *Review of Economic Dynamics*, 18:1003—-1022.

[Jayne et al., 2018] Jayne, T., Mason, N., Burke, W., and Ariga, J. (2018). Review: Taking stock of africa's second-generation agricultural input subsidy programs. *Food Policy*, 75:1–14.

[Kaboski and Townesend, 2011] Kaboski, J. and Townesend, R. (2011). A structural evaluation of a large-scale quasi-experimental microfinance initiative. *Econometrica*.

[Lagakos et al., 2020] Lagakos, D., Marshall, S., Mobarak, M., Waugh, M., and Vernot, C. (2020). Migration costs and observational returns to migration in the developing world. *Journal of Monetary Economics*.

[Lagakos and Waugh, 2013] Lagakos, D. and Waugh, M. (2013). Selection, agriculture, and cross-country productivity differences. *American Economic Review*, 103:948–980.

[Midrigan and Xu, 2014] Midrigan, V. and Xu, D. (2014). Finance and misallocation: Evidence from plant-level data. *American Economic Review*, 104:422–458.

[Moll, 2014] Moll, B. (2014). Productivity losses from financial frictions: Can self-financing undo capital misallocation? *Econometrica*, 104:3186—-3221.

[Omamo, 1998] Omamo, S. (1998). Transport costs and smallholder cropping choices: An application to siaya district, kenya. *American Journal of Agricultural Economics*, 80:116–123.

[Restuccia et al., 2020] Restuccia, D., Chen, C., Santaeulalia-Llopis, R., et al. (2020). The effects of land markets on resource allocation and agricultural productivity. Technical report.

[Restuccia and Santaeulalia-Llopis, 2017] Restuccia, D. and Santaeulalia-Llopis, R. (2017). Land misallocation and productivity. Technical report, National Bureau of Economic Research.

[Restuccia et al., 2008] Restuccia, D., Yang, D., and Zhu, X. (2008). Agriculture and aggregate productivity: A quantitative cross-country analysis. *Journal of Monetary Economics*, 55.

[Tetenyi, 2019] Tetenyi, L. (2019). Trade, misallocation, and capital market integration. Technical report, IWH-CompNet Discussion Papers.

[UN, 2014] UN (2014). Economic development in africa report 2014.

[Vollrath, 2009] Vollrath, D. (2009). How important are dual economy effects for aggregate productivity? *Journal of Development Economics*, 88:325–334.

A Additional Figures

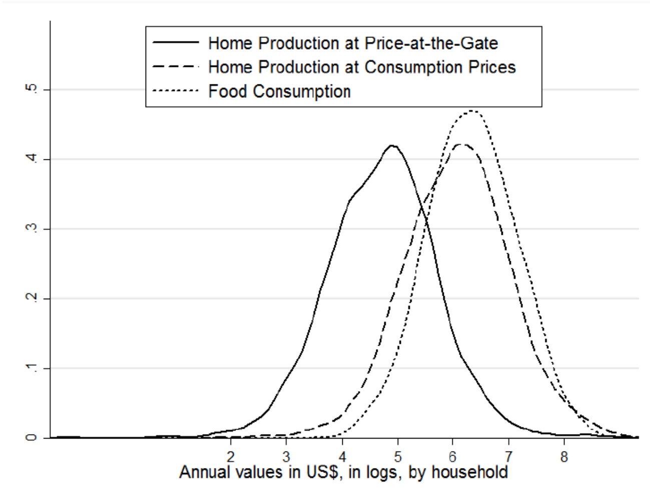

Figure 3: Densities of production value at at-the-gate vs consumption prices from [De Magalhaes and Santaeulalia-Llopis, 2018].