The Equilibrium Impact of Agricultural Support Prices and Input Subsidies

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Abstract

We study the implications of agricultural 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, landholdings, 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 features two tax-financed subsidy programs: input price subsidies that reduce the cost of intermediate inputs for all farmers, and a minimum support price program for the procurement of staples. 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 either policy reduces agricultural productivity and increases the agricultural productivity gap. However, abolishing either policy boosts welfare primarily by reducing the tax burden on all individuals. Thus, government policies can generate a dichotomy between promoting productivity and improving welfare.

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

Keywords: agriculture productivity gap, welfare, 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 income differences (Caselli, 2005; Gollin et al., 2014), especially since agriculture employs a substantial proportion of the workforce. Both the less intensive use of agricultural inputs (intermediate inputs, labour, etc.) and misallocation of these inputs (due to institutions or policies) have been identified as important factors responsible for low agricultural productivity in developing countries[1]. Given the importance of this sector, policymakers in these countries have rolled out various policies to boost farmers' productivity, often by directly influencing crop input and output prices[2]. In this paper, we develop a quantitative general equilibrium (GE) framework to investigate the impact of agricultural subsidies on agricultural and non-agricultural productivity and consumer welfare for a developing economy.

We focus on two types of tax-financed agriculture policies: (1) a minimum support price (MSP) program wherein the government procures a proportion of staple output at a predeclared price and redistributes it as rations to households, and (2) subsidies that reduce the cost of agriculture intermediate inputs. The quantitative model incorporates rich individual-level heterogeneity in sectoral productivities, land endowment and assets in the presence of sectoral mobility and financial frictions and incomplete asset markets, 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. Counterfactual experiments reveal that removing either policy reduces agricultural productivity and widens the agricultural productivity gap (i.e., the ratio of non-agricultural to agricultural labour productivity, hereafter referred to as APG[3]), but improves consumer welfare due to a lower tax incidence. Thus, this paper shows that agriculture policies can generate trade-offs between improving productivity and welfare (Juhász et al., 2023).

We develop a dynamic general equilibrium model featuring two sectors (agriculture and non-agriculture) and two crop types (staples and cash crops). Individuals realise their sectoral productivity at the beginning of a period, and are heterogeneous in their land and risk-free as-

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

[2] FAO data shows that more than 43 countries had some form of output price support in agriculture in the last decade, including US and China. 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.

[3] Our baseline measure of APG is based on sectoral output rather than value-added to avoid changes in input price to mechanically affecting APG. Reassuringly, conclusions are similar using either measure.

set holdings. They encounter mobility barriers in the form of a fixed operating cost of working in the non-agricultural sector. Conditional on being a farmer, idiosyncratic taste shocks determine cropping choice. Agricultural production involves combining the intermediate input and land through a decreasing returns to scale production function. Farmers face intra-period working capital constraints when purchasing intermediate inputs whose price is subsidized by the government. Staple crops are supported through a MSP program, which farmers can access by paying a fixed cost. Lastly, all agents decide their consumption of the three goods and asset holdings, leading to a wealth distribution in equilibrium. The government finances the two subsidy programs through a lump sum tax on all agents, which can be interpreted as a tax on the aggregate consumption bundle[4]. It also redistributes the procured crops as free rations to all households. The lump sum tax amounts to 4.89% of GDP in the benchmark economy with both subsidies in place.

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 in which a government cash transfer to landowning farmers (equivalent to 6.25% of farmers' annual income) led to an 8.5% increase in intermediate input use. We calibrate the persistence and standard deviations of the sectoral productivity shocks to match those obtained using individual panel data. The fixed cost of procurement targets the empirically observed 23% of staple crop procurement by the Indian government. As a test of external validity, the model successfully replicates several untargeted patterns from aggregate and micro-level data, including the aggregate saving rate, saving rates of agricultural and non-agricultural households, transition rates from agriculture to the non-agricultural sector, and key moments of the income distribution.

Through counterfactual exercises, we show that removing the fixed cost of operating in the non-agriculture sector and variance of taste shocks are important drivers of the APG. Eliminating the non-agricultural entry cost reduces APG by 18%. Lowering the variance of taste shocks significantly decreases the APG through higher crop prices and intermediate input use in equilibrium. Other model features, such as the fixed cost of obtaining the MSP and the working capital constraint, have a limited effect on the APG[5].

[4]We model tax revenue through a lump sum tax rather than a progressive income tax, as consumption taxes are the primary source of government revenue in India. According to IMF Government Finance Statistics data from 2000 to 2017, 54% of the tax revenue was generated through consumption taxes, while only 11% came from individual labour income taxes.

