The Equilibrium Impact of Agricultural Support Prices and Input Subsidies

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Abstract

We study the implications of agricultural minimum support price (MSP) programs and intermediate input subsidies for the agricultural productivity gap (labour productivity of non-agriculture to agriculture) and consumer welfare. We develop a dynamic general equilibrium model with agents heterogeneous in productivity and assets in the presence of mobility and financial frictions and incomplete asset markets, while allowing for endogenous sorting between sectors (agriculture and non-agriculture) and within agriculture (staple and cash crops). The benchmark economy includes agricultural subsidies that reduce the cost of intermediate inputs for all farmers, while MSP involves the procurement of staples at a support price. The model is calibrated to match a mix of macro data and quasi-experimental evidence pertaining to the Indian economy. Our counterfactual results highlight that removing MSP induces labour reallocation towards the non-agriculture sector and a small reduction in the agriculture productivity gap (APG). However, a reduction in intermediate input subsidy exacerbates APG significantly by reducing input intensity in agriculture. Policies that replace the support price or input subsidy programs with budget-equivalent income transfers improve welfare.

JEL Codes: J43, Q18, O13, Q11, E24

Keywords: productivity gap, welfare, agriculture, price support, input subsidies, general equilibrium, heterogeneous agents

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1 Introduction

Several studies argue that the low agricultural productivity in low-income countries is crucial for explaining cross-country differences in total factor productivity and living standards (Caselli, 2005; Gollin, Lagakos, & Waugh, 2014a), especially since agriculture employs a substantial proportion of the workforce[1]. Both the less intensive use of inputs (capital, intermediate inputs, land and labour) and misallocation of these inputs (due to institutions or policies) have been identified as important factors responsible for low agricultural productivity in developing countries[2]. Given the importance of this sector, policymakers in these countries have rolled out various policies to assist farmers, often by directly influencing crop input and sale prices[3]. In this paper, through the lens of a quantitative general equilibrium (GE) framework, we investigate the extent to which these policies impact agricultural and non-agricultural productivity and consumer welfare for a developing economy.

The model incorporates skill heterogeneity, mobility frictions, and financial market imperfections, including incomplete asset markets and financing frictions in agriculture for purchasing inputs, all of which are widely observed in developing countries (Restuccia & Rogerson, 2017). We calibrate the model to the Indian context, ensuring it aligns with both micro and macro moments, such as transition rates from agriculture to non-agriculture and measures of income inequality. Mobility frictions that hinder transitions to the non-agricultural sector (Lagakos & Waugh, 2013) and reduced intermediate input use due to risk (Donovan, 2021) are crucial drivers of the agricultural productivity gap (APG) – defined as the ratio of labour productivity between the non-agricultural and agricultural sectors Gollin et al. (2014b). A counterfactual analysis reveals that removing the government's support price and staple procurement reduces the APG by 3.7%, as labour reallocates to the non-agricultural sector. Conversely, halving the input subsidy increases the APG by nearly 30%, driven by a sharp decline in intermediate input use. Additionally, we demonstrate that these policies enhance welfare for the poorest farmers, who face limited insurance options (Mobarak & Rosenzweig, 2013); however, budget-equivalent transfers are more effective in improving welfare.

We develop a dynamic general equilibrium model featuring two sectors (agriculture and

[1] See Figures A1 and A2 in the Appendix

[2] See Buera et al. (2023), Gollin and Kaboski (2023), Herrendorf et al. (2014) and Restuccia and Rogerson (2013) for a review of the literature.

[3] FAO data shows that more than 43 countries had some form of output price support in agriculture in the last decade. Holden (2019) and Jayne et al. (2018) document that input subsidy programs account for a significant share of government spending in agriculture (14-26%) in African countries.

non-agriculture) and two crop types (staples and cash crops). Agents are heterogeneous in their productivity across sectors and can save in a risk-free asset, leading to a distribution of asset holdings in equilibrium within an environment of incomplete markets. In each period, individuals must pay a fixed cost to operate in the non-agricultural sector. Agents decide which sector to operate in and, if choosing agriculture, draw taste shocks that determine their cropping choice. Agricultural production requires an intermediate input, available at subsidized prices, but farmers face intra-period working capital constraints when purchasing it. Staple crops are supported by a Minimum Support Price (MSP) policy, which farmers can access by paying a fixed cost. Under this policy, the government procures staple crops at a fixed price and distributes them as free rations to all households. Both the MSP and input subsidy policies incentivize the use of intermediate inputs but distort agents' occupational choices at the margin (*selection effect*). We calibrate the stationary equilibrium of the benchmark economy, incorporating both the MSP and input subsidy policies.

The model is calibrated to replicate key moments of the Indian economy by combining quasi-experimental evidence with macroeconomic statistics. To identify the working capital constraint in the model, we exploit a natural experiment: an observed 8.5% increase in intermediate input intensity following a government cash transfer equivalent to 6.25% of farmers' annual income. As a test of external validity, the model successfully replicates several untargeted patterns from aggregate and micro-level data, including the aggregate and sectoral savings rates, transition rates from agriculture to the non-agricultural sector, and the income distribution. Additionally, the working capital constraint and taste shocks in the model generate a strong correlation between asset holdings, input intensity, and agricultural output, consistent with empirical observations.

Through counterfactual exercises, we show that removing the fixed cost of operating in the non-agriculture sector and risk are important drivers of APG. Eliminating the cost of working in the non-agriculture sector reduces APG by 36%, while lowering the variance of taste shocks significantly decreases the APG by encouraging greater use of intermediate inputs in equilibrium[4]. These findings are consistent with Mongey and Waugh (2024), who show that discrete choice economies are inefficient in environments with incomplete markets. Other model features, such as the subsistence consumption requirement, the elasticity of substitution between

[4]This finding aligns with Donovan (2021), where agents make input decisions before realizing sectoral productivity shocks, leading to lower input usage in incomplete asset market economies compared to complete market economies.

goods, the fixed cost of obtaining MSP and financial constraints to borrow inputs in agriculture have a limited effect on APG.

Using the calibrated model, we conduct counterfactual experiments to quantify the impact of each policy. In the first exercise, we remove the minimum support price and associated staple crop procurement and ration disbursal program, while retaining the input subsidy. In the second exercise, we reduce intermediate input subsidy by doubling the effective price of inputs, while keeping the support price program.

The removal of the MSP has a positive impact on agricultural productivity due to labour reallocation to the non-agricultural sector. Under fixed prices, eliminating the MSP leads to a 2 percentage points (pp) increase in non-agricultural employment. APG falls by 3.4%, though this reduction is partially offset by a decline in intermediate input usage. In GE, the market price of staple crops decreases as these crops, previously procured by the government under the MSP program, are now sold in the open market. The loss of rations only partially mitigates the decline in demand and prices for staple crops. Additionally, the demand for cash crops falls due to an income effect stemming from the reduction in farmers' incomes. This contributes to a further 1 pp increase in non-agricultural employment and a 2% rise in real non-agricultural output. Consequently, the APG decreases by 3.6% compared to the benchmark economy. Equilibrium outcomes are nearly identical when comparing the benchmark economy with an economy that replaces the MSP with budget-equivalent income transfers. Overall, the effects on the APG are modest, reflecting the limited salience of the program in the benchmark economy (Indian government procures only 30% of staple crop output).

Reducing the input subsidy has a significant negative impact on agricultural productivity by sharply decreasing the demand for intermediate inputs. Under fixed prices, this policy change reduces intermediate input demand by nearly 74%, resulting in a substantial labor shift out of agriculture (14 pp). However, in GE, the resulting increase in crop prices boosts both intermediate input demand and agricultural employment. Overall, agricultural employment shares increase by 2 percentage points relative to the benchmark economy. Despite this reallocation, intermediate input demand and agricultural output remain 42% and 18% lower, respectively, leading to a 30% rise in the APG. This underscores the importance of evaluating policies within a GE framework (Muralidharan & Niehaus, 2017). Furthermore, replacing the input subsidy with budget-equivalent income transfers exacerbates the APG by an additional 6%. This is driven by substantial income transfers, which significantly reduce savings

among risk-averse individuals, thereby lowering capital demand and non-agricultural labour demand. The increased demand for crops raises their prices, prompting a labour exodus from the non-agricultural sector. Consequently, non-agricultural productivity rises significantly due the marked fall in the non-agricultural employment share, resulting in a 36% higher APG compared to the benchmark economy.

These policies generate significant consumer welfare changes, measured using consumption equivalent variations. The removal of the MSP policy leads to a decrease in consumer welfare for all groups of agents (by at least 12%), primarily due to the loss of free rations. Alternative budget-equivalent policies, where government expenditure on procurement is redirected to make either in-kind transfers (mimicking ration disbursement) or income transfers to all households in the absence of an MSP, result in welfare improvements for all agents relative to the benchmark. A reduction in input price subsidies also causes welfare losses for all groups of agents (by at least 10%) relative to the benchmark, as individual incomes fall, market prices for both crops rise, and ration availability is reduced compared to the benchmark. However, a policy that compensates farmers with budget-equivalent lump-sum transfers fully mitigates these welfare losses.

In conclusion, the support price program for staple crops influences the APG by affecting sectoral employment shares (the *selection* effect), while input usage plays a significant role in shaping productivity when examining input subsidy policies.[5]. Welfare gains would be higher with budget-equivalent income transfer policies, but these transfers do not reduce the APG compared to the benchmark. Through the lens of our framework, we find that a conditional cash transfer program targeting non-agriculture workers would improve welfare and reduce the APG by alleviating sectoral mobility frictions (Lagakos, Mobarak, & Waugh, 2023).

Finally, we corroborate the model's prediction of lower agricultural output and higher prices using data from a fertilizer deregulation policy that led to increased fertilizer prices. Additionally, we exploit a natural experiment involving an exogenous increase in the MSP, unrelated to productivity factors, to demonstrate a positive relationship between the MSP, staple production, and intermediate input use, consistent with the model's predictions.

[5]The price of the intermediate input is assumed to be exogenous in this framework, given that India is a large net importer of fertilizers (Gaulier & Zignago, 2010). This assumption is not unique to India, as at least 50% of fertilizer consumption is imported in approximately 75% of countries worldwide (Hebebrand & Glauber, 2023). However, allowing input prices to vary in GE would mitigate some of the impact on agricultural productivity.

Related Literature

This paper contributes to three strands of literature. First, it adds to the macro-development literature that investigates the sources of large productivity gaps across countries. Low input intensity is widely recognized as a critical factor contributing to these gaps (Boppart et al., 2023; Caunedo & Keller, 2021; Restuccia et al., 2008), particularly low intermediate input usage (Donovan, 2021; McArthur & McCord, 2017; Pietrobon, 2024; Rodríguez-Sala, 2023). Additionally, input misallocation plays a significant role in exacerbating productivity differences across nations (Hsieh & Klenow, 2009; Restuccia & Rogerson, 2017)[6]. In this paper, we link misallocation to specific agricultural input and output price subsidy programs. To the best of our knowledge, we are the first to quantitatively examine the distortionary effects of agricultural price support policies on the APG. More broadly, our paper quantifies the role of selection (Adamopoulos et al., 2024; Lagakos & Waugh, 2013) and input intensity in the analysis of input and output subsidy policies.

Second, we contribute to the literature on the consequences of input subsidies and price support policies. Most existing literature on agricultural price support programs, in both developed and developing countries, focuses on the direct impact on agriculture or welfare (Alizamir et al., 2018; Demirdögen et al., 2016; Garg & Saxena, 2022; Lichtenberg & Zilberman, 1986). Most quantitative GE studies of agricultural input subsidy programs use static models (Bergquist et al., 2019; Ghose et al., 2023)[7]. In contrast, we employ a rich dynamic GE model that incorporates several frictions identified in the literature, asset heterogeneity, and incomplete asset markets to quantitatively assess these programs. The distribution of assets plays a crucial role in shaping equilibrium outcomes, particularly by influencing sectoral and cropping choices in the presence of labor mobility and financial frictions, while also providing insights into welfare implications. Furthermore, our empirical analysis of these subsidies in the Indian context aligns with studies in other settings (Beaman et al., 2013; Carter et al., 2021; Diop, 2022).

Our paper is most closely related to Mazur and Tetenyi (2023), who use a macroeconomic model to examine the effects of the input subsidy program in Malawi. They find that the introduction of input subsidies leads to an increase in the APG by inducing labor reallocation towards the agricultural sector. However, Diop (2022) finds that input subsidies increase mi-

[6] Various institutions and policies contribute to such misallocation, including labor market institutions (Donovan et al., 2023; Lagakos et al., 2023), financial market institutions (Buera et al., 2011), land market institutions (Adamopoulos et al., 2024; Manysheva, 2022), and spatial frictions (Chatterjee, 2023), among others.

[7] Bergquist et al. (2019) and Ghose et al. (2023) examine input subsidies in Uganda and Sri Lanka, respectively.

gration to urban areas, which aligns with the predictions of our model. A more detailed comparison of our findings with those of (Mazur & Tetenyi, 2023) is provided in Section 5.3.1.

Finally, we contribute to the body of research on anti-poverty initiatives and food security in low-income countries (Banerjee & Duflo, 2011; Barrett, 2002; Egger et al., 2022; Gadenne et al., 2024). A key objective of the MSP program is to distribute grains to the poor. In our framework, we complement the literature to analyse the welfare implications of policies supporting farmers, as well as their budget-neutral in-kind and cash-based alternatives by exploiting heterogeneity in household income and assets[8].

The rest of the paper is as follows. Section 2 discusses the empirical evidence, whereas the details of the general equilibrium macroeconomic framework are described in Section 3. Section 4 details the calibration exercise, which explains the parameter choices used to solve the model. Section 5 presents the results from the quantitative exercises. Section 6 presents empirical validation of model counterfactuals and Section 7 concludes.

2 Background: Indian agriculture and agriculture policies

Indian agriculture is characterized by low productivity of farmers, volatile yields and limited insurance options. First, labour productivity in the non-agricultural sector is four times higher than in agriculture, despite a significant proportion of the Indian workforce being employed in agriculture (Appendix Figures A3a and A3b). The majority of farmers in India are small and marginal, with 85% cultivating less than 2 hectares of land (Bolhuis et al., 2021). Second, agriculture production is particularly volatile; the time-series standard deviation in the growth of value-added is 4.1% and 1.5% for agriculture and non-agriculture, respectively[9]. Despite significant risk in agriculture, crop insurance take-ups are quite low, with less than 10% of agricultural households holding any crop insurance (2019 Land and Livestock Survey). Lastly, food insecurity remains a critical issue in India because 15% of the population (200 million) are still classified as undernourished[10].

Amidst these issues, various government initiatives were launched to boost agricultural production and enhance food security across the country. Ramaswami (2019) estimated that

[8]Our model is not designed to evaluate the relative benefits of in-kind versus cash transfers. For a detailed discussion on this topic, see Currie and Gahvari (2008), Gadenne et al. (2024), and the papers cited therein.

[9]Appendix Figure A4 shows that the mean (standard deviation) of growth in value added in agriculture and non-agriculture between 1980 and 2019 was 3.1% (4.1%) and 6.7% (1.5%), respectively.

[10]India ranked 102nd out of 117 countries in the 2019 Global Hunger Index.

agriculture subsidies (input, credit and price support subsidies) amount to 2.25% of GDP. Additionally, the government distributes in-kind transfers to nearly 180 million households, costing almost 1% of the GDP (Balani, 2013). In this section, we discuss the institutional background of the two prominent types of government subsidies: (1) input subsidies and (2) output subsidies in the form of minimum support price and procurement.

2.1 Input subsidies

India's Green Revolution in the late 1960s substantially improved farm yields by increasing the availability of high-yielding varieties, fertilizers, irrigation, and electricity (Moscona, 2023). Subsidies on fertilizer, electricity, and irrigation amount to USD 48 billion in 2022-2023, with fertilizer and electricity accounting for 45.6% and 30% of total input subsidies (Sengupta, 2024), respectively. Moreover, from a farmer's perspective the price paid for intermediate inputs is substantially lower than their cost of production or import. Monari (2002) finds that Indian farmers pay less than 10% of the cost of producing electricity. Besides, 40% of the total consumption of nitrogen, phosphorous, and potassium fertilizers is imported in India (FAO, 2019). These facts motivate the assumption in the model that input prices are fixed.

2.2 Minimum support price (MSP)

MSP was introduced in India during the time of the Green Revolution to ensure food security and stabilize farmer incomes. It entails the government announcing a price floor for 23 crops at which it commits to buy as much as a farmer is willing to sell. Though, in practice, the most amount of procurement happens in rice and wheat (Chatterjee & Kapur, 2016). Support price programs are also common in other countries like China and US. Under the Price Loss Coverage program in the US, farmers are compensated for the difference between the market price and a pre-determined price if the latter falls below the market price (Alizamir et al., 2018). Below, we discuss some of the key aspects of the Indian program.

First, the price floor is known to the farmers in advance, as it is announced nationally at the start of the agriculture season in June. The Commission for Agricultural Costs and Prices is responsible for setting the support price. It considers several factors, including a minimum margin over anticipated production costs, expected monsoon patterns, food security concerns, demand and supply dynamics and international market prices. Thus, in the model we will assume that there is no uncertainty with regard to the support price for the farmer.

Second, penetration of the program is incomplete; in recent years, the government has procured around 30% of national rice and wheat production (Figure 1a). Furthermore, delays in procurement after harvest and payments imply that the richer farmers are more likely to access MSP. Figure 1b shows that farmers with higher production levels were more likely to take advantage of the MSP program[11]. Although access is imperfect, Chatterjee et al. (2020) argue that MSP has encouraged farmers to grow staple crops, which are characterized by lower yield and price risk. We also provide reduced-form evidence in Section 6.2 that MSP affects agricultural production[12].

Figure 1: Incomplete penetration of MSP



(a) Proportion of procurement

(b) Heterogeneity in likelihood of MSP

Note: The figure on the left shows the fraction of output that is procured nationally. The figure on the right shows a binscatter of the fraction of farmers selling to a government agency (y-axis) against log of total quantity produced. The Land and Livestock Survey of 77th NSS Round was used to construct the right-hand figure along with 30 quintiles for each crop.

Lastly, the government either stores the procured crops for food security purposes or distributes them to low-income households at markedly reduced prices. On average, highly subsidized rations account for 30% of household rice and wheat consumption (Gadenne, 2020)[13]. We integrate these features into a general equilibrium model in Section 3 and use simulated data to analyze the effects of agricultural input and output price subsidies.

[11]Some of this variation is explained by variation in procurement at state-level due to political cycles and local-level procurement infrastructure. But, this pattern holds even after controlling for state fixed effects, as shown in Appendix Figure A5a. Furthermore, we demonstrate that this pattern remains consistent when measuring a farmer's wealth by land area rather than output (Appendix Figure A5b).

[12]Appendix Figures A6a and A6b show that there is little correlation between actual and potential yield for rice and wheat across Indian states. This suggests that differences in land quality are unlikely to the main factor driving cultivation patterns of Indian farmers, however, policies like the MSP may play a role.

[13]The ratio of median market to PDS price is 10 and 3 for rice and wheat (Gadenne, 2020), respectively.

3 Model

There are two sectors in the economy: agriculture and non-agriculture. The agricultural sector, in turn, comprises *staple* crops and *cash* crops. Time is discrete. The non-agricultural good serves as the numeraire, and its price is normalized to 1 $\forall t$. The prices of the staple (s) and cash crops (r) are denoted by $\{p_{st}, p_{rt}\}$ respectively. A measure one of infinitely-lived individuals face idiosyncratic sector-specific productivity shocks and crop-specific taste shocks that determine their occupational and cropping choices. Irrespective of their choice, they supply their unit endowment of labor inelastically[14].

3.1 Preferences

Individuals have preferences over the consumption of the two agricultural goods ($c_j,\ j \in \{s, r\}$) and the non-agricultural good (c_n). They maximize the expected discounted stream of utility from the consumption of the three goods:

$$\mathbb{E}_0\Big[\sum_{t=0}^{\infty} \beta^t u(c_{st}, c_{rt}, c_{nt})\Big]$$

The period utility function is non-homothetic and includes a subsistence requirement for staple crops following the literature on structural transformation (e.g. Herrendorf et al. (2014)).

$$u(\mathbf{c}) = \frac{\Big[\phi_s(c_s - \bar{c_s})^{1-\theta} + \phi_r(c_r)^{1-\theta} + (1 - \phi_s - \phi_r)(c_n)^{1-\theta}\Big]}{1-\theta} \tag{1}$$

Here, $\mathbf{c} = (c_s, c_r, c_n)$ is the bundle of consumption goods. $\bar{c_s}$ measures the subsistence level of consumption of the staple crop, and ϕ_j is the weight that individuals assign to the agricultural good $j = \{s, r\}$. θ is the coefficient of risk aversion and is inversely related to the elasticity of substitution across goods.

Households do not have access to insurance markets; thus, consumption can only be insured through saving in a risk-free asset that earns interest $\tilde{r_t}$, as in standard models with incomplete markets. Savings (a_t) is denominated in units of the non-agricultural good. Individuals cannot borrow to finance consumption, i.e. $a_t \geq 0$.

[14] We assume substantial labor market frictions, as evidenced by the predominance of family labor over hired labor in farming (Foster & Rosenzweig, 2022). In India, hired labor constitutes only 6.5% of total days worked in agriculture (IHDS-I).

3.2 Idiosyncratic Shocks

Each agent receives a draw of two idiosyncratic productivity shocks at the beginning of each period, corresponding to the agricultural and non-agricultural sectors, *after* which they make their sectoral choices. The idiosyncratic sectoral productivity shocks $\{z_{a,t}, z_{n,t}\}$ are persistent:

$$\log(z_{i,t+1}) = \rho_i \log(z_{i,t}) + \epsilon_{i,t+1}, \;\; \epsilon_{i,t+1} \sim N(0, \sigma_i^2); \;\; i = \{a, n\}$$

where $0 < \rho_i < 1$ and the innovations $\epsilon_{i,t+1}$ are i.i.d across agents, sectors and time.