[5]The assumption of incomplete asset markets also affects the APG, as Mongey and Waugh (2024) show that

The effect of removing the subsidies on the agricultural productivity gap (APG) is theoretically ambiguous even when prices are fixed. Both subsidies reduce the APG by promoting intermediate input use, but increase the APG by increasing farmers' profits and agricultural employment, thereby distorting occupational choices (*selection effect*). Using the calibrated model, we conduct counterfactual experiments to quantify the impact of each policy under fixed prices and general equilibrium (GE). In the first exercise, we eliminate the minimum support price and the subsequent staple crop procurement and rations disbursal by the government, while retaining the input subsidy. In the second exercise, we abolish the intermediate input subsidy while keeping the MSP program.

The removal of the MSP program increases the APG in general equilibrium. Under fixed prices, eliminating the MSP lowers the attractiveness of staple farming and the agriculture sector, leading to a 2.3 percentage point (pp) increase in non-agricultural employment. APG falls by 3%, though this reduction is partially offset by a decline in intermediate input use. In GE, where prices and government budget adjust, the lower tax burden increases consumption demand. The higher demand matches the increase in market supply due to staple crops not being procured by the government, resulting in no change in prices. Overall, the non-agricultural employment share falls by 0.2 pp, while agricultural productivity falls and consequently APG rises by 0.36% in the counterfactual relative to the benchmark economy.

Eliminating the input subsidy involves a 33% increase in input price, leading to an 8.5% increase in the APG in GE. Under fixed prices, this policy change reduces intermediate input demand by nearly 31%, leading to a 2.8 pp decline in agricultural employment. However, in GE, the resulting increase in crop prices – driven by reduced supply and an increased demand as a result of lower tax burden on households – stimulates both intermediate input demand and agricultural employment. As a result, non-agricultural employment falls by 2.2 pp relative to the benchmark economy, and the non-agricultural labour productivity increases by 2.5%. The reallocation of labour toward agriculture increases agricultural output; however, the decline in input use following the removal of the input subsidy results in a 5.4% decrease in agricultural productivity. Overall, both the change in employment shares and intermediate input use contribute to the rise in the APG.

Removing either of these policies boosts consumer welfare. Consumer welfare is higher by 0.8% in the counterfactual economy with no MSP than the benchmark, as the lower tax burden

discrete choice economies are inefficient in environments with incomplete markets.

offsets the loss of free staple rations. The lower tax incidence also drive welfare gains of 1.7% when input subsidies are removed relative to the benchmark economy. Apart from boosting consumption, the lower tax burden also leads to more staple crops being sold to the government and consequently more staple crops available as free rations. The additional free rations account for some of the welfare gains. Moreover, the lower consumption taxes resulting from the removal of either of the policies improve welfare for asset-poor individuals significantly more (around 80%) than for asset-rich individuals.

Eliminating both subsidies together also leads to a fall in agricultural productivity and an increase in the APG relative to the benchmark economy. Our main findings are robust to alternative subsidy financing schemes, including counterfactuals where at least half of the tax revenue is generated through a labour income tax levied on non-agricultural workers.

Finally, we corroborate the model's prediction of lower agricultural output and higher prices following a reduction in input subsidies by drawing on evidence from an increase in fertilizer prices due to a fertilizer deregulation policy in India. Additionally, we exploit a natural experiment involving an exogenous increase in MSP, unrelated to productivity, to demonstrate a positive relationship between the MSP program on both staple output and intermediate input use, consistent with the model's predictions of removing MSP under fixed prices.

In conclusion, agricultural subsidies can generate a trade-off between productivity indicators and consumer welfare[6]. The quantitative effects of removing either policy are modest in the Indian context because they have limited interaction in addressing some of the important drivers of the APG like, sectoral mobility and land frictions (Bolhuis et al., 2021). In contexts where agricultural policies directly target the drivers of the APG, the dichotomy between improving productivity and welfare could be sharper. Additionally, our counterfactual results underscore the importance of evaluating policies within a GE framework (Muralidharan & Niehaus, 2017), as implications under fixed prices are drastically different than under GE.