If agents choose agriculture, their cropping choice is influenced by idiosyncratic taste shocks, which are assumed to be independently and identically distributed across time and cropping choices, are additively separable, and are drawn from a Type-I extreme value distribution with scale parameter ν, following the quantitative trade and spatial literature (e.g. Artuç, Chaudhuri, and McLaren (2010)). We assume that agents make their sectoral choice (agriculture/non-agriculture) *after* they draw $\{z_{a,t}, z_{n,t}\}$, but prior to the realisation of the idiosyncratic taste shocks[15]. One could interpret these taste shocks as a parsimonious specification capturing other sources of idiosyncratic variation affecting cropping choice.

3.3 Technology

The non-agricultural good is produced by a representative firm, which uses capital k_{nt} and effective labour n_{nt}, hired at interest rate $\tilde{r}_t$ and wage w_t respectively, as inputs:

$$y_{nt} = A n_{nt}^{\alpha} k_{nt}^{1-\alpha}, \;\; 0 < \alpha < 1 \tag{2}$$

where, A is the economy-wide total factor productivity (TFP) and α is labour's share of income in a Cobb-Douglas production function.

The agricultural good of each type ($j = \{r, s\}$) is produced by home-operated farms according to the following production function, which only uses intermediate inputs (fertilisers) k_{jt}[16]:

$$y_{jt} = (A z_{a,t}) \left[k_{jt}^{\zeta}\right] \tag{3}$$

[15] These assumptions about the timing and distribution of the taste shocks will yield familiar expressions for the likelihood of choosing a crop and the expected value to an agent from choosing agriculture.

[16] The model does not feature land as an input. One might imagine that land could serve as an alternative collateralisable asset and could also deter agents from switching out of agriculture. While the former is analogous to the role of asset holdings in the credit constraint considered below, the latter is similar to receiving a higher draw of the persistent agricultural productivity shock.

where $\zeta < 1$ is the elasticity of production w.r.t intermediate inputs. Since transactions through land rental markets are rare in India (Deininger, Jin, & Nagarajan, 2008), we abstract from considering land as a choice variable and, thereby, do not consider the frictions associated with adjusting landholdings, which are the focus of a sizable literature, e.g., Adamopoulos and Restuccia (2014) and Bolhuis et al. (2021).

One unit of the intermediate input is produced by transforming p_k units of the non-agricultural good; hence p_k is the price of the intermediate input. Since the prices of fertilizers (a large share of the intermediate inputs) are regulated by the Indian government, with a sizeable fraction being imported, p_k is exogenous in the model.

Expenditure on the intermediate inputs $\left(p_k k_{jt}\right)$ must be incurred prior to the harvest by intra-period borrowing from lenders at rate $\tilde{r}_t$. Let the gross interest factor be denoted by $\tilde{R}_t = 1 + \tilde{r}_t$. Intra-period borrowing is subject to a working capital constraint that is a linear function of the asset holdings (a) of the borrower:

$$p_k k_{jt} \equiv b \leq \phi a_t \tag{4}$$

The parameter $\phi \geq 0$ represents the degree of financial frictions and could be interpreted as capturing frictions like limited financial intermediation, as in Buera et al. (2011). The constraint spans economies with no credit ($\phi = 0$) and those with perfect credit markets ($\phi = 1$).

3.4 Role of Government

Farmers who choose to cultivate staple crops also have the option to sell their produce to a procurement agency (the government) at the minimum support price (MSP), $\bar{p}_t$, subject to incurring a fixed cost, ρ. The MSP is announced at the start of the period before any occupational choices are made. We assume that cash crop farmers cannot avail of support prices, as mostly staple crops are procured by the Indian government.

The procured crops are redistributed freely among all households as rations, c^{ration}. We shall assume that procurement is open-ended, but rations are capped at an amount equal to 30 percent of household consumption of the staple crop, based on Gadenne (2020). Procured crops that are not distributed as rations are sold in the market, and the proceeds accrue to the government.

A change in the input subsidy program is modelled as an exogenous change in the inter-

mediate input price, which will affect the ability of farmers to invest in intermediate inputs.

3.5 Profit maximization

The profit maximization problem of the representative firm (in units of the non-agricultural sector) is standard:

$$\max_{n_{nt},k_{nt}} A n_{nt}^{\alpha} k_{nt}^{1-\alpha} - w_t n_{nt} - \tilde{r}_t k_{nt}$$

The profit maximization exercise yields first-order conditions that equate the marginal products of inputs to their factor prices.

The profit maximization problem for a cash crop farmer incorporates the working capital constraint and is described below:

$$\Pi_r(z_{at}, a_t) = \max_{k_{rt} \leq \frac{\phi a_t}{p_k}} p_{rt}(A z_{at}) \left[k_{rt}^{\zeta}\right] - \tilde{R}_t p_k k_{rt} \tag{5}$$

Through the collateral constraint, asset holdings of an individual can directly impact their intermediate input usage.

The profit maximization problem for a staple crop farmer is analogous to that of a cash crop producer, except that she has the option of selling her crops to the government at the support price, subject to incurring the fixed cost. Conditional on receiving a price, $\hat{p}_{st} \in \{p_{st}, \bar{p}_t\}$, her profits are given by:

$$\Pi_s(z_{at}, a_t; \hat{p}_{st}) = \max_{k_{st} \leq \frac{\phi a_t}{p_k}} \hat{p}_{st}(A z_{at}) \left[k_{st}^{\zeta}\right] - \tilde{R}_t p_k k_{st} - \mu(z_a, z_n, a)\rho \tag{6}$$

where the choice of procurement or not is denoted by $\mu(z_a, z_n, a) = 1$ and $\mu(z_a, z_n, a) = 0$ respectively, and is elaborated upon below. A detailed discussion of this exercise is available in Appendix D.1.

Notably, input subsidies directly enhance intermediate input use and boost agricultural productivity. Similarly, the support price for staples encourages greater input utilization, as intermediate input demand is positively correlated with crop prices.

3.6 Utility maximization and Occupational choice

An agent can choose to be either a farmer of cash or staple crops in the agricultural sector or a worker in the non-agricultural sector. As noted above, workers in the non-agricultural sector face idiosyncratic productivity shocks denoted by z_{nt}, leading to labour earnings of $z_{nt}w_t$. If the agent chooses to be a cash farmer (sector r), she obtains the profit from operating her farm, $\Pi_r(z_{at}, a_t)$ specified above. Similarly, if the agent chooses to be a staple crop farmer, she obtains the profit $\Pi_s(z_{at}, a_t; \hat{p}_{st})$ depending on the received price $\hat{p}_{st} \in \{p_{st}, \bar{p}_t\}$. To ease notation, we shall denote the shock vector (z_a, z_n, a) by $(\mathbf{z}, a)$.

Consider first the value associated with working in the non-agricultural sector.

$$V^w(\mathbf{z}, a) = \max_{c_r, c_n, c_s, a'} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}'|z} V(\mathbf{z}', a') \tag{7}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = w z_n + a(1 + \tilde{r}) - \xi$$

Individuals choosing to work in the non-agricultural sector incur a fixed cost ξ in each period, which could be interpreted as a cost of operating in the non-agricultural sector. If the non-agricultural sector is assumed to be based in urban areas, one could interpret ξ as the rental cost of housing in the urban area. Note that total staple crop consumption is the free ration c^{ration} plus the amount purchased, c_s.

Next, consider the value associated with becoming a farmer of the cash crop:

$$V^r(\mathbf{z}, a) = \max_{c_r, c_n, c_s, a'} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}'|z} V(\mathbf{z}', a') \tag{8}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi_r(z_a, a) + a(1 + \tilde{r})$$

Similarly, the value associated with becoming a farmer of the staple crop is the upper envelope of the value functions associated with receiving market or support prices:

$$V^s(\mathbf{z}, a, \hat{p}_s) = \max_{c_r, c_n, c_s, a'} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}'|z} V(\mathbf{z}', a') \tag{9}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi_s(z_a, a, \hat{p}_s) + a(1 + \tilde{r})$$

Hence, $V^s(\mathbf{z}, a) = \max\{V^s(\mathbf{z}, a, p_s), V^s(\mathbf{z}, a, \bar{p})\}$. This leads to associated procurement choices:

$$\mu(\mathbf{z}, a) = 1 \text{ if } V^s(\mathbf{z}, a, p_s) \leq V^s(\mathbf{z}, a, \bar{p}) \tag{10}$$

$$\mu(\mathbf{z}, a) = 0 \text{ if } V^s(\mathbf{z}, a, p_s) > V^s(\mathbf{z}, a, \bar{p}) \tag{11}$$

The value function $V(\mathbf{z}, a)$ for an agent with saving a and shocks $\mathbf{z} = \{z_a, z_n\}$ is the maximum of the value function for a worker and the *expected* value associated with agriculture $\left(\tilde{V}^a(\mathbf{z}, a)\right)$, following our assumption about the timing of sectoral choice:

$$V(\mathbf{z}, a) = \max\{\tilde{V}^a(\mathbf{z}, a), V^w(\mathbf{z}, a)\} \tag{12}$$

The expected value function for agriculture is defined as:

$$\tilde{V}^a(\mathbf{z}, a) = \mathbb{E} \max\{V^s(\mathbf{z}, a, \hat{p}_s) + e_s, V^r(\mathbf{z}, a) + e_r\} \tag{13}$$

where, e_s and e_r are the additively separable i.i.d Type-I extreme value taste shocks with shape parameter ν that are associated with growing staple and cash crops, respectively[17].

Conditional on choosing to be in agriculture, one obtains the *choice probabilities* associated with growing staple crops as:

$$\sigma(\mathbf{z}, a) = \frac{\exp\left(\frac{V^s(\mathbf{z},a,\hat{p}_s)}{\nu}\right)}{\exp\left(\frac{V^s(\mathbf{z},a,\hat{p}_s)}{\nu}\right) + \exp\left(\frac{V^r(\mathbf{z},a)}{\nu}\right)} \tag{14}$$

Finally, one can define the sectoral choice functions:

$$\omega(\mathbf{z}, a) = 1, \quad \text{if } V(\mathbf{z}, a) = V^w(\mathbf{z}, a) \tag{15}$$

$$\omega(\mathbf{z}, a) = 0, \quad \text{if } V(\mathbf{z}, a) = \tilde{V}^a(\mathbf{z}, a) \tag{16}$$

The agricultural productivity gap is defined as: $\frac{y_n}{p_s^* y_s + p_r^* y_r} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}}$. With fixed prices, subsidies influence the APG through two channels: (i) agricultural output via intermediate input intensity, and (ii) shaping individuals' sectoral employment choices (*selection effect*). Below, we explore the factors behind a farmer's decision to participate in MSP and examine how assets

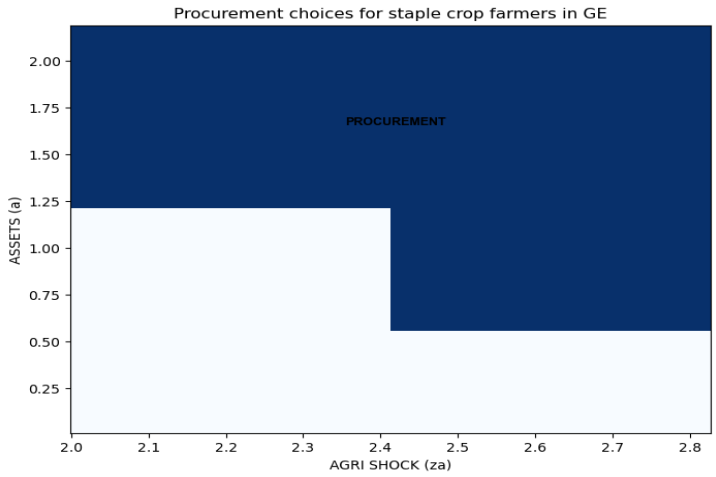
[17] Using the properties of the extreme value distribution (McFadden, 1973), the expected value function $\tilde{V}^a(\mathbf{z}, a)$ is given by the familiar log-sum formula: $\tilde{V}^a(\mathbf{z}, a) = \nu \log\left\{\exp\left(\frac{V^s(\mathbf{z},a,\hat{p}_s)}{\nu}\right) + \exp\left(\frac{V^r(\mathbf{z},a)}{\nu}\right)\right\}$

influence cropping and sectoral choices.

3.6.1 Procurement choice

As outlined earlier, staple crop farmers opt for procurement only when the value of selling their produce at the government-announced price exceeds the value of selling it at the market price, taking into account the fixed cost of procurement. Moreover, productive staple crop farmers with substantial assets, who face fewer constraints, are more likely to earn higher profits, enabling them to participate in government procurement. Figure 2 illustrates this relationship, showing that the asset threshold for opting into procurement decreases as farmers' productivity rises, as indicated by the blue-coloured region representing procurement choices.

Figure 2: Procurement choice for staple crop farmers



3.6.2 Role of assets in sectoral choices and input usage

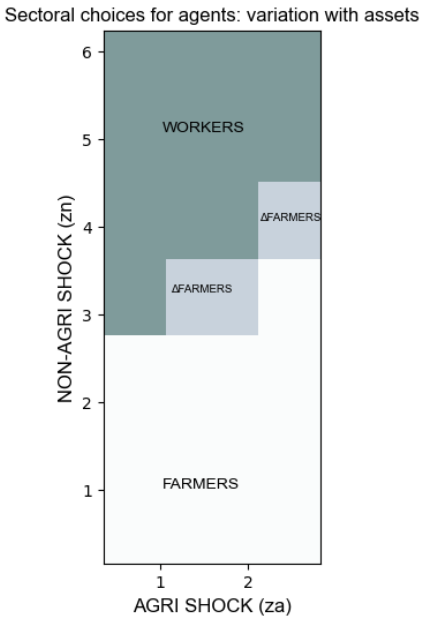
We now consider the channels whereby assets influence outcomes like sectoral choice and intermediate input usage. Asset holdings also influence the welfare gains or losses arising under various policies, which we discuss further in section 5.4.1.

An immediate implication of a dynamic environment with saving choices is an ability to study the importance of collateral constraints that depend on an agent's assets, as represented in equation (4). As one would expect, agents with low asset holdings are constrained in their choice of the intermediate input, which lowers their return from operating in the agricultural sector. If their relative sectoral productivity draws are similar, these 'asset-poor' agents might choose to operate as workers in the non-agricultural sector. Hence, individual asset holdings

can influence sectoral choices through the working capital constraint.

Another feature of our model is that sectoral choices are made before the realization of crop-specific taste shocks. This introduces an additional role for assets in the context of risk: agents with similar productivity draws but different asset holdings exhibit varying levels of absolute risk-aversion, which influences their sectoral decision. Specifically, the likelihood of choosing the riskier agricultural sector increases with asset holdings, as agents become less risk-averse.

Figure 3: Sectoral choices for agents and their variation with assets



Asset holdings could affect sectoral choices as operating in the non-agricultural sector requires a fixed cost; and agents with low (high) non-agricultural productivity but with high (low) asset holdings might be able to incur this cost. However, in our calibrated model, this channel has a limited role. Sectoral choices are driven primarily by relative sectoral productivity draws, with some variation by asset levels due to credit constraints and the risk-aversion channel discussed above. These patterns are corroborated in Figure 3, where we consider how sectoral choices vary with asset holdings. We note that the bands labeled 'ΔFARMERS', corresponding to the sectoral switches made by agents with higher asset holdings, are driven by lower risk aversion and non-binding credit constraints. The fixed cost of operating in the non-agriculture will matter in affecting sectoral choices, as we will show below, but variation in asset holdings will not be the primary reason driving those results. Finally, we note that asset holdings also influence the procurement choices of staple crop farmers, as depicted above in Figure 2.

3.7 Stationary equilibrium

A stationary competitive equilibrium comprises an invariant distribution F, value functions $\{V^s, V^r, V^w, \tilde{V}^a, V\}$ with associated decision rules $\{\omega, \sigma, \mu, c_r, c_s, c_n, a'\}$ and prices $\{p_s, p_r, \bar{p}, w, \tilde{r}\}$ that solve the agents' and firm's optimization problems detailed above. Staple and cash crops, non-agricultural good, asset and labour markets must clear and the distribution of agents in the economy F evolves as per:

$$TF(\mathbf{z}', a') = \int_{\mathbf{z}\times A} \mathbb{I}_{\{a'(\mathbf{z},a)=a'\}} \quad \Pi^a(z_a, z_a') \quad \Pi^n(z_n, z_n') \quad dF(\mathbf{z}, a) \qquad \forall(\mathbf{z}', a') \in \mathbf{z} \times A \quad (17)$$

Here, $\mathbb{I}_{\{a'(\mathbf{z},a)=a'\}}$ is an indicator function that takes the value 1 when an agent with state $(\mathbf{z}, a)$ has saving a'; and $\Pi^i(z_i, z_i')$, $i = \{a, n\}$ are the transition probabilities. T is an operator that maps distributions into distributions. Appendix Section D.2 describes the equilibrium in detail.

4 Calibration

We calibrate some parameters of the model internally, either to match certain moments of the Indian economy, or to match quasi-experimental empirical evidence from a cash transfer program in India. The rest of the parameters are chosen from the literature.

4.1 Internally calibrated parameters

Working capital constraint estimation

To pin-down the working capital constraint parameter ϕ, we bring to bear a permanent income transfer program in India that increased investment in intermediate inputs (fertilizers). The Pradhan Mantri Kisan Samman Nidhi (PMKSN) policy promises a perpetual cash transfer to landowning farmers of Rs 6000 (equivalent to 6.25% of their annual income). The government launched the program in 2019 to provide insurance against adverse income shocks, given the low take-up of crop insurance by farmers. Ghosh and Vats (2022) finds that the program increases farmers' income through higher credit demand and investments on the farm. We show that the program also helps in increasing intermediate input use by relaxing a farmer's financial constraints.

We employ a difference-in-differences (DiD) framework to estimate the impact of the program. Although the government attempted to implement the program nationwide, the state of

West Bengal initially opted out due to disagreements with the federal government over how the transfers should be distributed to farmers. They eventually joined the program in May 2021. The regression specification we employ is:

$$Y_{dt} = \alpha + \phi_d + \phi_t + \beta^{-1} \times \mathrm{T}_s \times 1_{\{2016 \leq t \leq 2017\}} + \beta \times \mathrm{T}_s \times 1_{\{t=2019\}} + \varepsilon_{dt} \tag{18}$$

where Y_{dt} is the outcome of district d at time t, T_s is a dummy referring to the treated states, $\mathbf{1}_{t=2019}$ is a dummy variable that takes value 1 for the year 2019 and $\mathbf{1}_{2016 \leq t \leq 2017}$ is a dummy variable that takes value 1 for years before 2018[18]. β measures the average treatment of the outcome of interest: the log of the total value of nitrogen, phosphorous and potash fertilizers[19].

The first column of Table 1 highlights the increase in output due to the policy, consistent with the findings in Ghosh and Vats (2022). The second column shows that some of the increase in output occurred through fertilizer consumption rising by 8.5%[20,21]. These results highlight the presence of financial frictions that limit the use of intermediate input use in the Indian context. The parameter ϕ in the working capital constraint is chosen to equal 0.25 to match the increase in aggregate intermediate input demand when farmers' cash-in-hand increases by 6.25% relative to their annual income. This parameter value is a bit higher compared to Buera et al. (2021) ($\phi = 0.08$), who choose it to match an aggregate moment: the external finance to GDP ratio in India. The lower estimated financial friction in this paper reflects the focus on the specific channel of working capital constraint affecting only intermediate input use in agriculture and ignoring other margins excluded in our model, such as farm mechanization (Ghosh & Vats, 2022).

Other internally calibrated parameters

We internally calibrate 8 other parameters. We describe the moment we target in the data to match them, with the caveat that they are all jointly targeted in equilibrium.

The standard deviation and persistence of the agriculture and non-agriculture productivity

[18] We exclude 2020 to ensure our estimates are not driven by the pandemic period, or the anticipation of West Bengal joining the program in 2021.

[19] We use data from CMIE States of India. Appendix C contains details about the dataset.

[20] The insignificant pre-treated effects imply that there were no differences in fertilizer use between the treated and control states. Appendix Figures A7a and A7b shows the estimates using an event-study specification.

[21] Appendix Table B1 shows the cash transfer program increased demand of nitrogen and phosphorous. Our results are consistent with Ghosh and Vats (2022) and Varshney et al. (2021) on the effect of the policy on fertilizer consumption. Varshney et al. (2021) show that the program increased the likelihood of farmers in Uttar Pradesh to use fertilizer (extensive margin), while Ghosh and Vats (2022) shows the beneficial impact on input usage on more versus less treated areas through a continuous difference-in-differences specification.

Table 1: Effect of transfer program on output and fertilizer use

Dependent variables: Log Output or Log of Total Fertilizer value		
	Output (tonne) (1)	Total Fertilizer value (Rs.) (2)
Treatment Effect	0.121***	0.085**
	(0.044)	(0.036)
Pre-treated effect	0.061	-0.025
	(0.050)	(0.029)
Observations	2216	1960
R^2	0.965	0.966
Outcome Mean	22.915	19.826

Note: The coefficients show the average treatment and pre-treated effects. The sample size changes as we restrict regressions to a balanced panel in each case. Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

shocks, σ_a, ρ_a, σ_n and ρ_n are calibrated to match the standard deviation of log agricultural harvest, first-order covariance of log harvest, standard deviation of log non-agriculture income and first-order covariance of log non-agriculture income, respectively. We use the six year panel of the ICRISAT Village Level Studies (VLS) data to compute the data moments. We focus on salaried income while considering non-agriculture income. We remove variation in log agricultural harvest and log non-agriculture income that are not modelled here, following Donovan (2021) and others. We control for village-time trend, age, age squared, education and gender of household head and dummies of the number of children, adult women and adult men, village and year. These factors explain 34% and 40% of the total variation in log agricultural harvest and log non-agricultural income, respectively. The standard deviation and persistence of agricultural shocks are 0.3 and 0.5, respectively. The standard deviation of agricultural shocks is almost identical to the estimated standard deviation of 0.32 in Donovan (2021) for India. The non-agricultural productivity shock has a slightly higher standard deviation of 0.345 than the agricultural productivity shock, and is also much more persistent (0.82).

The subsistence requirement, $\bar{c}$, is chosen to match the 2003 agricultural employment share of 57.4%. The scale parameter ν associated with the crop taste shocks is chosen to match the staple crop farmer share of 65.9% obtained from the first wave of the Indian Human Development Survey (IHDS-I)[22]. The fixed cost of procurement, ρ, is chosen to match the mean share

[22]IHDS-I is a nationally representative data that contains detailed questions on the types and value of crops grown. Appendix Figure A9 shows the distribution of area devoted to staple crop farming in the IHDS-I data. Farmers with more than 75% of area devoted to staple crop farming are defined as staple crop farmers.