This paper contributes to multiple strands of literature. First, we contribute to the literature on the consequences of input subsidies and price support policies. To the best of our knowledge, ours is the first paper to investigate the impact of price support policies on the APG and welfare in a quantitative GE model, whereas existing studies analyse these policies in settings

[6]The price of the intermediate input is assumed to be exogenous in line with other studies (Donovan, 2021). Allowing input prices to vary in GE would potentially mitigate some of the impact on agricultural productivity. On the other hand, if subsidies generate positive learning externalities (Diop, 2022) or are targeted towards high-productive farmers (Basurto et al., 2020), elements missing from our model, then their removal would dampen agricultural productivity more than our estimates.

that do not fully account for the feedback effects of prices on employment and consumption (Alizamir et al., 2018; 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), while we employ a dynamic GE framework incorporating several frictions identified in the literature, such as skill heterogeneity, mobility and working capital frictions, intra-period shocks and incomplete asset markets. The intra-period working capital constraint and taste shocks in the model generate a strong positive correlation between asset holdings and both agricultural input use and output, consistent with the empirical observations. Asset holdings in combination with the intra-period shocks and frictions also affect occupational choices. Lastly, improvement in welfare from abolishing the policies varies significantly by asset holdings. These additional channels that affect the APG and the role of assets in influencing welfare are missing in static models.

Our paper is closely related to Mazur and Tetenyi (2023), who also study input subsidies using a dynamic GE model. Our results on the fall in agricultural productivity and higher welfare from removing the input subsidy policy complement those of Mazur and Tetenyi (2023). However, our results diverge from theirs along the dimensions of the APG and agricultural employment due to differences in the key underlying frictions driving the APG. Specifically, we find that eliminating input subsidies leads to an increase in agricultural employment – consistent with empirical evidence in other settings (Diop, 2022) – and, consequently, a rise in the APG, in contrast to their findings. We provide a detailed comparison of our findings with those of Mazur and Tetenyi (2023) in Section 5.5.2. A key takeaway is that incorporating the specific frictions driving the APG is crucial for accurately evaluating the effects of agricultural policies.

Second, it adds to the macroeconomic 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). Additionally, input misallocation plays a significant role in exacerbating productivity differences across nations (Restuccia & Rogerson, 2017)[7]. In this paper, we link misallocation to specific agricultural input and output price subsidy programs. We complement the literature by disentangling the role of selection (Adamopoulos et al., 2024; Lagakos

[7]Various institutions and policies contribute to such misallocation, including labour 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.

& Waugh, 2013) and input intensity in the analysis of input and output subsidy policies.

The rest of the paper is as follows. Section 2 discusses the empirical evidence, whereas the details of the quantitative model are described in Section 3. Section 4 details the calibration strategy and model parametrization. Section 5 presents the results from the quantitative exercises. Section 6 presents empirical validation of model predictions and Section 7 concludes.

2 Background: Indian agriculture and agriculture policies

Indian agriculture is characterized by low productivity of farmers 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 A1a and A1b). The majority of farmers in India are small and marginal, with 85% cultivating less than 2 hectares of land (Bolhuis et al., 2021). Second, agricultural production is particularly volatile; the standard deviation of the growth of value-added between 1980 and 2019 is 4.1% and 1.5% for agriculture and non-agriculture, respectively. Yet, crop insurance take-ups are quite low suggesting that asset markets are incomplete[8].

Amidst these issues, various government initiatives were launched to boost agricultural production. In this section, we discuss the institutional background of two prominent types of subsidies: (1) input subsidy and (2) output subsidy through 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, irrigation, and subsidized fertilizers and electricity (Moscona, 2023). Monari (2002) finds that Indian farmers pay less than 10% of the actual cost of electricity generation. Additionally, about 40% of India's total consumption of nitrogen, phosphorus, and potassium fertilizers is imported (FAO, 2019), while the government subsidizes domestic production to regulate retail fertilizer prices. Drawing on estimates from the U.S. Department of Agriculture and Indian government reports, we calculate that fertilizer and energy input subsidies averaged 1.25% of GDP between 2000 and 2019. Given the extensive price regulation by the government, we assume that input prices are fixed in the model and input subsidies amount to 1.25% of GDP in the benchmark economy.

[8] Less than 10% of agricultural households holding any crop insurance (2019 Land and Livestock Survey)

2.2 Minimum support price (MSP)

MSP was introduced in India during the time of the Green Revolution to increase staple crop production 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 et al., 2020). 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 and pre-determined prices if the latter falls below the market price (Alizamir et al., 2018). Below, we discuss the key aspects of the Indian program that we map into the model.

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[9]. Thus, in the model we will assume that there is no uncertainty with regard to the support price for the farmer.