Table 2: Internally calibrated parameters

Parameter	Value	Target/Source	Data	Model
Standard dev. of agricultural prod. shock σ_a	0.3	Variance of log crop harvest (ICRISAT VLS)	1.02	1.2
Standard dev. of non-agri shock σ_n	0.345	Variance of log non-agri income (ICRISAT VLS)	0.58	0.405
Persistence of agri prod. shocks ρ_a	0.5	First order auto-covariance of log harvest (ICRISAT VLS)	0.667	0.662
Persistence of non-agri prod. shocks ρ_n	0.822	First order auto-covariance of log non-agri income (ICRISAT VLS)	0.32	0.39
Subsistence requirement $\bar{c}$	0.005	Agricultural employment share in 2003 (RBI India KLEMS)	57.4%	58%
Fixed cost of procurement ρ	0.1	Mean share of staple crops procured in 2000-09 (RBI)	26%	26%
Fixed cost of operating in non-agriculture ξ	0.665	Agricultural productivity gap in 2003 (RBI India KLEMS)	4.24	4.085
Working capital constraint ϕ	0.25	$\frac{\Delta(\sum_j k_j)}{\Delta\text{Income}}\|_{\Delta\text{Income}=6.25\%}$ (Table 1)	8.5%	5.75%
Scale parameter ν	0.8	Share of staple crop farmers (IHDS-I)	65.9%	57.6%

of staple crops procured in the decade between 2000 and 2009, which is 26% (Reserve Bank of India). Finally, the operating cost associated with the non-agricultural sector, ξ, is chosen in order to match the APG of 4.24.

4.2 Externally chosen parameters

We normalize the sector-neutral TFP A to 1. We calibrate the preference parameters to the US as a benchmark, setting $\phi_s = 0.13$ and $\phi_r = 0.06$. Staple includes food, whereas expenditure on beverages, clothes, personal care and tobacco captures spending on cash crops. Using the consumption shares for the US economy implies that preferences are not changing along the development path, which is standard practice in the literature. θ, the risk-aversion coefficient, which is also inverse of the elasticity of substitution across crops, is set at 2. The discount factor, $\beta = 0.96$, is standard in the literature (e.g. Donovan (2021)). Moreover, we show below that the model-implied saving rates are quite close to their empirical counterparts.

The labour share of income, $\alpha = 0.67$, as is standard. The intermediate input price is exogenously set at $p_k = 1.56$ using the Productivity Level Database (Inklaar et al., 2023), following the procedure used by Restuccia and Rogerson (2008). Specifically, they argue that the price of the intermediate input is the purchasing power parity (PPP) price of the agricultural intermediate input relative to the PPP price of non-agricultural output, which is then normalized relative to

the corresponding U.S. value. The agricultural production function parameter ζ, which captures the intermediate input share, is chosen to be 0.4, following Donovan (2021). Lastly, the support price $\bar{p}$ is set to be $1.07 * p_s$, based on the empirical ratio of MSP to market price[23].

4.3 External validity: comparing the model's predictions against the data

We now consider a couple of external validity tests of the model. In the first set of tests, we compare the model's performance in the aggregate versus the data. Finally, we compare the model's predictions about the relationship between asset holdings, intermediate input usage and harvest value at the household level. Overall, the model and the data match well.

4.3.1 Non-targeted moments

In Table 3, we report some over-identifying moments that have not been targeted in the calibration. First, the implied aggregate saving rate of the economy equals 25.2%, which is quite close to the 23.2% saving rate in 2004 obtained from the World Bank World Development Indicators data. Furthermore, our model also captures the pattern of savings rates by occupation reasonably well. The model implied saving rate of agricultural workers (23%) is below the saving rate of non-agricultural saving rate (28.5%), which also holds in the micro data (IHDS-I). This indicates that the value of $\beta = 0.96$ that we set leads to saving behaviour consistent with the data. The model matches the transition rates from staple to cash crops and agriculture to non-agriculture sectors quite well. Finally, the model matches the income distribution very well, which were obtained from the World Inequality Database (WID) for the year 2005 (Chancel et al., 2022). This validates the calibration of the sectoral productivity shocks.

4.3.2 Relationship between assets, intermediate input usage and harvest value

We estimate the relationship between asset holdings and intermediate input usage or harvest value using simulated data obtained from the model and in the data. To compute the regressions in the model, we simulate 500,000 households in the stationary equilibrium of the calibrated model. As households in the simulated data can switch across sectors, the regressions

[23] We use the nationally representative Land and Livestock Holding Survey of 2018 (NSS 77th Round) to determine the price received by the farmer for rice or wheat. Price is equal to the average value divided by the quantity sold. We compare the price received with the national support price. Appendix Figure A8 shows the distribution of market price to support price. Chatterjee et al. (2020) also reports that market price can fall below the support price in regions with low procurement of grains.

Table 3: Non-targeted moments

Moment	Source	Data	Model
Aggregate saving rate	World Bank	23.2%	25.2%
Agricultural saving rate	IHDS-I	15.9%	22.9%
Non-agricultural saving rate	IHDS-I	29.4%	28.5%
Transition rate between agriculture and non-agri sectors	ICRISAT VLS	6.41%	10.62%
Transition rate between staple and cash crop farmers	ICRISAT VLS	14.7%	13%
Income share of top 10%	WID	45.48%	30.35%
Income share of bottom 50%	WID	18.39%	16.9%
Income share of bottom 10%	WID	1.27%	1.53%

are run using simulated data for households in periods where they choose the agricultural sector. We follow Donovan (2021) to obtain these relationships in the ICRISAT VLS data. Lagged asset holding is the main independent variable to limit issues of reverse causality. We regress lagged asset holdings on intermediate input expenditure and harvest value, while controlling for household characteristics, village and year dummies, and village-level time trend in the empirical regressions[24].

Appendix Table B2 demonstrates that a positive association between asset holdings and input expenditure and harvest value, both in the model and the data. Financial frictions and taste shocks induce a positive association between assets and input expenditure and subsequently on production. The model underestimates the relationship observed in the data; however, without financial frictions and intra-temporal risk, the relationship in the model would be even weaker.

5 Results

In this section, we present results from our quantitative exercises. First, we discuss the role of various model features (subsistence requirement, risk aversion) and frictions (credit, operating, and procurement costs) on outcomes relative to the calibrated benchmark model, featuring both the minimum support price and the input subsidy policies. Next, in order to highlight the impact of the MSP, we conduct a counterfactual exercise wherein we evaluate equilibrium outcomes when the support price program is removed, followed by a decomposition of the channels driving the results obtained. We then proceed to investigate the role of

[24]Other controls include number of adult men, adult women and kids in the household, and gender, education, age and age squared of the household head.

the input price subsidy by conducting a counterfactual exercise wherein we double the price of the intermediate input, p_k, from its benchmark value of 1.56 and then evaluate the resulting equilibrium outcomes. Finally, we discuss the welfare implications of removing the support price program or lowering the input subsidy policy.

5.1 Role of frictions and preferences

The APG is given by $\frac{y_n}{p_s^* y_s + p_r^* y_r} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}}$. We discuss the importance of frictions and certain modelling features on sectoral employment shares and the APG. In each exercise, we remove the model feature or friction in question alone, keeping the rest of the model unchanged and compare the equilibrium outcomes to the benchmark in Table 4.

Table 4: Change in outcomes with alternate frictions and preferences

Outcome	Benchmark	$\bar{c} = 0$	$\rho = 0$	$\phi = 1$	$\xi = 0$	$\theta = 1$	$\nu = 0.2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment share in non-agriculture	42%	41.7%	40%	40.88%	48.3%	56.6%	43.6%
Share of staple crops procured	26%	26%	100%	29.45%	69.8%	18.2%	30%
Intermediate input usage	0.118	0.118	0.126	0.128	0.21	0.0465	0.1344
Agricultural productivity gap	4.09	4.1	4.15	3.95	2.63	4.26	3.7
Labour productivity of non-agri sector†	3.45	3.46	3.54	3.441	3.105	2.816	3.37
Labour productivity of agricultural sector*	0.844	0.843	0.853	0.871	1.18	0.661	0.91
Labour productivity of cash crop sector	0.597	0.596	0.606	0.615	0.838	0.421	0.639
Labour productivity of staple crop sector	0.661	0.66	0.664	0.686	0.924	0.574	0.72

Note: †Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$
* Labour productivity of the agricultural sector computed using benchmark equilibrium prices as $\frac{p_r^* Y_r + p_s^* Y_s}{\text{Agricultural employment share}}$

Column (2) illustrates the impact of the subsistence requirement ($\bar{c}$) on target outcomes relative to the calibrated benchmark. Removing the subsistence requirement has little effect on the employment shares and sectoral productivities, as the calibrated $\bar{c}$ (0.005) is smaller than rations (0.0576), which reduces the salience of the subsistence requirement.

Next, we consider the role of the fixed cost of procurement which is calibrated to match the share of staple crops procured by the government. We lower the fixed cost ρ to 0 from its calibrated value of 0.1. Column (3) of Table 4 indicates that this leads to all staple crops being procured, while also leading to a higher employment share of staple crop farmers at the expense of cash crop farmers and the non-agricultural sector. The influx of staple crop farmers drives down staple crop prices, while cash crop prices are raised. Intermediate input usage

rises slightly as staple crop farmers all avail of the (higher) support price, while cash crop farmers also earn a higher revenue. Higher intermediate input usage offsets the negative impact of higher agricultural employment on the labour productivity of agriculture. Non-agricultural labour productivity is higher, driven mainly by the lower non-agricultural employment share. Overall, removing the fixed cost of procurement marginally increases the APG (1.5%).

We then consider the role of the working capital constraint. Relaxing the constraint, we find in Column (4) of Table 4 that the employment share of agriculture rises slightly. Intermediate input consumption by farmers rises, which outweighs the higher agricultural employment share to raise the labour productivity of agriculture. Labour productivity in the non-agricultural sector falls marginally, as the falling employment share is not sufficient to overcome the fall in output in that sector. The APG falls by 3.4%.

Next, we drop the fixed cost associated with operating in the non-agricultural sector. Column (5) of Table 4 shows that the employment share of agriculture drops significantly (6.3 pp). Consequently, crop prices rise by around 50%, and over two-thirds of staple producers choose procurement. Higher crop prices raise revenue and intermediate input usage. As one would expect, the sizable drop in agricultural employment raises agricultural (staple and cash crop) labour productivity, while non-agricultural labour productivity falls significantly leading to a 36% reduction in APG.

To understand the effect of the elasticity of substitution ($1/\theta$), we reduce the value of θ from 2 in the benchmark to 1. The higher elasticity of substitution lowers the agricultural employment share significantly (14.6 pp) due to higher demand for the cheaper non-agricultural good. The lower demand for agriculture goods results in reduced prices, intermediate input use and agricultural productivity. Non-agricultural labour productivity also falls, as the reduced asset supply raises the interest rate, and lowers capital usage and non-agricultural output, while the non-agricultural employment share also rises. Overall, the APG rises a bit by 4%.

Finally, to assess the role of intra-temporal risk, we reduce the standard deviation of the taste shocks (ν). A decrease in the volatility of the taste shock lowers the expected value of agriculture, thereby reducing the agricultural employment share. This results in a rise in crop prices, which encourages greater input use and increases agricultural productivity. In equilibrium, APG decreases by 9.5%.

In conclusion, risk and the fixed cost of operating in the non-agricultural sector are important factors in understanding the APG.

5.2 Counterfactual exercise: removing the MSP

In the benchmark model, agents with low realizations of z_a relative to z_n choose to be workers in the non-agricultural sector. The operating cost (ξ) in the non-agriculture sector results in farming being chosen when agents have similar draws of the sectoral shocks. In addition, agents with high asset holdings choose to be farmers. These agents are more likely to be unconstrained and are less risk-averse, which makes them willing to choose the risky agricultural sector with relatively higher net return.

In the absence of the minimum support price policy, which served to raise received crop prices for staple farmers and boosted their demand for the intermediate input, individuals with relatively low productivity in the agricultural sector are incentivised to move out of staple crop farming toward the non-agricultural sector.

Table 5 displays the quantitative results obtained from removing the support price program and the subsequent distribution of free rations when prices are kept fixed (Column 2), when prices adjust in general equilibrium (GE) (Column 3), and the GE results when the support price program is replaced by a budget-equivalent income transfer program to all agents (Column 4); alongside equilibrium outcomes in the benchmark specification (Column 1).

We begin by considering equilibrium outcomes in column 2 when all prices are fixed at the benchmark equilibrium values. There is some outflow from growing cash and staple crops toward the non-agriculture sector, although the outflow from cash crop farming is greater. This is mainly because, for any agent with a favourable draw of z_a, the higher benchmark equilibrium staple crop price (due to subsistence requirements for staple crop consumption and the higher expenditure share on staple crops) still makes staple crop farming relatively profitable, particularly when the agent must compensate for the loss of rations through market purchases at the (high) fixed prices. Higher employment in the non-agricultural sector boosts output, resulting in higher aggregate real output (evaluated at benchmark equilibrium prices). The overall quantitative effects are small under fixed prices, as the salience of the program is limited (the government procures 30% of the staple output).

In general equilibrium (column 3), an outflow of staple crop farmers to the non-agricultural sector raises the share of non-agricultural workers. The influx of labour into the non-agricultural sector also increases capital demanded by non-agricultural firms due to complementarity between the two inputs, which is outweighed by the higher saving of workers who earn a higher

Table 5: Comparison of equilibrium outcomes upon removal of MSP

	Benchmark	No MSP (fixed prices)	No MSP (GE)	No MSP (balanced)*
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output, $\sum_j p_j Y_j$	1.936	1.958	1.968	1.931
Real Output† , $\sum_j p_j^* Y_j$	1.936	1.965	1.974	1.931
Non-agricultural Good, y_n	1.446	1.491	1.51	1.443
Cash Crop, y_r	0.147	0.138	0.147	0.15
Staple Crop, y_s	0.221	0.218	0.203	0.216
Rations, c^{ration}	0.0576	0	0	0
Intermediate input demand, $k_s + k_r$	0.118	0.113	0.11	0.116
Capital demand, k_n	4.2	4.33	4.4	4.19
Labour productivity of non-agri sector‡	3.45	3.361	3.34	3.45
Labour productivity of agricultural sector	0.844	0.85	0.848	0.838
Labour productivity of cash crop sector	0.597	0.611	0.618	0.602
Labour productivity of staple crop sector	0.661	0.658	0.653	0.65
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	1.272	1.272	1.272	1.272
Staple Crop, p_s	1.372	1.372	1.343	1.372
Support Price, $\bar{p}$	1.467	-	-	-
Interest rate, r	0.017	0.017	0.0166	0.0172
Wage, w	1.143	1.143	1.145	1.142
Employment Shares				
Non-agricultural Sector	0.42	0.443	0.452	0.418
Cash Crop Farmers	0.246	0.225	0.237	0.249
Staple Crop Farmers	0.334	0.331	0.311	0.333

Note: *For this exercise we consider income transfers to all agents that amount to government expenditure on the MSP program in the benchmark equilibrium
†p^* represents prices in the benchmark
‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

income, leading to a slightly lower interest rate. The higher capital used also raises the marginal product of labour and hence the non-agricultural wage.

There is a slight decline in the staple crop price, p_s. This is because staple crops hitherto procured by the government are now supplied to the market, which brings down the market price of staple crops. The resulting fall in staple farmers' incomes lowers their demand for both crops, while the substitution of demand away from the cash crop to the cheaper staple crop exactly offsets the reduced share of cash crop farmers, thereby keeping the price of the cash crop unchanged. Cash crop farmers choose to move to the non-agricultural sector with higher

wages to compensate for the loss of rations. The absence of procurement reduces intermediate input demand and, hence, production for farmers of staple crops. However, the reduction of agricultural production is countered by a rise in non-agricultural production, as more agents switch toward that sector, and capital usage also rises due to the lower interest rate.

The overall value of production, $\sum_j p_j y_j$, and real output rise as the production of the staple crop doesn't fall enough to offset the increased production of the non-agricultural good.

The average labour productivity in each sector is computed using prices in the benchmark equilibrium, $\{p_s^*, p_r^*\}$, in the counterfactual experiment. The average labour productivity of the non-agricultural sector falls with the removal of the MSP program, as more individuals join the non-agricultural sector. The labour productivity of the staple crop sector falls slightly, as some individuals leaving staple farming partially offset the decline in productivity due to lower intermediate input use. The labour productivity of the cash crop sector increases due to sectoral reallocation of labour. APG falls by 3.6% due to the rise in non-agricultural employment, which offsets the reduction in intermediate input usage and the increased production in the non-agricultural sector.

The final column of Table 5 replaces the support price program with *budget-equivalent* income transfers to all agents in the economy: the total amount available for disbursal is the expenditure of the government on procurement, $\bar{p} * c^{\text{ration}}$. We shall also refer to this budget equivalent transfer policy as a balanced budget transfer policy. Briefly, we note that income transfers, by boosting the resources of agents, boost spending, agricultural production, and crop prices relative to the no MSP counterfactual in column 3. However, equilibrium outcomes under the income transfer program are very similar to the benchmark equilibrium outcomes listed in column 1. In particular, the agricultural employment share rises slightly above its benchmark equilibrium level; and although the cash transfer reduces capital usage and non-agricultural production, labour productivity in the non-agricultural sector is unchanged. Consequently, the APG is driven by labour productivity in the agricultural sector, which falls due to a slightly higher agricultural employment share. Hence, the APG widens marginally (by 0.7%) relative to the benchmark economy.

5.2.1 Decomposing the effects of removing the MSP

The results above highlight three effects associated with the removal of MSP, viz. (a) the loss of support prices received by staple crop farmers, (b) the loss of staple crop rations by all agents

in the economy, and (c) the release of formerly procured staple crops on the market. We disentangle these effects by taking away one of these three attributes of the support price program at a time and evaluating equilibrium outcomes. This will allow us to consider the importance of the dropped attribute in explaining the equilibrium outcomes listed in column 3 of Table 5.

We begin by considering an environment where the MSP policy is retained, but all (or a significant fraction of) procured crops are disposed of or thrown away[25]. We shall refer to this as the 'procure-disposal' program. This program retains two facets of the support price program: (i) procurement at support prices and (ii) the limited supply to the market. However, rations are replaced (reduced). Appendix Table B3 demonstrates that such a program results in a higher staple crop price, as the loss of rations boosts staple crop demand which dovetails with a reduction in the supply of staple crops to the market. This also leads to a rise in the employment share of both crops.

Next, we consider an environment with support prices where the government retains a scaled-down rations program and transfers the remainder of the procured crops to the market. We shall refer to this as the 'procure-rations-market sale' program. This program retains the following two facets of the MSP: (i) limited procurement at support prices and (ii) rations. However, the reduction in market supply of staple crops that would be associated with procurement and rations disbursal is now diminished, as the rations program is scaled down and all procured crops that are not distributed as rations are sold on the market. We find that such a program results in a lower staple crop price. It also leads to a slight decline in the employment share of both crops. Both patterns are consistent with the GE results of removing MSP in column 3 of Table 5.

Finally, we consider an environment with no procurement by the government (and therefore no support prices for staple crop farmers) but with a scheme where the government purchases a quantity of staple crops at market prices equivalent to the rations provided in the benchmark equilibrium, and redistributes them to all agents in the economy. We shall refer to this as the 'market redistribution' program. We find that there is no difference in outcomes relative to the benchmark equilibrium.

These results suggest that the key feature whose removal yields equilibrium outcomes that are consistent with the GE counterfactual outcomes of removing MSP is the supply of hitherto

[25] In Table B3, we report outcomes for the case when a quarter of the procured staple crops are disposed of, with the remainder being used as rations. The results are qualitatively similar when a larger fraction of the procured crops are thrown away.

procured crops to the market, which we considered in the 'procure-rations-market sale' exercise. The additional market supply drives down staple crop prices, pushing agents away from staple crop production toward the non-agricultural sector. On the other hand, removing the other facets of the program does not increase the non-agricultural employment share. Hence, we conclude that the effects of MSP removal arise from the increased supply of staple crops to the market.

In conclusion, the removal of the MSP impacts sectoral employment shares but has minimal effect on the APG. The rise in staple crop prices from reduced market supply is insufficient to significantly address the underlying frictions that cause the APG.

5.3 Counterfactual exercise: reducing the input subsidy

Table 6 displays the quantitative results obtained from reducing the input subsidy when prices are kept fixed (Column 2), when prices adjust in general equilibrium (GE) (Column 3), and the GE results when the lower input subsidy is compensated by a budget-equivalent income transfer program to all agents (Column 4); alongside equilibrium outcomes in the benchmark specification (Column 1). A reduction in input subsidies is captured by an exogenous doubling of the price of the intermediate input, p_k.

When prices are kept fixed at the benchmark equilibrium values, we observe a rise in the employment share of the non-agricultural sector. As the input price is doubled, intermediate input usage falls to a quarter of its benchmark equilibrium value, which halves the production of both crops. The lower ensuing profit margins for farmers drive the outflow toward the non-agricultural sector. This boosts capital demand and non-agriculture output, resulting in higher real output.

The quantitative results in GE are listed in Column 3 of Table 6. Preferences for agricultural goods consumption mandate an upward adjustment in crop prices to incentivize crop production; essentially, the reduction in intermediate input usage is compensated by adding more agents in the agricultural sector in order to boost crop production. The net effect is that sectoral employment shares actually shift in favour of agriculture, owing to the significant (over 40%) GE increase in crop prices. While the rise in crop prices partially offsets the effect of higher intermediate input prices on crop production, the overall effect is a fall relative to the benchmark. This also results in a fall in real output, calculated using benchmark equilibrium prices. However, the value of crop production rises as the prices of both crops rise. Non-

Table 6: Equilibrium outcomes in benchmark and following input subsidy reduction

	Benchmark	Low subsidy* (fixed prices)	Low subsidy (GE)	Low subsidy (balanced)**
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output, $\sum_j p_j Y_j$	1.936	2.11	1.995	1.999
Real Output† , $\sum_j p_j^* Y_j$	1.936	1.958	1.817	1.734
Non-agricultural Good, y_n	1.446	1.706	1.415	1.277
Cash Crop, y_r	0.147	0.072	0.126	0.137
Staple Crop, y_s	0.221	0.117	0.176	0.205
Rations, c^{ration}	0.0576	0.007	0.057	0.061
Intermediate input demand, $k_s + k_r$	0.118	0.031	0.069	0.085
Capital demand, k_n	4.2	4.96	4.15	3.77
Labour productivity of non-agri sector‡	3.45	3.058	3.549	3.82
Labour productivity of agricultural sector	0.844	0.571	0.669	0.686
Labour productivity of cash crop sector	0.597	0.402	0.479	0.48
Labour productivity of staple crop sector	0.661	0.445	0.521	0.541
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	1.272	1.272	1.862	1.991
Staple Crop, p_s	1.372	1.372	1.96	2.185
Support Price, $\bar{p}$	1.467	1.467	2.097	2.337
Interest rate, r	0.017	0.017	0.0159	0.0153
Wage, w	1.143	1.143	1.149	1.152
Employment Shares				
Non-agricultural Sector	0.42	0.558	0.399	0.335
Cash Crop Farmers	0.246	0.178	0.263	0.286
Staple Crop Farmers	0.334	0.264	0.338	0.379

Note: *In the low subsidy exercises, we double the price of input, p_k, from 1.56 to 3.12
**For this exercise we consider income transfers to all agents that amount to government expenditure on the input subsidy program in the benchmark equilibrium
†p^* represents prices in the benchmark
‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

agricultural production falls, driven mainly by the lower employment in that sector, which also lowers capital demand despite the slight decline in interest rates.

The labour productivity of the non-agricultural sector is higher than the benchmark due to the reduction in the share of non-agricultural workers. Labour productivity in the cash and staple crop sectors decline by around 20% because of the substantial decrease in intermediate input usage. APG rises by 30%, driven by significant fall in agricultural production and limited sectoral reallocation of labour [26].

[26] Recall that APG = $\frac{y_n}{p_s^* y_s + p_r^* y_r} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}}$. Hence, a reduction in the non-agricultural employment share coupled with the fall in agricultural production leads to greater APG.

The final column of Table 6 compensates for the reduction in the input subsidy with *budget-equivalent* income transfers to all agents in the economy: the total amount available for disbursal is the expenditure of the government on the input subsidy, $p_k k^a$, where k^a represents aggregate intermediate input usage by farmers. This shall also be referred to as a balanced budget transfer policy.

We note that income transfers, by boosting the resources of agents, boost spending, agricultural production and crop prices relative to the low subsidy counterfactual in column 3. The fall in real output is primarily due to a large reduction in savings and capital demand, even though aggregate consumption rises. Note that crop prices rise even more relative to the benchmark ($\sim$ 60%) than they do when the reduced subsidy isn't compensated ($\sim$ 40%), as the income transfer induces a positive demand effect that supplements the crop price increase required to incentivize agricultural production. The striking increase in crop prices lowers the non-agricultural employment share by 8.5 pp below its benchmark economy. Labour productivity in the non-agricultural sector rises sizably, driven by the fall in non-agricultural employment. On the other hand, labour productivity in the agricultural sector falls relative to the benchmark but is higher than when the lower subsidy is not compensated because the higher crop prices boost intermediate input usage and crop production enough to overcome the rise in agricultural employment. The APG widens significantly relative to the benchmark (by 36.5%) as well as relative to the uncompensated GE value in column 3 (by 5%)[27].

The rise in APG is substantial (30%) when input subsidies are increased by 100%. Appendix Table B4 demonstrates that APG increases by 9.3% and 16.9% relative to the benchmark economy when input prices are raised by 25% and 50%, respectively. Furthermore, APG increases even more in each scenario when the reduction in input subsidy is replaced with budget-equivalent income transfers.

5.3.1 Discussion of the impact of input subsidies on APG

Our findings on the APG resulting from the reduction in the input subsidy are partially aligned with those of Mazur and Tetenyi (2023). Like their study, we find that input subsidies enhance output and labor productivity in the agricultural sector. However, in contrast to their results, our model indicates that an increase in input subsidies *reduces* the productivity gap between the

[27] Large-scale fiscal transfers can be recessionary in an environment with incomplete asset markets (Aiyagari & McGrattan, 1998).

agricultural and non-agricultural sectors. This difference arises because our model predicts an increase in non-agricultural employment following the introduction of input subsidies, a result not observed in Mazur and Tetenyi (2023).

The model environment in their paper differs in many aspects from the one presented above, but one crucial difference is that transaction costs associated with staple crop purchases increase the price of purchasing staples relative to producing them[28]. This generates a high proportion of unproductive staple farmers and a large APG[29]. An input subsidy further distorts this margin leading to a rise in agricultural employment and APG. This is unlikely to be a relevant channel in the Indian context as the government provides staples as in-kind transfers to households, diminishing farmers' incentives to produce staple crops (Gadenne, 2020; Li, 2023). This mechanism would also be less applicable in many other developing countries, as 44% of safety net recipients in the world benefit from in-kind transfers (Honorati et al., 2015). Furthermore, consistent with the predictions of our model, Diop (2022) finds an increase in migration to urban areas following a large-scale input subsidy program in Zambia.

5.4 Welfare

In this section, we discuss the effect of each agricultural policy on welfare. The welfare measure that we use in this paper is based on Buera and Shin (2011), which is an aggregate consumption equivalent measure. The welfare cost reported is in units of permanent consumption compensation necessary to make an individual of each type (workers, staple crop farmers, and cash crop farmers) indifferent between the status quo (the benchmark stationary equilibrium) and the counterfactual equilibrium. Appendix Section D.3 provides details on the construction of the welfare measure.

Consider first the effect on consumer welfare entailing removing the MSP in column 1 of Table 7). Noting from the previous discussion (Section 5.2.1) of removing MSP including rations, a policy that removes rations without compensating agents by means of an alternative policy (such as an income transfer) is reduces welfare significantly. Furthermore, welfare losses are

[28] Mazur and Tetenyi (2023) permit cash crop farmers to allocate shares of their land toward both crops and correlated shocks across rural and urban areas. However, their environment does not feature crop-specific taste shocks.

[29] Mazur and Tetenyi (2023) also point out that the fixed transaction cost implies perfect competition among intermediaries. Chatterjee (2023) presents evidence of substantial intermediary market power in Indian agriculture, while Bergquist and Dinerstein (2019) and Casaburi and Reed (2022) offer similar findings for Kenya and Sierra Leone. Incorporating market power through a fixed reduction in price received as a farmer will not change the logic of our arguments.

Table 7: Welfare changes under counterfactual policies

Group	No MSP	No MSP (balanced)	No MSP (in-kind)	Higher p_k	Higher p_k (transfer)	Higher p_k (fixed ration)
	(1)	(2)	(3)	(4)	(5)	(6)
Workers	12%	–0.6%	–0.6%	12.6%	–12.4%	–11.8%
Staple crop farmers	14.7%	–0.7%	–0.7%	9.8%	–17.5%	–16.9%
Cash crop farmers	14.4%	–0.7%	–0.7%	10.1%	–17.1%	–16.5%

greater for farmers than workers, as real wages rise when MSP is removed.

A more reasonable comparison is with welfare in environments where the MSP is replaced with budget equivalent transfers[30]. We begin by considering income transfers to all agents in the economy, where the total amount available for disbursal is the expenditure of the government on procurement, $\bar{p} * c^{\text{ration}}$. Column 2 of Table 7 shows that there are small welfare gains from replacing the MSP program with an income transfer. These gains arise from the increase in consumption, primarily of the non-agricultural good, by all groups following the transfer relative to the benchmark equilibrium, due to non-homothetic preferences[31].

A replacement policy that is a natural contrast to income transfers is a balanced budget program that uses the amount spent on the MSP program to purchase staple crops on the open market that are then disbursed to all agents as rations: an *in-kind* transfer policy. Column 3 of Table 7 shows that this also results in welfare gains compared to the no MSP counterfactual (column 1), suggesting that the provision of rations or in-kind transfers is valued by agents. Equilibrium outcomes are virtually identical in the in-kind and income transfer budget-equivalent programs of MSP removal, as agents offset the loss of rations by purchasing staples using the transfers.

The second counterfactual we consider is a reduction of the input subsidy (specifically, a doubling of the price p_k), keeping the MSP policy in place. Noting from Table 6 that the real income of farmers falls and prices of all crops rise significantly in the counterfactual that reduces the input subsidy, the welfare of all agents falls in the counterfactual economy (column 5 of Table 7). Welfare losses are higher for workers than farmers when input subsidy is reduced because the rise in real wage is significantly smaller than the increase in crop prices and farmer

[30] Appendix Table B5 shows the equilibrium outcomes under these alternative policies

[31] Aggregate consumption by occupation and good across the benchmark, two counterfactuals corresponding to support price removal and subsidy reduction, and the corresponding income transfer replacement policies are listed in Appendix Table B7 in the appendix. Note that while non-agricultural output declines slightly when the support price is replaced by a budget-equivalent income transfer, as seen in column 4 of Table 5, this decline is driven by a fall in saving and rise in aggregate consumption (column 3 of Appendix Table B7).

incomes.

A budget-equivalent policy with the reduction in input subsidy offset with income transfers results in welfare gains for all agents relative to the status quo. The higher transfers boosts farmer income due to higher crop prices leading to higher consumption by farmers relative to their benchmark levels, as shown in column 5 of Appendix Table B7. However, aggregate consumption of workers' declines as the transfers do not adequately offset the rise in crop prices. Note that the welfare measure characterizes agents by their occupation in the benchmark economy. Many workers in the benchmark equilibrium sort into agriculture in the budget-equivalent income transfer equilibrium, wherein their incomes are higher, which is accounted for while computing the welfare gains.

A final alternative policy we consider that acts as a replacement when the input subsidy is reduced is to retain budget equivalent income transfers but keep the quantity of rations disbursed fixed at the benchmark equilibrium level of 0.0577. Equilibrium outcomes under this alternative are listed in column 3 of Appendix Table B6. The fixed rations policy essentially keeps equilibrium outcomes unchanged relative to the reduced subsidy with income transfers counterfactual. Hence, this leads to welfare gains relative to the benchmark, and they are slightly lower than the income transfer budget balanced policy due to lower rations.

5.4.1 Variation with assets

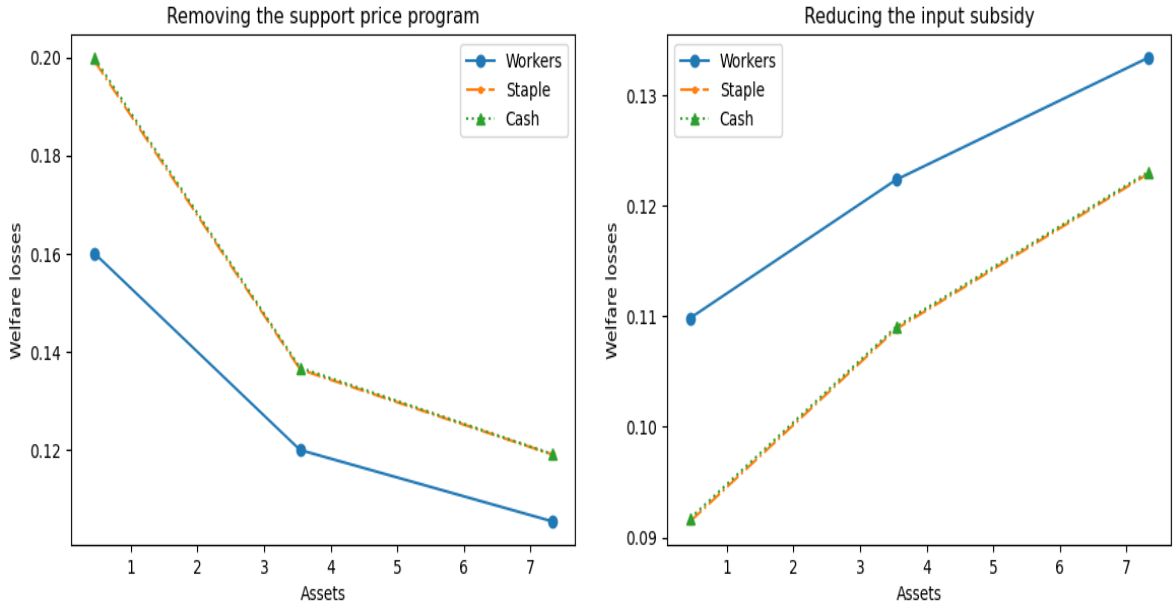
We compute the consumption equivalent variation measure of welfare loss relative to the benchmark equilibrium at three asset levels (low, medium, and high) for the equilibrium arising from either the removal of the support price program or the reduction of the input subsidy. At each asset level, the mean employment fractions by sector and crop (summing up to 1 at each asset level) are depicted in Appendix Figure A10. This figure shows that sectoral choices at low asset levels are driven by the working capital constraint in the agricultural sector, while agents at higher asset levels are less risk-averse and are more willing to choose farming, particularly for relatively low draws of the sectoral productivity shocks.

Figures 4a and 4b depict that both policy changes result in welfare losses for all agents in the absence of a compensatory scheme such as an income or in-kind transfer. The near alignment of welfare losses for farmers of both crops stems from the assumption that crop choice is driven by a taste shock for farmers facing a crop-independent agricultural productivity shock.

Welfare losses differ substantially by asset levels, but the variation in welfare losses by as-

set levels for any given occupation is much smaller in magnitude with the reduction in input subsidy than the removal of the MSP. Welfare losses are higher by 5 pp for for individuals with low assets compared to those with highest due to the loss of rations when MSP is removed, as shown in Figure 4a. Conversely, welfare losses are higher for agents with higher assets by around 2 pp compared with low assets, as the wealthier agents reduce consumption much more drastically than asset-poor individuals (Figure 4b).

Figure 4: Welfare losses by asset levels and occupations



(a) Removal of MSP

(b) Removal of input subsidy

5.5 Welfare-enhancing and APG improving policies

In Section 5.1, we found that the fixed cost (ξ) of operating in the non-agricultural sector and changes in intermediate input use due to lower risk were the largest contributors to the APG. Given that these are the main drivers of the APG, the MSP program has a limited effect on these frictions and on the APG, as demonstrated in Section 5.2. The input subsidy program has a substantial impact on the APG, but replacing the reduction in input subsidies with uniform budget-equivalent income transfers yields higher welfare. However, such uniform transfers exacerbate the APG by reducing employment in the non-agricultural sector. Furthermore, higher crop prices lead to a lower non-agricultural employment share, further increasing the APG. This suggests that a budget-equivalent income transfer policy targeted at reducing mobility frictions would decrease the APG and generate welfare gains compared to the benchmark

economy. Such a policy could be interpreted as a conditional cash transfer, available to agents choosing the non-agricultural sector, in a manner similar to the migration subsidies examined in Bryan, Chowdhury, and Mobarak (2014) and Lagakos et al. (2023).

We briefly explore this idea through a couple of policy exercises. First, we consider a budget-equivalent income transfer program that allocates 60% of the amount spent on the MSP program to agents choosing the non-agricultural sector, with the remainder offered to farmers[32]. As expected, this increases the non-agricultural employment share by 1.1 pp relative to its benchmark equilibrium value. It also reduces the APG by approximately 5%, while resulting in welfare gains of about 0.8% across occupations. However, a similarly weighted income transfer program for agents in the non-agricultural sector does not reduce the APG, as crop prices rise by nearly 70%, offsetting the movement of agents away from agriculture.

These results illustrate that replacement policies aimed at increasing welfare and reducing the APG need to incentivize agents to transition to the non-agricultural sector.

6 Empirical validation of model counterfactuals

In this section, we present empirical evidence that supports the model's predictions. First, we illustrate the effect of a reduction in input subsidies and then the impact of MSP on agricultural production.

6.1 Input subsidy

The model predicts that a reduction in input subsidy will substantially reduce agriculture output and increase prices of both staple and cash crops. To validate the predictions of the model relating to a reduction in input subsidies, we exploit the deregulation of key fertilizers from its cost of production by the government in 2010 (Garg & Saxena, 2022). Garg and Saxena (2022) document that the policy led to price of non-urea fertilizers increasing by more than 100% and a significant reduction in their use.

Though, the policy is at the national level, districts differed in their exposure to the policy due to the intensity of using fertilizers. Garg and Saxena (2022) demonstrate that the reduction in input subsidy induced by the policy reduced agricultural production more post-2010 in areas that used fertilizers more intensely before the policy. We employ a continuous difference-in-

[32] Equilibrium outcomes from some of these conditional transfers are reported in Appendix Table B8.

differences (DiD) framework to analyze the effect of the policy.

$$\begin{aligned} Y_{dt} &= \alpha + \phi_d + \phi_t + \beta \times \text{Treatment intensity}_d \times \text{Post}_t \\ &+ \beta^{-1} \times \text{Treatment intensity}_d \times \text{Pre}_t + \gamma X_{dt} + \varepsilon_{dt} \end{aligned} \tag{19}$$

where, Y_{dt} is the outcome of district d at time t, Post_t is an indicator for treatment periods (2010-2016), Pre_t is an indicator for pre-treatment periods (2004-2008), ϕ_d and ϕ_t are district and period dummies, respectively. Treatment intensity is defined as the logarithm of 1 plus the fertilizer use at the district level to minimize the influence of areas with extremely large or small fertilizer use[33]. X_{dt} includes the logarithm of annual rainfall to account for productivity changes unrelated to the policy. β and β^{-1} measure the effect of higher use of fertilizers in the treatment and pre-treatment periods relative to the omitted period (2009), respectively[34].

The main outcomes of interest are output and price of staple and cash crops. The Ministry of Agriculture & Farmers Welfare provides district-crop-level data on output, yield and area sown covering 20 major Indian states over time. Agriculture output is computed as the price weighted average of crop output[35]. Staple crops includes cereals and pulses, whereas cash crops includes oilseeds, fibre crops, sugarcane and tobacco. Moreover, district-level data on crop prices comes from ICRISAT.

Column 1 of Table 8 shows that agricultural output fell more in areas that experienced a greater reduction in fertilizer subsidy, in line with Garg and Saxena (2022). This result is consistent with studies in other countries analyzing the impact of fertilizer subsidies on agricultural output (Beaman et al., 2013; Carter et al., 2021; Diop, 2022; Ghose et al., 2023). Columns 2 and 3 show that output of both cash and staple crops fell by similar magnitude in areas more exposed to the policy, respectively[36]. Lastly, the insignificant coefficients associated with the pre-treatment periods and treatment intensity imply a lack of significant pre-trends in output

[33] Fertilizer use at the district level is computed by taking a weighted average of non-urea fertilizer consumption per unit of cultivated area at the district level between 2004 and 2009. ICRISAT provides data on district-level fertilizer consumption, and the median price paid by a farmer in the Cost of Cultivation survey is used to compute fertilizer price. Appendix C contains more details about the construction of the measure.

[34] Appendix Figures A11a and A11b illustrate through a binned scatter plot that the reduction in average agricultural output and yield after the policy is substantially larger in districts that used fertilizers more intensely, which motivates this regression specification.

[35] An average price of each crop from 2004 to 2009 is used as weights after removing monthly seasonality and deflating by annual Consumer Price Index.

[36] Appendix Table B9 shows that most of the decrease in production of both crops can be accounted by the reduction in yield (production per unit of area). Appendix Figures A12 and A13 illustrate event-study estimates of output, yield and area for cash and staple crops, respectively. Overall, there are some pre-trends relating to the area and yield of staple crops, but the estimated post-treatment effects are much larger than the pre-treatment effects, which indicates that the interpretations of the empirical findings remain valid.

among areas with high and low fertilizer usage.

Table 8: Effect of fertilizer deregulation on agricultural production

Dependent variables: Log Output			
	All	Cash Crops	Staple Crops
	(1)	(2)	(3)
Post × Treatment Intensity	-0.29***	-0.27***	-0.28***
	(0.05)	(0.09)	(0.05)
Pre × Treatment Intensity	0.03	0.02	-0.02
	(0.06)	(0.11)	(0.06)
Observations	6552	6305	6552
R^2	0.94	0.94	0.92
Outcome Mean	20.04	18.47	19.44

Note: Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

Table 9 shows the results from applying a similar DiD framework on the log price of 16 agricultural crops, and separately for the group of staple and cash crops[37]. Column 1 shows that crop prices rose more in districts more exposed to the policy. Furthermore, columns 2 and 3 show that prices of both cash and staple crops rose more in areas with higher fertilizer use. The pre-treatment coefficient of staple crops is significant, but opposite in sign to the treatment effect. Hence, the conclusions of our empirical findings remain valid[38]. The empirical results align with the model's predictions that a reduction in input subsidy raises prices of agriculture goods due to general equilibrium forces. However, the empirical and model implied change in outcomes from an increase in input price are not directly comparable, as the estimated empirical β does not capture the *level* treatment effect of a policy in a continuous DiD setting (Callaway et al., 2024).

6.2 MSP

We will use two factors in our empirical approach to test the effect of price support on agricultural output. First, farmers know the support price because it is announced at the start of the

[37] The regression specification is:

$$Y_{cdt} = \alpha + \phi_{cd} + \phi_{ct} + \beta \times \text{Treatment intensity}_d \times \text{Post}_t + \beta^{-1} \times \text{Treatment intensity}_d \times \text{Pre}_t + \gamma X_{dt} + \varepsilon_{cdt}$$

where Y_{cdt} is price of crop c at time t in district d. Crops include cereals, pulses, oilseeds, sugarcane and cotton. Cash crops include oilseeds, sugarcane and cotton and rest are classified as staple crops.

[38] Appendix Figure A14 shows the event study estimates of all, cash and staple crops. A negative pre-treatment coefficient of staple crops in regions with greater fertilizer use is consistent with the notion that higher area is devoted to staple crops in these districts, as discussed before.

Table 9: Effect of fertilizer deregulation on agricultural prices

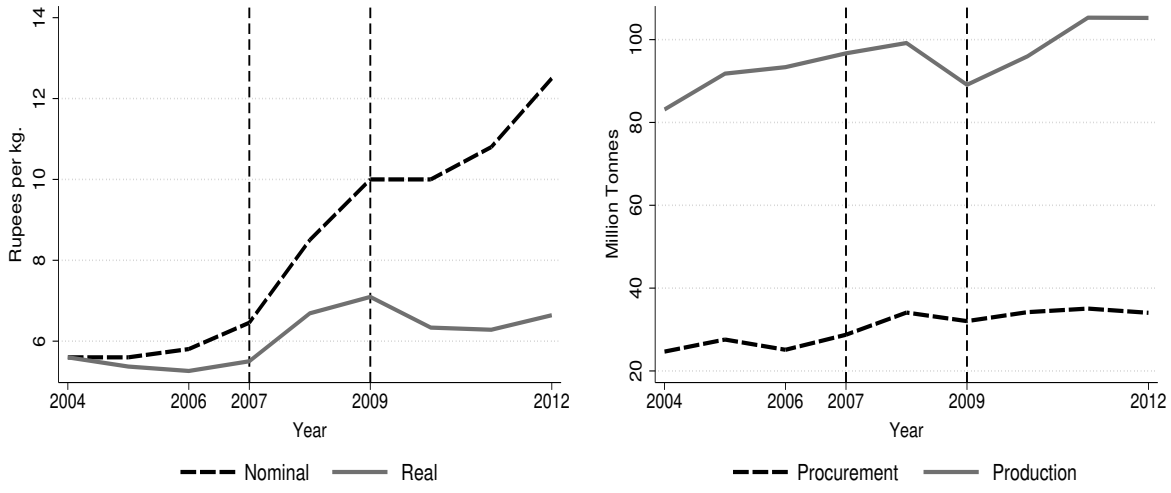
Dependent variables: Log Price			
	All	Cash Crops	Staple Crops
	(1)	(2)	(3)
Post × Treatment Intensity	0.08***	0.11***	0.07***
	(0.02)	(0.03)	(0.02)
Pre × Treatment Intensity	-0.03	0.00	-0.04*
	(0.02)	(0.03)	(0.02)
Observations	25194	8457	16737
R^2	0.93	0.76	0.90
Outcome Mean	7.01	7.58	6.72

Note: Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

cultivation season. Second, the quantity procured by the government varies at the state level.

Before 2007, though the support price of rice in nominal terms was rising, the support price in real terms had stagnated (Figure 5a). But, over reliance of imports during the global spike in international food prices (De Hoyos & Medvedev, 2011) and falling stocks of surplus grains (Saini & Gulati, 2016), led to higher support prices for three consecutive years (2007-2009). Consequently, rice production also increased during this period (Figure 5b).

Figure 5: Minimum Support Price and Production over time of Rice



(a) Nominal and Real MSP

(b) Quantity of Production and Procurement

Though, correlations at the national level may be confounded by many factors. To better address such concerns, we exploit the intensity of procurement across states that varies due to procurement infrastructure and political considerations. Appendix Figure A15 shows there

exists substantial variation in procurement across states between 2004 and 2006. On average, more than 50% of rice output is procured in states like Punjab and Haryana, where as a state like West Bengal procures less than 7% of its output even though it contributes to around 17% of India's rice production[39].

We employ a DiD framework to understand the effect of price support through variation in procurement intensity. The regression specification we use is:

$$\begin{aligned} Y_{dt} &= \alpha + \phi_d + \phi_t + \beta \times \text{Procurement intensity}_s \times \text{Post}_t \\ &+ \beta^{-1} \times \text{Procurement intensity}_s \times \text{Pre}_t + \gamma X_{dt} + \varepsilon_{dt} \end{aligned}$$

where, Post_t is an indicator for treatment periods (2007-2009), Pre_t is an indicator for pre-treatment periods (2004-2006) and $\text{Procurement intensity}_s$ is the average procurement in a state in the years before the increase in support price. The period of analysis is restricted until 2009 as support prices in real terms did not rise further and to prevent contaminating our analysis due to the fertilizer price deregulation program[40,41]. We control for the logarithm of annual rainfall and logarithm of irrigated area to account for trends by district-year that can influence agricultural production.

Table 10 shows the impact of a change in support price on output and area at the district level by intensity of procurement. The results show that states with a 10% higher procurement share, increased output and area sown of rice by 2% and 1%, respectively. Furthermore, we show in Appendix Table B10 that some of the higher output can be attributed to greater use of intermediate inputs. Using the nationally representative Cost of cultivation survey, Appendix Table B10 demonstrates that rice farmers used more labour (own and hired) and purchased more seeds in states with greater procurement after the increase in MSP. The empirical findings here are in line with other studies and the model's predictions that output subsidy for a crop induces greater output of that crop through higher employment and intermediate input use (Chatterjee et al., 2024; Krishnaswamy, 2018).

[39] The support price of wheat also rose between 2006 and 2008 (Saini & Gulati, 2016), but there is far lesser variation in procurement across states to causally estimate the effect of support price for wheat production.

[40] We drop Tamil Nadu and Rajasthan from the analysis as their procurement policy changed substantially during this period.

[41] Spillovers across state boundaries are unlikely to be a concern because Agriculture Produce and Marketing Committee (APMC) Acts restrict farmers from selling across state boundaries (Chatterjee, 2023).

Table 10: Effect of change in support price on rice output and area

Dependent variables: Log Output or Log Area		
	Output (tonne) (1)	Area (hectare) (2)
Post × Procurement Intensity	0.002**	0.001**
	(0.001)	(0.001)
Pre × Procurement Intensity	0.001	-0.001
	(0.001)	(0.000)
Observations	2538	2538
R^2	0.97	0.98
Outcome Mean	11.07	10.63

Note: Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

7 Conclusion

This article examines the productivity and welfare consequences of policies that provide output subsidies for staple crops and input price subsidies in the context of India. To do so, we develop a dynamic quantitative model featuring heterogeneous agents, mobility and financial frictions, and incomplete asset markets. The benchmark economy includes both input and output subsidies for the agricultural sector. Our results indicate that these policies impact the APG through distinct channels: *selection* and intermediate input use. Eliminating the MSP program modestly reduces the APG by reallocating labor away from the agricultural sector. In contrast, reducing the input subsidy significantly exacerbates the APG due to a sharp reduction in input use. These outcomes arise from the interaction of sectoral mobility, intermediate input usage, and crop price changes in GE following the policy change. The model results align with quasi-experimental evidence on the relationship between agricultural input and output subsidies and agricultural production.

Welfare gains arise when the support price and input subsidy programs are replaced with budget-neutral income or in-kind transfers; however, these policies do not reduce the APG relative to the benchmark economy. Counterfactual exercises reveal that reducing sectoral mobility frictions through targeted transfers to non-agricultural workers both lowers the APG and enhances welfare.

References

Adamopoulos, T., Brandt, L., Chen, C., Restuccia, D., & Wei, X. (2024). Land Security and Mobility Frictions. *The Quarterly Journal ofEconomics, 139*(3), 1941–1987.

Adamopoulos, T., & Restuccia, D. (2014). The size distribution of farms and international productivity differences. *American Economic Review, 104*(6), 1667–97.

Aiyagari, S. R., & McGrattan, E. R. (1998). The optimum quantity of debt. *Journal of Monetary Economics, 42*(3), 447–469.

Alizamir, S., Iravani, S. F., & Mamani, H. (2018). An analysis of price vs. revenue protection: Government subsidies in the agriculture industry. *Management Science, 65*(1), 32–49.

Artuç, E., Chaudhuri, S., & McLaren, J. (2010). Trade shocks and labor adjustment: A structural empirical approach. *American economic review, 100*(3), 1008–1045.

Balani, S. (2013). *Functioning of the public distribution system: An analytical report* (Tech. Rep.). New Delhi: PRS Legislative Research.

Banerjee, A. V., & Duflo, E. (2011). *Poor economics: A radical rethinking of the way to fight global poverty*. New York: PublicAffairs.

Barrett, C. B. (2002). Food security and food assistance programs. *Handbook of agricultural economics, 2*, 2103–2190.

Beaman, L., Karlan, D., Thuysbaert, B., & Udry, C. (2013). Profitability of fertilizer: Experimental evidence from female rice farmers in mali. *American Economic Review, 103*(3), 381–86.

Bergquist, L. F., & Dinerstein, M. (2019). Competition and entry in agricultural markets: Experimental evidence from kenya. *American Economic Review, 110*(12), 3705–3747.

Bergquist, L. F., Faber, B., Hoelzlein, M., Miguel, E., & Rodriguez-clare, A. (2019). Scaling Agricultural Policy Interventions : Theory and Evidence from Uganda. *NBER Working Paper 30704*.

Bolhuis, M. A., Rachapalli, S. R., & Restuccia, D. (2021). Misallocation in indian agriculture. *NBER Working Paper 29363*.

Boppart, T., Kiernan, P., Krusell, P., & Malmberg, H. (2023). The macroeconomics of intensive agriculture. *NBER WP 31101*.

Bryan, G., Chowdhury, S., & Mobarak, A. M. (2014). Underinvestment in a profitable technology: The case of seasonal migration in bangladesh. *Econometrica, 82*(5), 1671–1748.

Buera, F. J., Kaboski, J. P., & Shin, Y. (2011). Finance and development: A tale of two sectors. *American economic review*, *101*(5), 1964–2002.

Buera, F. J., Kaboski, J. P., & Shin, Y. (2021). The macroeconomics of microfinance. *The Review of Economic Studies*, *88*(1), 126–161.

Buera, F. J., Kaboski, J. P., & Townsend, R. M. (2023). From micro to macro development. *Journal of Economic Literature*, *61*(2), 471–503.

Buera, F. J., & Shin, Y. (2011). Self-insurance vs. self-financing: A welfare analysis of the persistence of shocks. *Journal of Economic Theory*, *146*(3), 845–862.

Callaway, B., Goodman-Bacon, A., & Sant'Anna, P. H. (2024). Difference-in-Differences with a Continuous Treatment. *NBER Working Paper 32117*. doi: 10.2139/ssrn.4716683

Carter, M., Laajaj, R., & Yang, D. (2021). Subsidies and the african green revolution: Direct effects and social network spillovers of randomized input subsidies in mozambique. *American Economic Journal: Applied Economics*, *13*(2), 206–29.

Casaburi, L., & Reed, T. (2022). Using individual-level randomized treatment to learn about market structure. *American Economic Journal: Applied Economics*, *14*(4), 58–90.

Caselli, F. (2005). Accounting for cross-country income differences. *Handbook of economic growth*, *1*, 679–741.

Caunedo, J., & Keller, E. (2021). Capital obsolescence and agricultural productivity. *The Quarterly Journal of Economics*, *136*(1), 505–561.

CEDA. (2023). *CEDA Agri Market Data (CEDA-AMD), 2000-2023, Centre for Economic Data & Analysis, Ashoka University*. Retrieved from https://ceda.ashoka.edu.in/agmarknet

Chancel, L., Piketty, T., Saez, E., & Zucman, G. (2022). *World inequality report 2022*. Harvard University Press.

Chatterjee, S. (2023). Market power and spatial competition in rural india. *The Quarterly Journal of Economics*, *138*(3), 1649–1711.

Chatterjee, S., & Kapur, D. (2016). Six Puzzles in Indian Agriculture. *India Policy Forum*.

Chatterjee, S., Krishnamurthy, M., Kapur, D., & Bouton, M. (2020). A study of the agricultural markets of bihar, odisha and punjab. final report. *Center for the Advanced Study of India, University of Pennsylvania*.

Chatterjee, S., Lamba, R., & Zaveri, E. D. (2024). The role of farm subsidies in changing india's water footprint. *Nature Communications*, *15*, 8654.

Currie, J., & Gahvari, F. (2008). Transfers in cash and in-kind: Theory meets the data. *Journal*

of economic literature, *46*(2), 333–383.

De Hoyos, R. E., & Medvedev, D. (2011). Poverty effects of higher food prices: a global perspective. *Review of Development Economics*, *15*(3), 387–402.

Deininger, K., Jin, S., & Nagarajan, H. K. (2008). Efficiency and equity impacts of rural land rental restrictions: Evidence from india. *European Economic Review*, *52*(5), 892-918.

Demirdögen, A., Olhan, E., & Chavas, J.-P. (2016). Food vs. fiber: An analysis of agricultural support policy in turkey. *Food Policy*, *61*, 1–8.

Diop, B. Z. (2022). Upgrade or migrate: The consequences of input subsidies on household labor allocation. *Working Paper*.

Donovan, K. (2021). The equilibrium impact of agricultural risk on intermediate inputs and aggregate productivity. *The Review of Economic Studies*, *88*(5), 2275–2307.

Donovan, K., Lu, W. J., & Schoellman, T. (2023). Labor market dynamics and development. *The Quarterly Journal of Economics*, *138*(4), 2287–2325.

Egger, D., Haushofer, J., Miguel, E., Niehaus, P., & Walker, M. (2022). General equilibrium effects of cash transfers: experimental evidence from kenya. *Econometrica*, *90*(6), 2603–2643.

Foster, A. D., & Rosenzweig, M. R. (2022). Are there too many farms in the world? labor market transaction costs, machine capacities, and optimal farm size. *Journal of Political Economy*, *130*(3), 636–680.

Gadenne, L. (2020). Can rationing increase welfare? theory and an application to india's ration shop system. *American Economic Journal: Economic Policy*, *12*(4), 144–177.

Gadenne, L., Norris, S., Singhal, M., & Sukhtankar, S. (2024). In-kind transfers as insurance. *American Economic Review*, *114*(9), 2861–2897.

Garg, S., & Saxena, S. (2022). Redistribution through prices in indian agricultural markets. *Working Paper*.

Gaulier, G., & Zignago, S. (2010). *Baci: International trade database at the product-level. the 1994-2007 version* (Working Papers No. 2010-23). CEPII. Retrieved from https://www.cepii.fr/CEPII/fr/publications/wp/abstract.asp?NoDoc=2726

Ghose, D., Fraga, E., & Fernandes, A. (2023). Fertilizer Import Bans, Agricultural Exports, and Welfare Evidence from Sri Lanka. *World Bank Policy Research Working Paper 10642*.

Ghosh, P., & Vats, N. (2022). Safety nets, credit, and investment: Evidence from a guaranteed income program. *SSRN 4265112*.

Gollin, D., & Kaboski, J. P. (2023). New views of structural transformation: insights from recent literature. *Oxford Development Studies, 51*(4), 339–361.

Gollin, D., Lagakos, D., & Waugh, M. E. (2014a). Agricultural productivity differences across countries. *American Economic Review, 104*(5), 165–70.

Gollin, D., Lagakos, D., & Waugh, M. E. (2014b). The agricultural productivity gap. *The Quarterly Journal of Economics, 129*(2), 939–993.

Hebebrand, C., & Glauber, J. W. (2023). The russia-ukraine war after a year: Impacts on fertilizer production, prices, and trade flows. In *Ifpri book chapters* (pp. 1–8). International Food Policy Research Institute (IFPRI).

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2014). Growth and structural transformation. In *Handbook of economic growth* (Vol. 2, pp. 855–941). Elsevier.

Holden, S. T. (2019). Economics of farm input subsidies in africa. *Annual Review of Resource Economics, 11*(1), 501–522.

Honorati, M., Gentilini, U., & Yemtsov, R. G. (2015). *The state of social safety nets 2015* (Tech. Rep.). Washington, DC: World Bank.

Hsieh, C.-T., & Klenow, P. J. (2009). Misallocation and manufacturing tfp in china and india. *The Quarterly Journal of Economics, 124*(4), 1403–1448.

India Data Portal. (2024, May 7). *Datasets.* Retrieved from https://www.indiadataportal.com (Retrieved May 7, 2024, from India Data Portal (INDIA DATA PORTAL))

Inklaar, R., Marapin, R., & Gräler, K. (2023). *Tradability and sectoral productivity differences across countries.* (GGDC Research Memorandum 195)

Jayne, T. S., Mason, N. M., Burke, W. J., & Ariga, J. (2018). Taking stock of africa's second-generation agricultural input subsidy programs. *Food Policy, 75*, 1–14.

Krishnaswamy, N. (2018). At what price? price supports, agricultural productivity, and misallocation. *Working paper*.

Lagakos, D., Mobarak, A. M., & Waugh, M. E. (2023). The welfare effects of encouraging rural–urban migration. *Econometrica, 91*(3), 803–837.

Lagakos, D., & Waugh, M. E. (2013). Selection, agriculture, and cross-country productivity differences. *American Economic Review, 103*(2), 948–80.

Li, N. (2023). In-kind transfers, marketization costs and household specialization: Evidence from Indian farmers. *Journal of Development Economics, 164*, 103130.

Lichtenberg, E., & Zilberman, D. (1986). The welfare economics of price supports in us agri-

culture. *American Economic Review*, *76*(5), 1135–1141.

Manysheva, K. (2022). Land property rights, financial frictions, and resource allocation in developing countries. *Working Paper*.

Mazur, K., & Tetenyi, L. (2023). The macroeconomic impact of agricultural input subsidies. *Working Paper*.

McArthur, J. W., & McCord, G. C. (2017). Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of development economics*, *127*, 133–152.

McFadden, D. (1973). Conditional logit analysis of qualitative choice behavior. *Frontier in Econometrics*.

Mobarak, A. M., & Rosenzweig, M. R. (2013). Informal Risk Sharing, Index Insurance, and Risk Taking in Developing Countries. *American Economic Review: Papers & Proceedings*, *103*(3), 375–380.

Monari, L. (2002). *Power subsidies: A reality check on subsidizing power for irrigation in india* (No. 244). Washington, D.C..

Mongey, S., & Waugh, M. E. (2024). Discrete choice, complete markets, and equilibrium. *NBER Working Paper No. 32135*.

Moscona, J. (2023). Agricultural development and structural change, within and across countries. *Working Paper*.

Muralidharan, K., & Niehaus, P. (2017). Experimentation at scale. *Journal of Economic Perspectives*, *31*(4), 103–124.

Pietrobon, D. (2024). The dual role of insurance in input use: Mitigating risk versus curtailing incentives. *Journal of Development Economics*, *166*, 103203.

Ramaswami, B. (2019). *Agricultural subsidies* (Tech. Rep.). New Delhi: Study Prepared for the XV Finance Commission.

Restuccia, D., & Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic dynamics*, *11*(4), 707–720.

Restuccia, D., & Rogerson, R. (2013). Misallocation and productivity: Editorial. *Review of Economic Dynamics*, *16*(1), 1–10.

Restuccia, D., & Rogerson, R. (2017). The Causes and Costs of Misallocation. *Journal of Economic Perspectives*, *31*(3), 151–74.

Restuccia, D., Yang, D. T., & Zhu, X. (2008). Agriculture and aggregate productivity: A quantitative cross-country analysis. *Journal of Monetary Economics*, *55*(2), 234–250.

Rodríguez-Sala, A. (2023). Essays on risk, insurance, and economic development. *Doctoral Dissertation Universitat Autònoma de Barcelona*.

Saini, S., & Gulati, A. (2016). India's food security policies in the wake of global food price volatility. In B. Johnston & J. Swinnen (Eds.), *Food price volatility and its implications for food security and policy* (pp. 331–352). Springer.

Sengupta, R. (2024). *Agricultural subsidies in india: A critical balancing act* (Tech. Rep.). International Institute for Sustainable Development (IISD). Retrieved from https://www.iisd.org/articles/policy-analysis/agricultural-subsidies-india

Varshney, D., Kumar, A., Mishra, A. K., Rashid, S., & Joshi, P. K. (2021). India's covid-19 social assistance package and its impact on the agriculture sector. *Agricultural Systems*, *189*, 103049.

Appendix

A Additional Figures

Figure A1: Employment shares across sectors in rich and poor countries

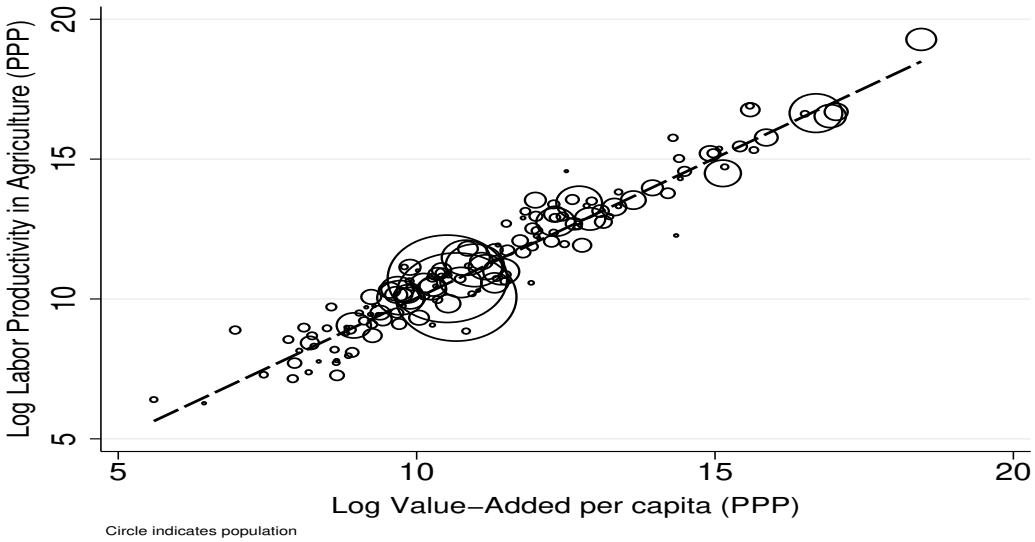


Figure A2: Employment shares across sectors in rich and poor countries

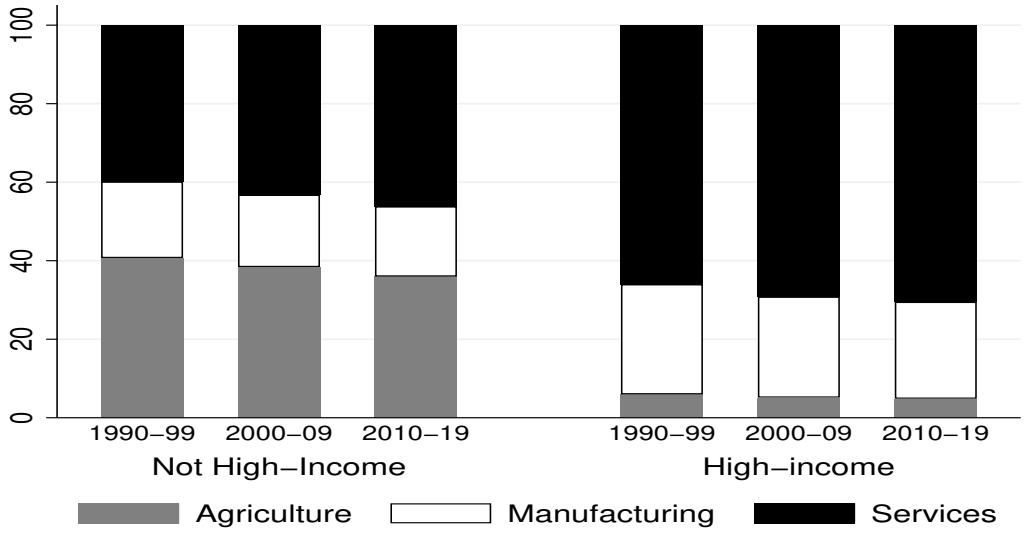
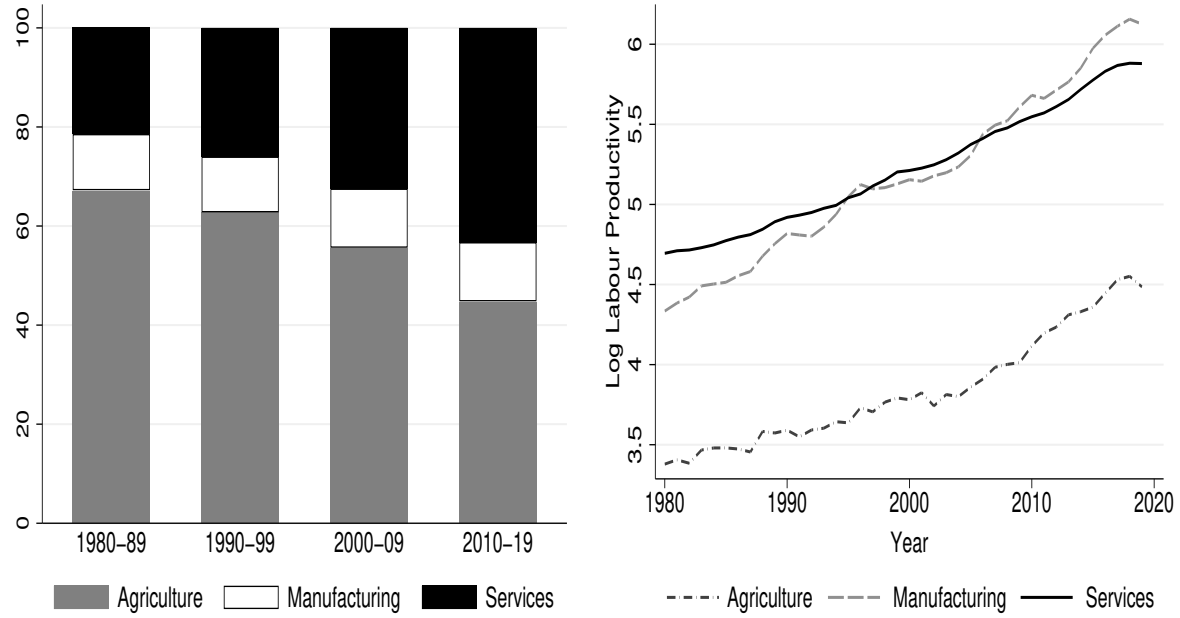


Figure A3: Employment shares and labour productivity in India by sectors



(a) Employment Shares

(b) Labour Productivity

Note: Data on sectoral employment shares and value added were sourced from the RBI India KLEMS Database.

Figure A4: Growth in value added by sectors in India

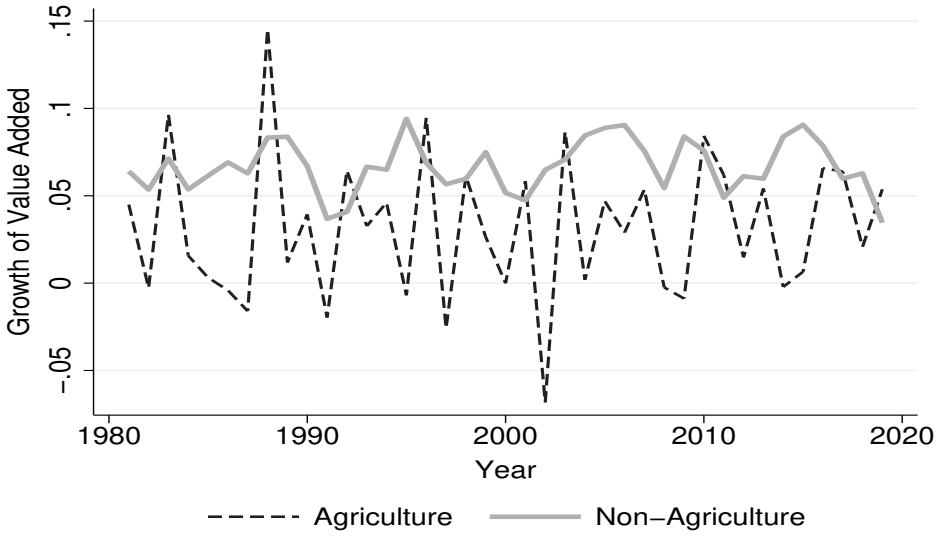
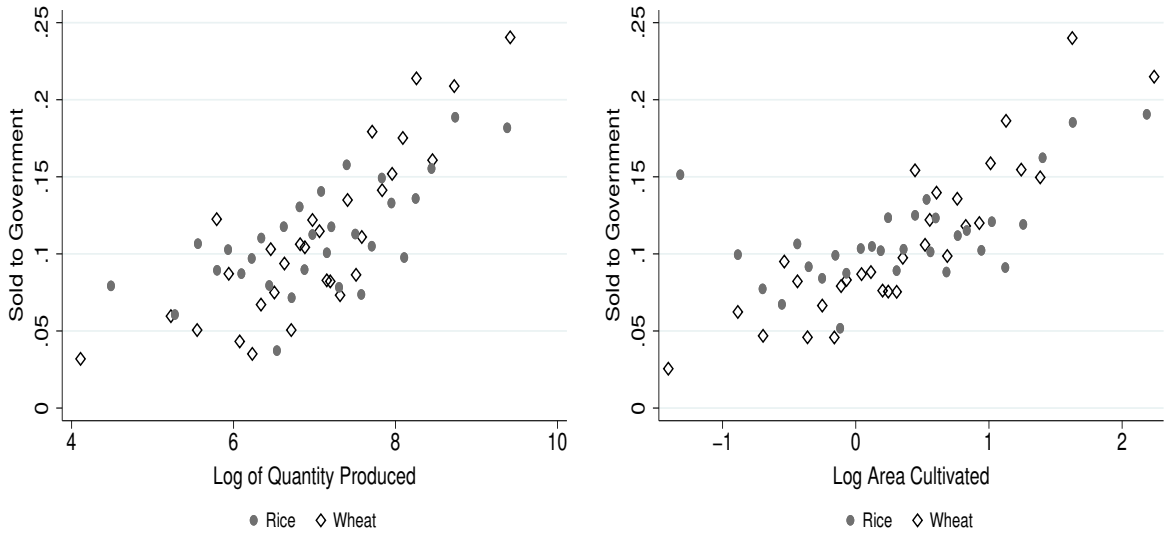


Figure A5: Incomplete penetration of MSP: controlling for state fixed effects

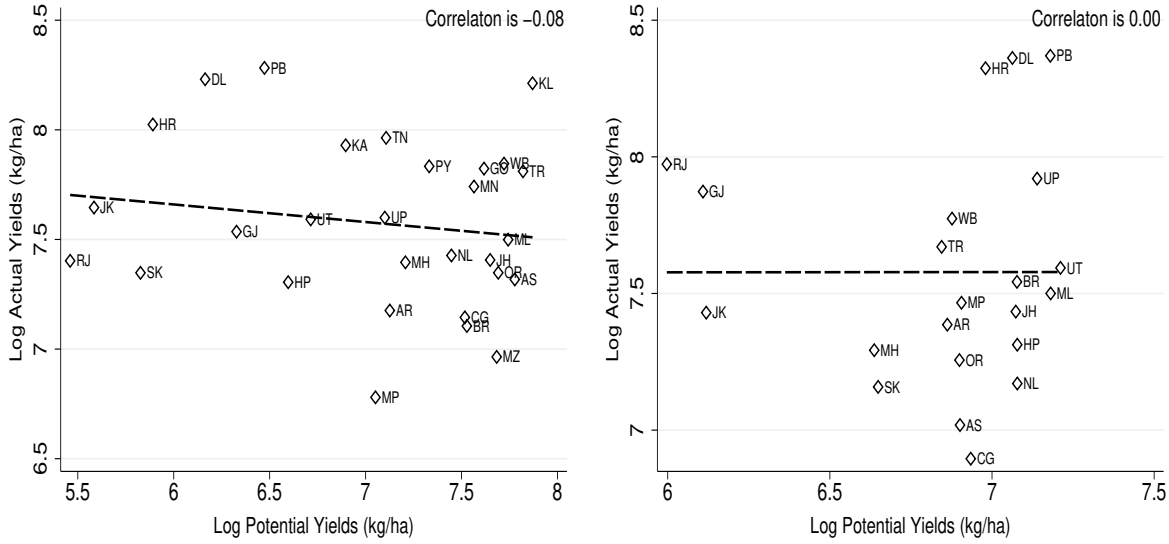


(a) Log quantity produced

(b) Log area cultivated

Note: The y-axis is an indicator variable taking the value 1 if output sold to a government agency. The x-axis is log quantity produced and log total area cultivated for left- and righ-hand side, respectively. Both plots control for state dummies and use 30 quintiles for each crop. The figure uses the Land and Livestock Survey of 77th NSS Round.

Figure A6: Relationship between actual and potential yield for rice and wheat across Indian states

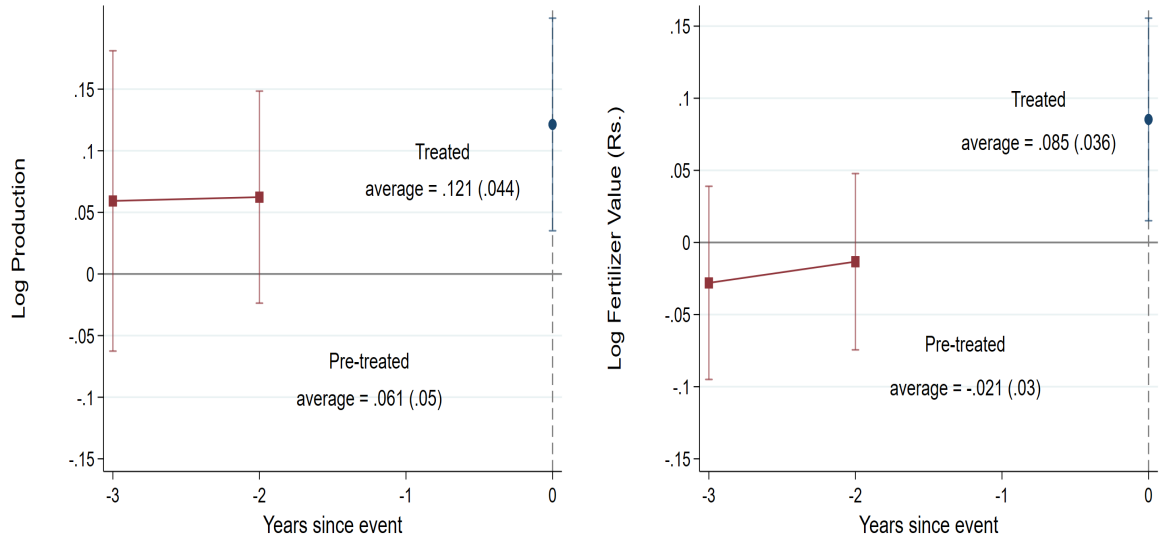


(a) Rice

(b) Wheat

Note: Data on actual and potential yield are from Reserve Bank of India Handbook of Statistics on Indian States and GAEZ FAO, respectively. Actual and potential yield are averaged between 2004 and 2009 for each state. Standard errors are robust to heteroscedasticity.

Figure A7: Effect on log output and log fertilizer consumption to cash transfer program



(a) Output (b) Fertilizer

Note: Figure reports treatment and pre-treatment effect averages and 95% confidence intervals in response to the cash transfer program. Standard errors in parentheses are clustered at the district level.

Figure A8: Distribution of market price of rice and wheat to MSP

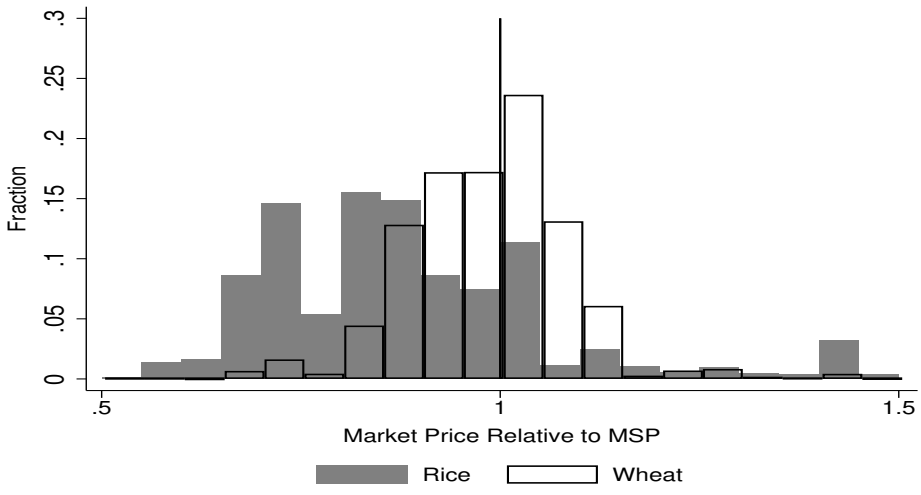


Figure A9: Distribution of the share of area devoted to staple crops

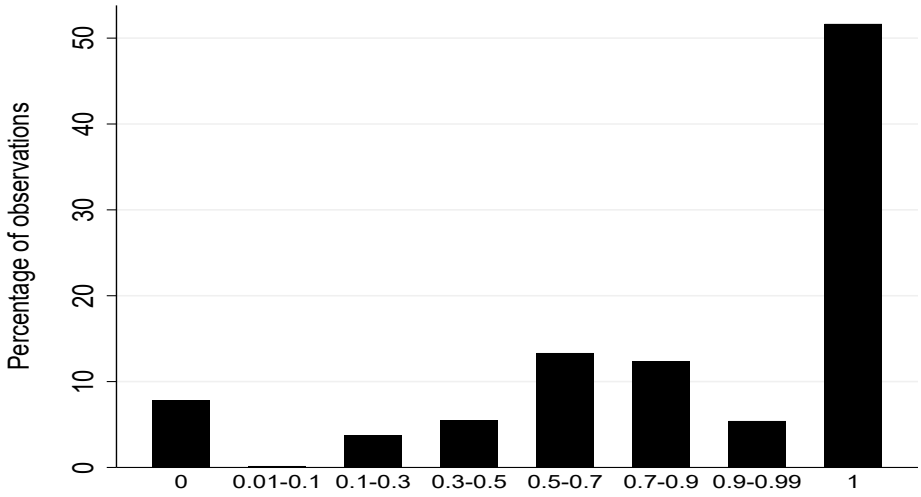


Figure A10: Sectoral employment fractions: variation across asset levels

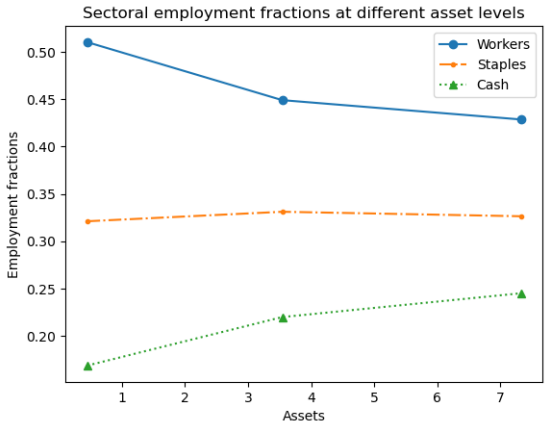
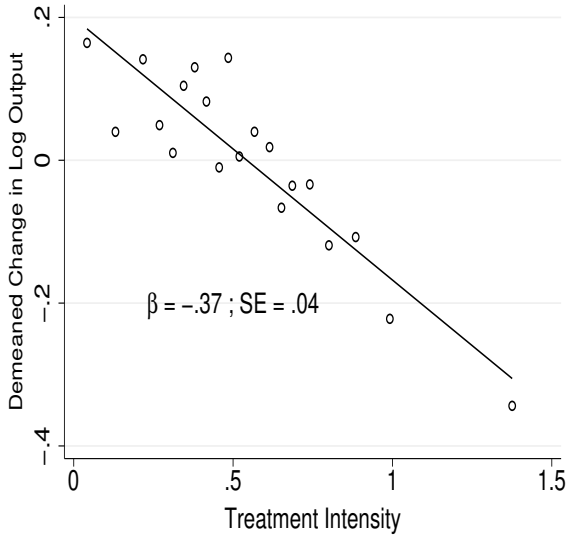
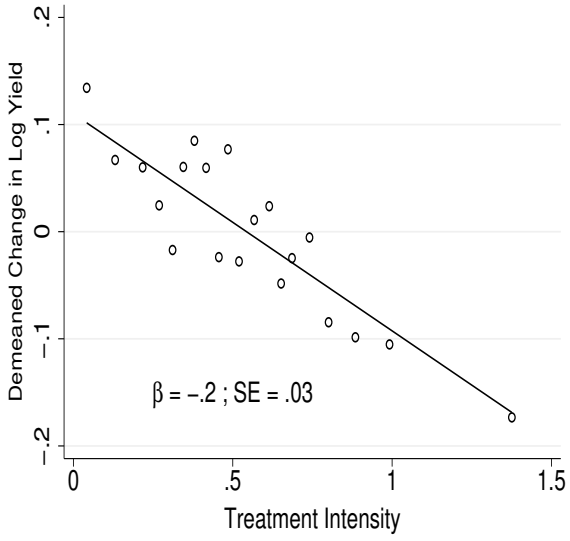


Figure A11: Binscatter of change in agricultural production and yield before and after the policy by quantiles of treatment intensity

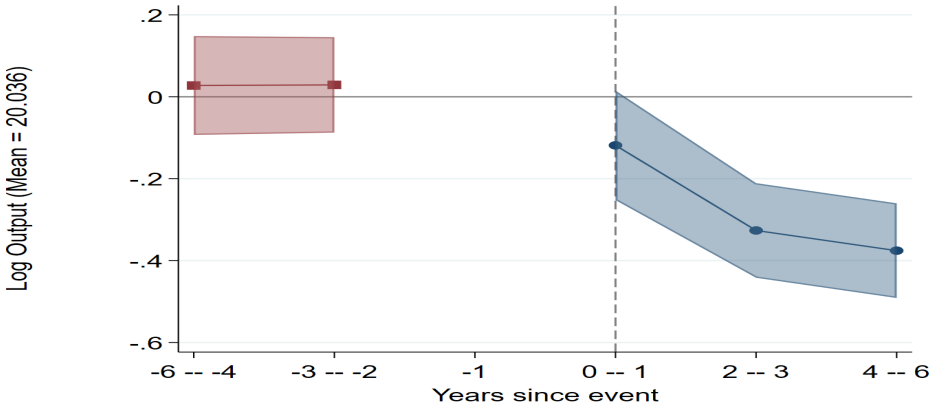


(a) Production

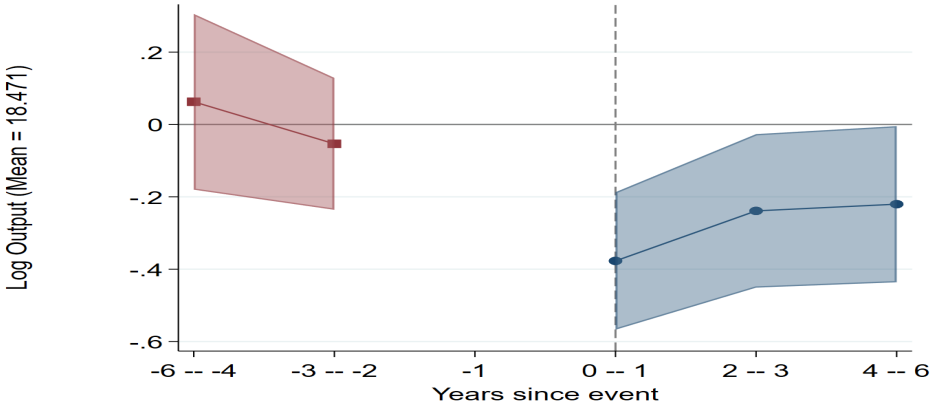


(b) Yield

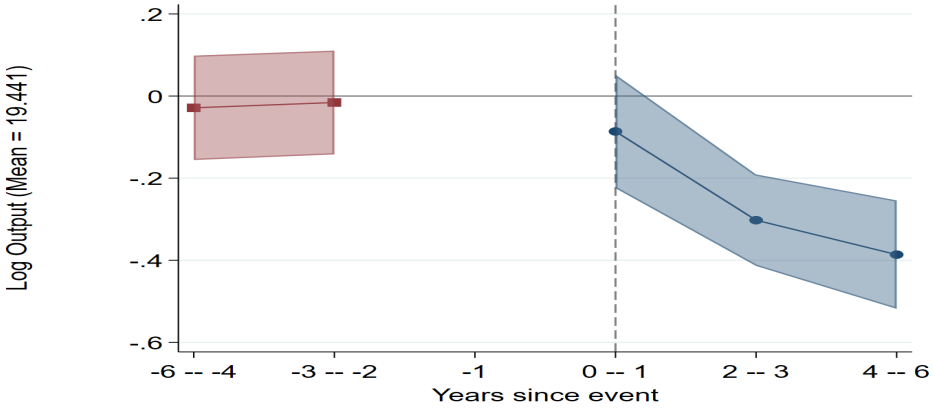
Figure A12: Effect of fertilizer price deregulation on agriculture output



(a) All



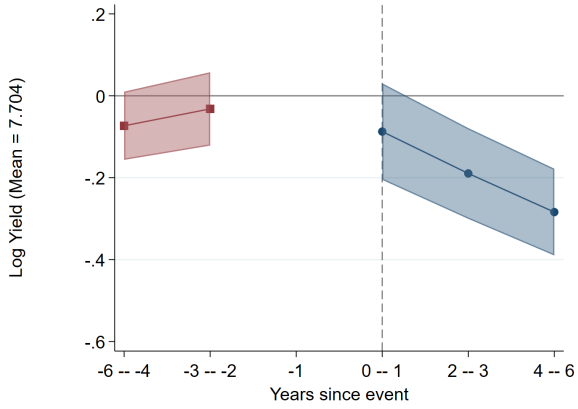
(b) Cash



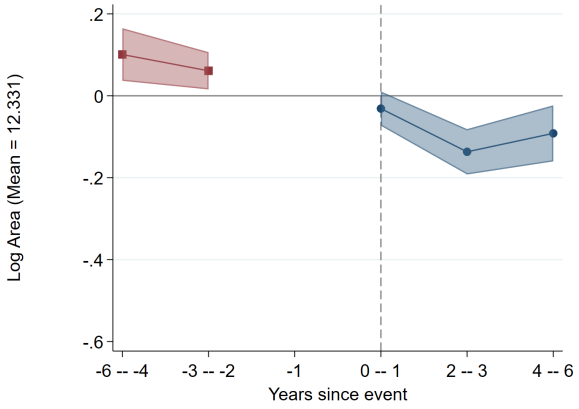
(c) Staples

Note: Figure reports the coefficients of treatment and pre-treatment periods interacted with treatment intensity and 95% confidence intervals. Treatment and pre-treatment periods combined into 2-year or 3-year bins. Standard errors in parentheses are clustered at the district level.

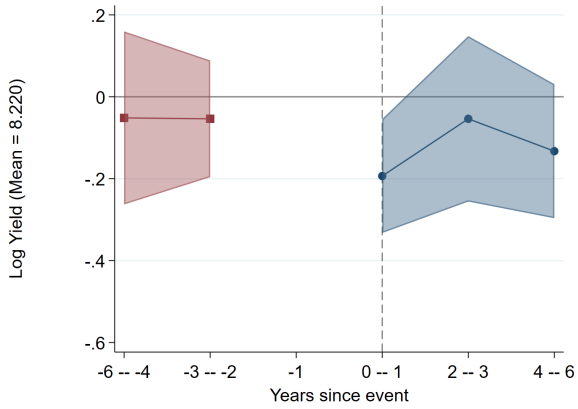
Figure A13: Effect of fertilizer price deregulation on agriculture yield and area



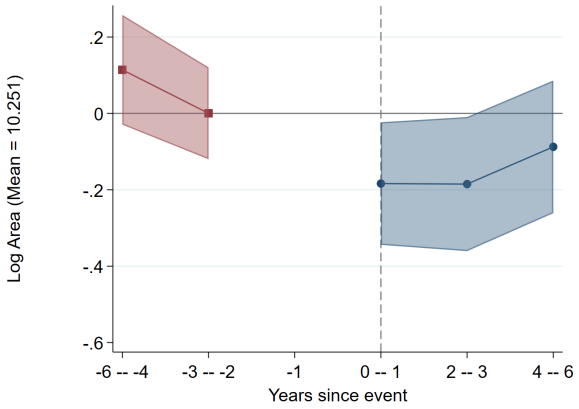
(a) All: Yield



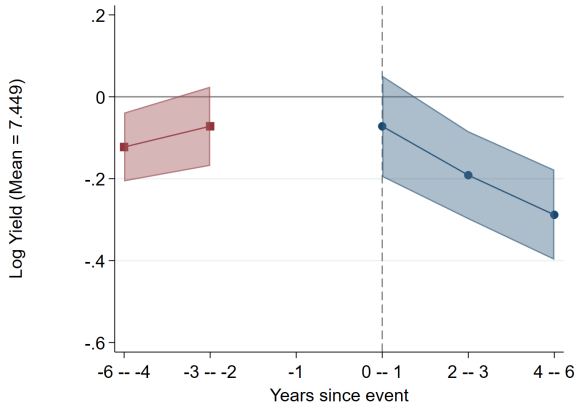
(b) All: Area



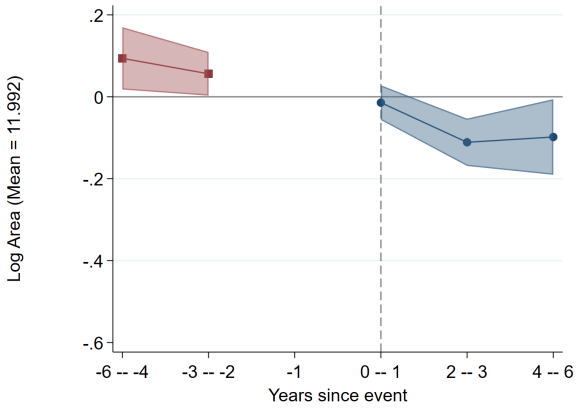
(c) Cash: Yield



(d) Cash: Area



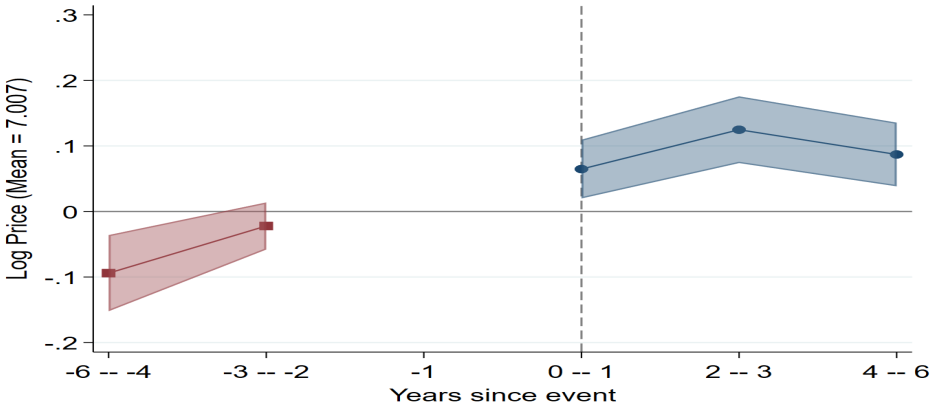
(e) Staples: Yield



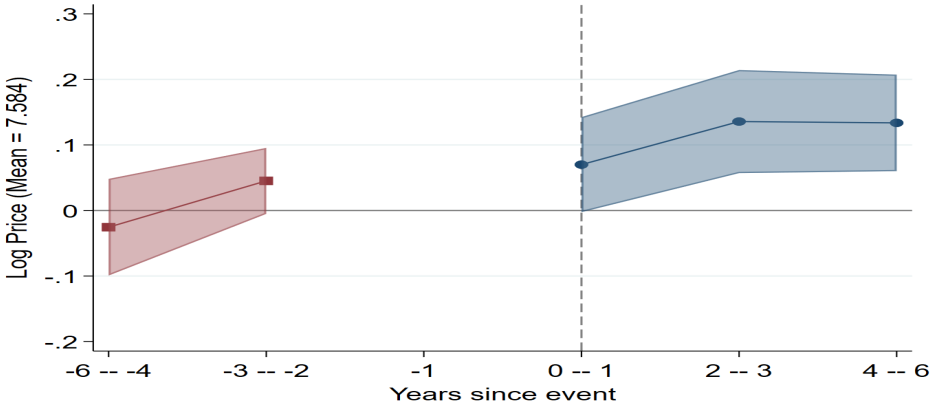
(f) Staples: Area

Note: Figure reports the coefficients of treatment and pre-treatment periods interacted with treatment intensity and 95% confidence intervals. Treatment and pre-treatment periods combined into 2-year or 3-year bins. Standard errors in parentheses are clustered at the district level.

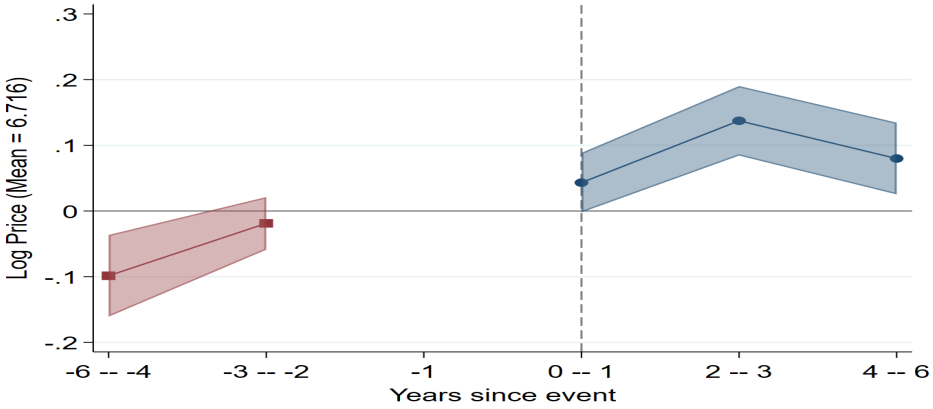
Figure A14: Effect of fertilizer price deregulation on agriculture prices



(a) All



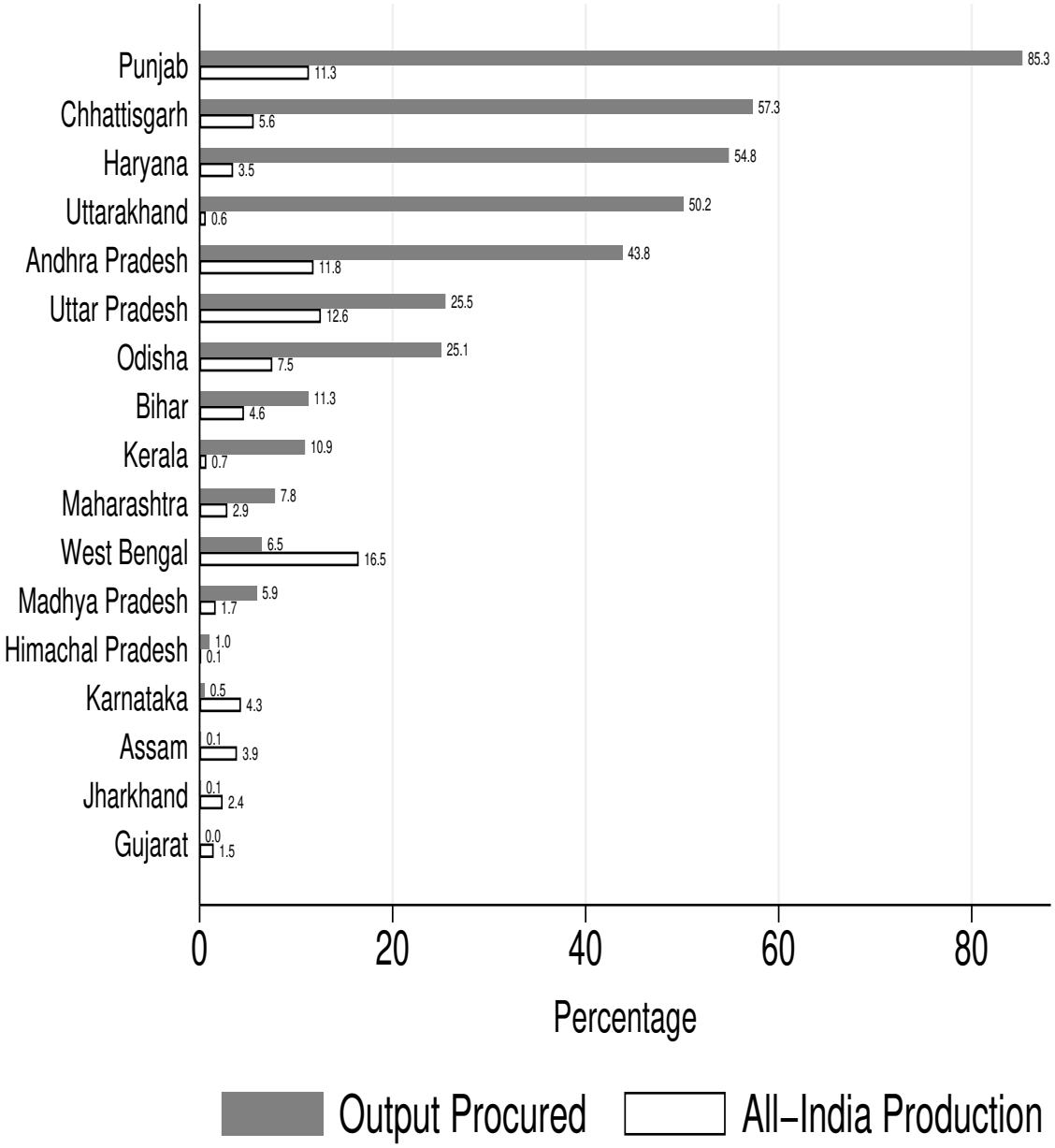
(b) Cash



(c) Staples

Note: Figure reports the coefficients of treatment and pre-treatment periods interacted with treatment intensity and 95% confidence intervals. Treatment and pre-treatment periods combined into 2-year or 3-year bins. Standard errors in parentheses are clustered at the district level.

Figure A15: Variation in average proportion of output procured between 2004 and 2006



B Additional Tables

Table B1: Effect of transfer program on different fertilizers use

Dependent variables: Log of Total Fertilizer value or Log Quantity				
	Total value (Rs.)	Nitrogen (kg)	Phosphorous (kg)	Potash (kg)
	(1)	(2)	(3)	(4)
Treatment Effect	0.08**	0.08***	0.08**	0.01
	(0.04)	(0.02)	(0.04)	(0.05)
Pre-treated effect	-0.02	-0.07	-0.01	-0.03
	(0.03)	(0.04)	(0.04)	(0.04)
Observations	1960	1956	1952	1908
R^2	0.97	0.97	0.96	0.93
Outcome Mean	19.83	16.67	15.71	14.36

Note: The coefficients show the average treatment and pre-treated effects. The sample size changes as we restrict regressions to a balanced panel in each case. Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

Table B2: Savings and agricultural outcomes: model and data

	Input expenditure		Harvest value	
	Data	Model	Data	Model
	(1)	(2)	(3)	(4)
Saving	0.414***	0.269***	0.382***	0.164***
	(0.066)	(0.023)	(0.080)	(0.021)
Observations	2390	n.a.	2390	n.a.
R^2	0.335	0.08	0.334	0.033

Significance at 0.01, 0.05 and 0.1 levels are denoted by ***, ** and * respectively. Standard errors shown in parentheses. Standard errors in the data are clustered at household level. Standard errors in the model are bootstrapped using 1000 samples of 478 individuals. Standard errors are computed by bootstrapping 1000 samples of populations equal to the ICRISAT sample size. Dependent and independent variables are normalized by sample mean. The regressions using the empirical data control for number of adult men, adult women and kids in the household, and gender, education, age and age squared of the household head, dummies for village and year and village-year linear trend.

Table B3: MSP decomposition: outcomes

	Procure-disposal*	Procure -rations-market sale†	Market redistribution
	(1)	(2)	(3)
Aggregate Quantities			
Aggregate Output	2	1.964	1.933
Real Output	1.915	1.97	1.933
Non-agricultural Good, y_n	1.344	1.498	1.446
Cash Crop, y_r	0.163	0.146	0.149
Staple Crop, y_s	0.265	0.208	0.216
Rations, c^{ration}	0.104	0.01	0.0577
Intermediate input demand, $k_s + k_r$	0.156	0.113	0.116
Capital demand, k_n	3.97	4.37	4.195
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	1.434	1.272	1.272
Staple Crop, p_s	1.589	1.343	1.372
Support Price, $\bar{p}$	1.7	1.436	-
Interest rate, r	0.0152	0.017	0.017
Wage, w	1.152	1.145	1.142
Employment Shares			
Non-agricultural Sector	0.363	0.447	0.42
Cash Crop Farmers	0.262	0.24	0.248
Staple Crop Farmers	0.374	0.31	0.332

Note: *A quarter of the procured staple crops are disposed of in this exercise, with the remainder being disbursed as rations.
†Rations are capped at 5% of total staple consumption, as opposed to 30% in the baseline.

Table B4: Equilibrium outcomes upon varying the input subsidy

	Low sub* (25%)	Low sub-transfer** (25%)	Low sub (50%)	Low sub-transfer (50%)
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output, $\sum_j p_j Y_j$	1.96	1.96	1.967	1.97
Real Output† , $\sum_j p_j^* Y_j$	1.89	1.877	1.862	1.823
Non-agricultural Good, y_n	1.423	1.397	1.425	1.353
Cash Crop, y_r	0.141	0.149	0.139	0.149
Staple Crop, y_s	0.211	0.211	0.19	0.205
Rations, c^{ration}	0.055	0.055	0.057	0.063
Intermediate input demand, $k_s + k_r$	0.102	0.107	0.086	0.0981
Capital demand, k_n	4.162	4.074	4.168	3.948
Labour productivity of non-agri sector‡	3.52	3.57	3.515	3.652
Labour productivity of agricultural sector	0.787	0.788	0.736	0.746
Labour productivity of cash crop sector	0.559	0.562	0.529	0.531
Labour productivity of staple crop sector	0.616	0.615	0.573	0.585
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	1.46	1.495	1.599	1.68
Staple Crop, p_s	1.564	1.597	1.68	1.792
Support Price, $\bar{p}$	1.672	1.708	1.799	1.917
Interest rate, r	0.0162	0.0166	0.0162	0.0165
Wage, w	1.147	1.145	1.147	1.146
Employment Shares				
Non-agricultural Sector	0.404	0.391	0.405	0.37
Cash Crop Farmers	0.253	0.266	0.263	0.28
Staple Crop Farmers	0.342	0.343	0.332	0.35

Note: *Each odd column reports outcomes when we the price of input, p_k is raised by x%
** Each even column reports outcomes when we the price of input, p_k is raised by x% and agents are compensated with budget equivalent income transfers
†p^* represents prices in the benchmark
‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

Table B5: Equilibrium outcomes under replacement policies when MSP is removed

	No MSP	No MSP (balanced)	No MSP (in-kind)
Aggregate Quantities			
Aggregate Output	1.968	1.931	1.931
Real Output	1.974	1.931	1.931
Non-agricultural Good, y_n	1.51	1.443	1.443
Cash Crop, y_r	0.147	0.15	0.15
Staple Crop, y_s	0.203	0.216	0.216
Rations, c^{ration}	0	0	0.05
Intermediate input demand, $k_s + k_r$	0.11	0.116	0.116
Capital demand, k_n	4.4	4.19	4.186
Labour productivity of non-agri sector‡	3.34	3.45	3.452
Labour productivity of agricultural sector	0.848	0.838	0.838
Labour productivity of cash crop sector	0.618	0.602	0.602
Labour productivity of staple crop sector	0.653	0.65	0.65
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	1.195	1.272	1.272
Staple Crop, p_s	1.24	1.372	1.372
Interest rate, r	0.0575	0.0172	0.0172
Wage, w	0.98	1.142	1.142
Employment Shares			
Non-agricultural Sector	0.452	0.418	0.418
Cash Crop Farmers	0.23	0.249	0.249
Staple Crop Farmers	0.32	0.333	0.333

Table B6: Equilibrium outcomes under replacement policies when input subsidy is reduced

	Higher p_k	Higher p_k (balanced)	Higher p_k (fixed ration)	Higher p_k (balanced:farmers)*
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output	1.995	1.999	2	1.81
Real Output	1.817	1.734	1.736	1.6
Non-agricultural Good, y_n	1.415	1.277	1.28	1.144
Cash Crop, y_r	0.126	0.137	0.137	0.135
Staple Crop, y_s	0.176	0.205	0.205	0.207
Rations, c^{ration}	0.057	0.061	0.057	0.06
Intermediate input demand, $k_s + k_r$	0.069	0.085	0.085	0.079
Capital demand, k_n	4.15	3.77	3.77	3.3
Labour productivity of non-agricultural sector	3.549	3.82	3.815	4.15
Labour productivity of agricultural sector	0.669	0.686	0.686	0.63
Labour productivity of cash crop sector	0.479	0.48	0.48	0.436
Labour productivity of staple crop sector	0.521	0.541	0.541	0.499
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	1.862	1.991	1.991	1.81
Staple Crop, p_s	1.96	2.185	2.185	2.02
Support Price, $\bar{p}$	2.097	2.337	2.337	2.16
Interest rate, r	0.0159	0.0153	0.0152	0.0178
Wage, w	1.149	1.152	1.152	1.14
Employment Shares				
Non-agricultural Sector	0.399	0.335	0.335	0.276
Cash Crop Farmers	0.263	0.286	0.285	0.31
Staple Crop Farmers	0.338	0.379	0.379	0.414

Note: *For this exercise we consider budget equivalent income transfers to farmers alone

Table B7: Consumption by occupations and goods in GE across policies

	Benchmark	No MSP	No MSP (balanced)	Low subsidy	Low subsidy (balanced)
	(1)	(2)	(3)	(4)	(5)
By occupation					
Aggregate worker consumption*	0.585	0.618	0.619	0.503	0.495
Aggregate staple farmer consumption	0.268	0.2483	0.294	0.251	0.362
Aggregate crop farmer consumption	0.202	0.196	0.225	0.1973	0.271
By good					
Aggregate non-agri consumption**	0.6348	0.592	0.636	0.6125	0.731
Aggregate staple crop consumption	0.165	0.21	0.223	0.133	0.142
Aggregate cash crop consumption	0.153	0.143	0.154	0.122	0.141

Note: *For each group j, we compute aggregate consumption using benchmark equilibrium crop prices as $p_s^* c_{js} + p_r^* c_{jr} + c_{jn}$
Note: **For each good i, we compute aggregate consumption across occupations j as $\sum_j c_{ji}$

Table B8: Comparison of GE outcomes with disproportionate transfers to workers

	Benchmark	No MSP (balanced)*	Low subsidy (balanced)†
	(1)	(2)	(3)
Aggregate Quantities			
Aggregate Output, $\sum_j p_j Y_j$	1.936	1.988	2.307
Real Output , $\sum_j p_j^* Y_j$	1.936	1.963	1.926
Non-agricultural Good, y_n	1.446	1.464	1.47
Cash Crop, y_r	0.147	0.151	0.14
Staple Crop, y_s	0.221	0.223	0.203
Rations, c^{ration}	0.0576	0	0.0608
Intermediate input demand, $k_s + k_r$	0.118	0.125	0.098
Capital demand, k_n	4.2	4.25	4.36
Labour productivity of non-agri sector‡	3.45	3.395	3.34
Labour productivity of agricultural sector	0.844	0.876	0.823
Labour productivity of cash crop sector	0.597	0.63	0.585
Labour productivity of staple crop sector	0.661	0.679	0.644
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	1.272	1.335	2.35
Staple Crop, p_s	1.372	1.442	2.5
Support Price, $\bar{p}$	1.467	-	2.67
Interest rate, r	0.017	0.0172	0.0147
Wage, w	1.143	1.142	1.155
Employment Shares			
Non-agricultural Sector	0.42	0.431	0.445
Cash Crop Farmers	0.246	0.24	0.239
Staple Crop Farmers	0.334	0.328	0.315

Note: * For this exercise we allocate 60% of the amount spent on the support price program in the benchmark equilibrium to workers in the non-agri sector.
†For this exercise we allocate all of the amount spent on the input subsidy program in the benchmark equilibrium to workers in the non-agri sector.

Table B9: Effect of fertilizer deregulation on agricultural yield and area

Dependent variables: Log Yield or Log Area			
	All	Cash Crops	Staple Crops
	(1)	(2)	(3)
	A: Yield (tonne per hectare)		
Post × Treatment Intensity	-0.20***	-0.13*	-0.20***
	(0.05)	(0.08)	(0.05)
Pre × Treatment Intensity	-0.06	-0.05	-0.10**
	(0.04)	(0.09)	(0.04)
Observations	6552	6305	6552
R^2	0.86	0.88	0.74
Outcome Mean	7.70	8.22	7.45
	B: Area (hectare)		
Post × Treatment Intensity	-0.09***	-0.14*	-0.08**
	(0.03)	(0.08)	(0.03)
Pre × Treatment Intensity	0.08***	0.07	0.08**
	(0.03)	(0.07)	(0.03)
Observations	6552	6305	6552
R^2	0.98	0.96	0.97
Mean Dependent	12.33	10.25	11.99

Note: Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively.

Table B10: Effect of change in support price on intermediate input use

Dependent variables: Log Amount Spent (Rupees)					
	Labour	Seed	Fertilizers	Machine	Others
	(1)	(2)	(3)	(4)	(5)
Post × Procurement Intensity	0.004***	0.004*	0.001	0.002	0.001
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)
Pre × Procurement Intensity	0.002	0.001	0.001	0.001	0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Observations	20281	20281	20281	20281	20281
R^2	0.31	0.28	0.49	0.32	0.52
Outcome Mean	9.11	6.89	7.41	7.94	8.92

Note: Standard errors clustered at the district level are reported in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively. Controls include log of annual rainfall and log of net irrigated area at state level. For columns 2-5, outcome is log of one plus intermediate input in rupees.

C Data

This section describes the various datasets used for empirical analysis and calibrating the model. Additionally, we describe the sample selection undertaken for the various empirical exercises.

Ministry of Agriculture & Farmers Welfare

District level area, production, yield and price data for 48 crops and 6 composite crop groups covering 20 major states comes from the Ministry Of Agriculture and Farmers Welfare, Govt. Of India[42]. We focus on the states: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand and West Bengal. Quantity of all crops is converted into tonne[43]. We ignore the composite crop groups in the analysis as prices for these groups are not available. We do not include fruits, vegetables and spices as the data is quite sparse. We exclude data for cowpea as data is not available for all years. Finally, we exclude urad and khesari crops from the analysis as farm price for these crops was unavailable during the pre-treatment periods (2004-2009). This leaves us with 32 crops which we use in our analysis.

We also categorize the crops into staple and cash crops.

Table C1: List of staple and cash crops

Staple	Cash
Cereals: Bajra, Barley, Jowar, Maize, Ragi, Rice, Small Millets, Wheat	Oilseeds: Castor seed, Coconut, Groundnut, Linseed, Niger seed, Rapeseed, Safflower, Sesamum, Soyabean, Sunflower
Pulses: Arhar, Bengal Gram, Horse Gram, Masoor, Moong, Moth, Pea	Fibre: Cotton, Jute, Mesta, Sannhemp Miscellaneous: Guarseed, Sugarcane, Tobacco

For the fertilizer subsidy exercise in Section 6.1, we only consider districts with observations for all periods in the sample. After harmonizing the districts across time, we are left with a sample of 504 districts. Our sample contains 6552 district-year observations with 13 periods (2004-2016).

[42] Data was accessed using the India Data Portal (2024) who compiled the data.

[43] Data for cotton, jute and mesta is available in bales and hence, converted into tonne using the conversion factor of 1 bale = 170, 180 and 180kg, respectively. Also, data for coconut available in units and hence, converted into tonne for copra using the conversion factor of 5000 units of coconut = 1 metric tonne of copra (Source: https://documents1.worldbank.org/curated/en/309941468180567229/pdf/FAU4.pdf).

For the MSP exercise in Section 6.2, we drop districts that had zero area under rice cultivation for all years in the sample (2004-2009). Moreover, we drop Tamil Nadu and Rajasthan from the analysis because there was a stark difference in its procurement policy during this period. Tamil Nadu procured less than 10% of its rice output before the treatment periods, but doubled it post the implementation of the policy. On the other hand, Rajasthan procured 15% of its output on in 2005, but completely stopped procurement from 2009 onwards. With 6 years (2004-2009) and 423 districts leads to 2538 district-year observations.

Centre for Economic Data & Analysis (CEDA)

In order to aggregate output and yield over crops, we weight them using prices. Monthly price data by crop is available at (CEDA, 2023). We use the price of the crop Sannhemp as the price of Mesta given they are both closely related fibre crops. We remove seasonality and time trends from the prices.

ICRISAT–TCI

Annual district-level data on manufacturing and service output at constant 2004 prices, covering the period from 2007 to 2013, were obtained from the ICRISAT–TCI (Tata-Cornell Institute of Agriculture and Nutrition). Annual district-level prices for 16 agricultural crops from 2004 to 2016 also came from this source. Crops include cereals (barley, jowar, maize, ragi, rice, sorghum and wheat), pulses (chickpea and pigeonpea), oilseeds (castorseed, groundnut, linseed, rapeseed, sesame), sugarcane and cotton. These data were used to analyse the effect of the fall in fertilizer subsidy in Section 6.1. Prices are deflated by annual CPI. Furthermore, district-level annual consumption of N, P and K fertilizers from 2004 to 2016 was also provided by ICRISAT–TCI. This helped in the creation of a measure of fertilizer intensity at the district-level.

Cost of Cultivation Survey (CCS)

The Cost of Cultivation is a nationally representative survey on the input usage and costs faced by the farmers in India to grow various crops.

We use the years 2004-2009 to compute the area weighted median nominal price of fertilizers N, P and K per kg in Section 6.1. The median nominal prices are quite stable over the years

due to the government's intervention in the fertilizer market. Hence, we use nominal rather than real prices across years.

Moreover, to analyze the effect of the rise in support price in Section 6.2, we consider only rice farmers. We drop those whose value of output was zero or price was below the bottom 1 percentile. We dropped those with missing weights. We dropped the year 2006 as data for many states was not collected. We also add the cost across all land parcels for a farmer leaving us with 20281 observations at the farmer level for 5 years.

Lastly, we use the area weighted nominal median price for the years between 2016-2018 to aggregate fertilizer consumption across N, P and K fertilizers, which we use in Section 4.1 while investigating the impact of the cash transfer program on intermediate input use. We use real fertilizer prices by deflating the median nominal prices with the annual CPI.

Land and Livestock Holding Survey (NSS 77th Round)

The Land and Livestock Holding Survey by the National Sample Survey (NSS) is a survey to collect information about the asset holdings, income and expenditure of rural households. We use both the visits of the 77th Round to compute the ratio of market price of rice and wheat to the national support price for the year 2018-19. We only consider rice and wheat as they are the two crops with the highest amount of procurement. Market price is defined as the value of the crop sold divided by the quantity. We keep the 20 major Indian states and drop the smaller states and union territories.

CMIE States of India

Annual data on fertilizer use of Nitrogen, Phosphorus and Potash and production and area data from 2017 to 2020 comes from this source. ICRISAT–TCI only provides data until 2017. Hence, this led to the use of a different data provider. We use the median real prices from CCS to construct the total value of fertilizer consumption at the district level. We use districts with 4 years of observations in all the regressions related to the cash transfer program. We are left with 490 districts and 1960 district-year observations for the regression on log total fertilizer. Moreover, we have 554 districts and 2216 district-year observations for the production and yield regressions.

India Human Development Survey

The India Human Development Survey (IHDS) is a national- and state-level representative data. There are two waves of the data corresponding to the years 2004-05 and 2010-11. It provides detailed information on household income and consumption in both waves. Additionally, it contains detailed questions on the kinds and value of crops grown and agricultural production inputs in the first wave. The second wave provides individual level data on income from agriculture and non-agricultural activities.

We focus on the 19 major Indian States while computing any statistic from the IHDS dataset. When estimating the variance of crop harvest, we winsorize the top and bottom 1% of the crop harvest distribution. Moreover, we focus on households living in rural areas with non-missing information on education and positive net land (land holdings minus land rented out plus land rented in) used in agriculture.

ICRISAT Village Level Studies (VLS)

The ICRISAT VLS data is a panel dataset for 6 years (2009-2014) covering six Indian states. They collect detailed information about cropping choice, agricultural input use, income from non-agriculture, consumption and savings of rural households.

While estimating the variance and covariance of log harvest and log non-agricultural income, we drop households that were interviewed for less than six years. We remove the bottom and top 1 percentile of log agricultural harvest and log non-agricultural income.

To compute the rate of transition between staple and cash farmers in the data, we remove observations where a household is interviewed only once or total area cultivated is zero.

Other Data

Some of the other data sources are listed below in Table C2.

Table C2: List of other data sources

	Variable	Source
1	Annual CPI	World Development Indicators
2	MSP Procurement Price	Reserve Bank of India Handbook of Indian Statistics
3	National and State Level Procurement	IndiaStat
4	Sectoral employment shares and value added for India	RBI India KLEMS Database
5	Worldwide sectoral employment shares	International Labour Organization (ILO)
6	Worldwide sectoral value added	World Development Indicators
7	Actual yield of rice and wheat by states	Reserve Bank of India Handbook of Statistics on Indian States
8	Potential yield	GAEZ FAO

D Model

D.1 Profit maximization

The profit maximization problem of the representative firm (in units of the non-agricultural sector) is standard and yields first-order conditions that equate the marginal products of inputs to their factor prices:

$$\max_{n_{nt},k_{nt}} An_{nt}^{\alpha}k_{nt}^{1-\alpha} - w_t n_{nt} - \tilde{r}_t k_{nt} \tag{20}$$

$$w_t = \alpha A k_{nt}^{1-\alpha} n_{nt}^{\alpha-1} \tag{21}$$

$$\tilde{r}_t = (1-\alpha) A k_{nt}^{-\alpha} n_{nt}^{\alpha} \tag{22}$$

An individual observes her idiosyncratic sectoral productivity shocks and the MSP of the staple crop before making sectoral and farm input choices. As noted above, the cropping choices of farmers are made prior to observing the idiosyncratic taste shocks. Staple crop farmers also differ from cash crop farmers in their ability to sell produce at the MSP.

A farmer of crop r with state vector $\{z_{at}, z_{nt}, a_t\}$ solves the following:

$$\max_{k_{rt} \leq \frac{\phi a_t}{p_k}} p_{rt}(Az_{at})\left[k_{rt}^{\zeta}\right] - \tilde{R}_t p_k k_{rt} \tag{23}$$

Note that the problem above incorporates the working capital constraint, $k_{rt} \leq \frac{\phi a_t}{p_k}$.

The optimal unconstrained choice of farm input by a cash crop farmer is denoted by $k_{rt}^{u} = k_r^{u}(z_{rt})$.

Combining the first-order conditions of the problem above, one obtains:

$$k_r^{u}(z_{at}) = \left(\frac{\zeta_r A z_{at} p_r}{p_k \tilde{R}}\right)^{\frac{1}{1-\zeta}} \tag{24}$$

However, the actual amount of capital rented by a farmer is:

$$k_r(z_{at}, a_t) = \min\{k_{rt}^{u}(z_{at}), \frac{\phi a_t}{p_k}\} \tag{25}$$

Plugging this back into the production function and the profit expression yields:

$$y_r(z_{at}, a_t) = (Az_{at})\left[k_{rt}^{\zeta}\right] \tag{26}$$

$$\Pi_r(z_{at}, a_t) = p_{rt}(Az_{at})\left[k_{rt}^{\zeta}\right] - \tilde{R}_t p_k k_{rt} \tag{27}$$

In the expressions above, the dependence on asset holdings is made explicit. This, in turn, arises from the collateral constraint affecting farm input choice.

A farmer of the staple crop is assumed to hold the option to sell her produce at the announced support price $\bar{p}_t$ subject to incurring a fixed cost associated with procurement, ρ. The staple farmer decides whether she wishes to sell her produce at the support price $\bar{p}_t$ as opposed to selling it at the market price p_{st}, based on a comparison of the value functions associated with the two options.

A staple crop farmer s with state vector $\{z_{at}, z_{nt}, a_t\}$ solves a similar optimization problem for input choices, with the difference that the staple crop farmer could sell her crop at the support price. Hence, there are two sets of equations for input choice, yield and profit, corresponding to the prices received by farmers.

A staple crop farmer receiving the market price chooses the intermediate input as per:

$$\max_{k_{st} \leq \frac{\phi a_t}{p_k}} p_{st}(Az_{at})\left[k_{st}^{\zeta}\right] - \tilde{R}_t p_k k_{st} \tag{28}$$

A staple crop farmer receiving the MSP chooses the intermediate input as per:

$$\max_{k_{st} \leq \frac{\phi a_t}{p_k}} \bar{p}_t(Az_{at})\left[k_{st}^{\zeta}\right] - \tilde{R}_t p_k k_{st} \tag{29}$$

The expression for k_{st}^{u} for a farmer receiving price $\hat{p}_{st} \in \{p_{st}, \bar{p}_t\}$ is analogous to the corresponding one derived above for cash crop farmers' intermediate input choices:

$$k_s^u(z_{at}, \hat{p}_{st}) = \left(\frac{\zeta_s A z_{at} \hat{p}_{st}}{p_k \tilde{R}}\right)^{\frac{1}{1-\zeta}} \tag{30}$$

The input choice for the staple crop farmer receiving price $\hat{p}_{st}$ is:

$$k_s(z_{at}, a_t; \hat{p}_{st}) = \min\{k_s^u(z_{at}, \hat{p}_{st}), \frac{\phi a_t}{p_k}\} \tag{31}$$

Henceforth, we shall denote the dependence of the input choice on received price $\hat{p}_{st}$ parsimoniously by $k_{st}(\hat{p}_{st})$. One obtains an expression for staple crop production that is similar to the corresponding expression derived for cash crop farmers.

The profit of a staple crop farmer with state vector $\{z_{at}, z_{nt}, a_t\}$, saving a_t and receiving price $\hat{p}_{st}$ is:

$$\Pi_s(z_{at}, a_t; \hat{p}_{st}) = \hat{p}_{st}(Az_{at})\left[k_{st}(\hat{p}_{st})^{\zeta}\right] - \tilde{R}_t p_k k_{st}(\hat{p}_{st}) - \mu(z_a, z_n, a)\rho \tag{32}$$

Depending on whether procurement is chosen or not, i.e. if $\mu(z_a, z_n, a) = 1$ or $\mu(z_a, z_n, a) = 0$, one obtains the following input choices, staple crop output and profit:

$$k_s(z_{at}, a_t) = \mu(z_a, z_n, a) \times k_s(z_{at}, a_t; \bar{p}) + \big(1 - \mu(z_a, z_n, a)\big) \times k_s(z_{at}, a_t; p_{st}) \tag{33}$$

$$y_s(z_{at}, a_t) = \mu(z_a, z_n, a) \times y_s(z_{st}, a_t; \bar{p}) + \big(1 - \mu(z_a, z_n, a)\big) \times y_s(z_{at}, a_t; p_{st}) \tag{34}$$

$$\Pi_s(z_{at}, a_t) = \mu(z_a, z_n, a) \times \Pi_s(z_{at}, a_t; \bar{p}) + \big(1 - \mu(z_a, z_n, a)\big) \times \Pi_s(z_{at}, a_t; p_{st}) \tag{35}$$

D.2 Stationary Equilibrium

A stationary competitive equilibrium comprises an invariant distribution F, value functions $\{V^s, V^r, V^w, \tilde{V}^a, V\}$ with associated decision rules $\{\omega, \sigma, \mu, c_r, c_s, c_n, a'\}$ and prices $\{p_s, p_r, \bar{p}, w, \tilde{r}\}$ that solve the agents' and firm's optimization problems detailed above. The market clearing conditions and the equation that updates the distribution of agents in the economy are:

1. Staple and cash crop markets, asset market and labour market clears. By Walras Law, the non-agricultural goods market will clear as well.

   (a) Cash crop:

$$\int_{\mathbf{z}\times A} c_r(\mathbf{z}, a)\, dF(\mathbf{z}, a) = \int_{\mathbf{z}\times A} \big(1 - \sigma(\mathbf{z}, a)\big)\big(1 - \omega(\mathbf{z}, a)\big)\, y_r(z_a, a)\, dF(\mathbf{z}, a) \tag{36}$$

   (b) Marketed staple crops: total staple crops purchased for an agent with state $(\mathbf{z}, a)$ is given by $c_s(\mathbf{z}, a)$. Rations are capped at a certain level (ψ) of average staple crop consumption C_s. Consumption of rations $\left(c^{\text{ration}}\right)$ is:

$$c^{\text{ration}} = \min\left\{c_s^{\text{procured}},\ \psi C_s\right\} \tag{37}$$

where $c_s^{\text{procured}} = \int_{\mathbf{z}\times A} \sigma(\mathbf{z}, a)\mu(\mathbf{z}, a)\ y_s(z_s, a)\ dF(\mathbf{z}, a)$. If procurement exceeds the cap on rations, then the remainder is released on the market. Thus, equilibrium in the staple crop market entails:

$$\begin{aligned}\int_{\mathbf{z}\times A} c_s(\mathbf{z}, a)\ dF(\mathbf{z}, a) &= \int_{\mathbf{z}\times A} \big(1 - \mu(\mathbf{z}, a)\big)\ \sigma(\mathbf{z}, a)\ y_s(z_a, a)\ dF(\mathbf{z}, a) \\ &+ \mathbb{I}_{c_s^{\text{procured}} > \psi C_s} \times \left(c_s^{\text{procured}} - \psi C_s\right) \end{aligned} \tag{38}$$

(c) Asset market:

$$\int_{\mathbf{z}\times A} a'(\mathbf{z}, a)\ dF(\mathbf{z}, a) = k_n + \int_{\mathbf{z}\times A} \big(1 - \omega(\mathbf{z}, a)\big) p_k k_j(\mathbf{z}, a)\ dF(\mathbf{z}, a) \tag{39}$$

(d) Labour market: Demand for workers by non-agricultural firms equals effective labour supplied to the non-agricultural sector:

$$n_n = \int_{\mathbf{z}\times A} \omega(\mathbf{z}, a)\ z_n\ dF(\mathbf{z}, a) \tag{40}$$

2. The distribution F evolves as per:

$$TF(z_a', z_n', a') = \int_{\mathbf{z}\times A} \mathbb{I}_{\{a'(\mathbf{z},a)=a'\}}\ \Pi^a(z_a, z_a')\ \Pi^n(z_n, z_n')\ dF(\mathbf{z}, a)\ \ \forall (z_a', z_n', a') \in \mathbf{z}\times A \tag{41}$$

Here, $\mathbb{I}_{\{a'(\mathbf{z},a)=a'\}}$ is an indicator function that takes the value 1 when an agent with state $(\mathbf{z}, a)$ has saving a'; and $\Pi^i(z_i, z_i'),\ i = \{a, n\}$ are the transition probabilities. T is an operator that maps distributions into distributions.

D.3 Welfare

We first define the aggregate welfare function of the benchmark stationary equilibrium, defined as:

$$W^{j*} = \int V^*(\mathbf{z}, a)\ \mathbb{I}_j^*\ dF^*(\mathbf{z}, a) \tag{42}$$

In the expression above, $\mathbb{I}_j^*$ is an indicator for an individual belonging to group j in the benchmark stationary equilibrium (here, with MSP and the input price subsidy). This welfare measure is defined for each group $j \in \{s, r, w\}$. This measures the welfare of an individual belonging to group j under the 'veil of ignorance', i.e. the welfare calculation of a planner who

weights every agent of group j in the stationary distribution equally.

Similarly, define the welfare of a model economy, using the stationary distribution of agents $F^*(\mathbf{z}, a)$ in the benchmark model, under the counterfactual equilibrium:

$$\hat{W^j} = \int \hat{V}(\mathbf{z}, a)\ \mathbb{I}_j^*\ dF^*(\mathbf{z}, a) \tag{43}$$

Note that we are considering the welfare of agents who belonged to group j in the benchmark stationary equilibrium. Hence, we are tracking the welfare of agents belonging to group j in the benchmark stationary equilibrium in the new stationary equilibrium under the counterfactual policy.

The welfare cost reported is in units of permanent consumption compensation necessary to make an individual of group j indifferent between the status quo (the benchmark stationary equilibrium) and the counterfactual equilibrium:

$$\chi^j = \left[\frac{W^{j*}}{\hat{W^j}}\right]^{\frac{1}{1-\theta}} - 1 \tag{44}$$

To obtain the above expression, we scale up subsistence consumption levels $\bar{c_s}$ by χ^j as well[44]. A negative value for χ^j would indicate that agents of group j are better off in the new stationary equilibrium corresponding to the counterfactual exercise.

[44]Given the small calibrated value of $\bar{c_s}$ and our finding in Table 4 that the subsistence requirement doesn't alter outcomes greatly, one could also think of the welfare measure as approximating the exact consumption equivalent measure in the absence of a subsistence requirement