Second, farmers face barriers to access the MSP program. In recent years, the government has procured around 25% of national rice and wheat output (Figure 1a). Furthermore, delays in procurement after harvest and payments imply that the richer farmers are more likely to access the MSP. Figure 1b shows that farmers with higher production levels were more likely to take advantage of the MSP program[10]. Although access is imperfect, Chatterjee et al. (2020) documents using surveys that the MSP program has encouraged farmers to grow staple crops. We provide reduced-form evidence in Section 6.2 that the MSP affects agricultural production.

Lastly, the government either stores the procured crops for food security purposes or distributes them to nearly 180 million low-income households at markedly reduced prices. Highly subsidized rations account for, on average, 30% of household rice and wheat consumption (Gadenne, 2020) [11]. 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.

[9]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.

[10]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 A2a. Furthermore, we demonstrate that this pattern remains consistent when measuring a farmer's wealth by land area rather than output (Appendix Figure A2b).

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

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 with 30 quintiles of the fraction of farmers selling to a government agency against log of total quantity produced.

3 Model

There are two sectors in the economy: agriculture and non-agriculture. Farmers can produce staple or 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 affect their sectoral and cropping choices. Individuals inelastically supply one unit of labour [12]. All agents have a fixed endowment of land (their *landholdings*), which they cannot adjust due to land market frictions[13]. The share of agents with land endowment l_i is denoted by G_{l_i}, such that $\sum_i G_{l_i} = 1$.

3.1 Preferences

Individuals have preferences over the consumption of the two agricultural goods (c_s, c_r) and the non-agricultural good (c_n). They maximize the expected discounted stream of utility from

[12] We assume substantial labour market frictions in agriculture (Foster & Rosenzweig, 2022), as hired labour constitutes only 6.5% of total days worked in India (IHDS-I).

[13] Foster and Rosenzweig (2022) note that there is effectively no market for land purchases and sales in India, while Bolhuis et al. (2021) find only 0.32% of farms reporting renting in or renting out land.

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 (Herrendorf et al., 2014).

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

Here, $\bar{c}_s$ 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 affects 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 (a_t) that earns interest $\tilde{r}_t$, as is standard in incomplete market models. Individuals cannot borrow to finance consumption, i.e., $a_t \in A = [0, \bar{a}]$.

3.2 Idiosyncratic Shocks

Agents make their sectoral choice at the beginning of each period after observing the realizations of two idiosyncratic sectoral productivity shocks, which evolve according to:

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

where, $0 < \rho_i < 1$ and the innovations ϵ_{it+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 (Artuç et al., 2010). We assume that agents make their sectoral choice *after* they draw $\{z_{at}, z_{nt}\}$, but prior to the realization of the idiosyncratic taste shocks. One can interpret these taste shocks as a parsimonious way of capturing other sources of idiosyncratic variation affecting farmers' cropping choice.

3.3 Technology

A representative firm produces the non-agricultural good using capital k_{nt}, which depreciates at rate δ, and effective labour n_{nt}, hired at interest rate $\tilde{r}_t$ and wage w_t, respectively.

$$y_{nt} = A n_{nt}^{\alpha} k_{nt}^{1-\alpha}, \ \ 0 < \alpha < 1 \tag{3}$$

where, A is the economy-wide total factor productivity (TFP) and α is labour's share of income.

The resulting profit maximization problem of the representative firm is standard:

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

The first-order conditions equate the marginal products of inputs to their prices.

The agricultural good of each type ($j = \{r, s\}$) is produced by an agent-farmer who combines intermediate inputs (e.g., fertilizers, electricity) k_{jt} with a fixed land endowment l:

$$y_{jt} = (A z_{jt}) \left[k_{jt}^{\zeta} \, l^{\chi} \right] \tag{4}$$

where, $0 < \zeta < 1$ and $0 < \chi < 1$ are the elasticities of production with respect to intermediate inputs and land, respectively.

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 and electricity (a large share of the intermediate inputs) are regulated by the Indian government, p_k is assumed to be exogenous in the model.

Expenditure on the intermediate inputs $\left(p_k k_{jt}\right)$ must be incurred prior to the harvest through intra-period borrowing from lenders at rate $\tilde{r}_t$. Intra-period borrowing is subject to a working capital constraint that is a linear function of the asset holdings of the agent:

$$p_k k_{jt} \equiv b \leq \phi a_t \tag{5}$$

The parameter $\phi \geq 0$ captures the degree of financial frictions and can be interpreted as reflecting constraints such as limited financial intermediation, as in Buera et al. (2011). The constraint spans economies with no credit ($\phi = 0$) and those with perfect credit markets ($\phi = 1$). As landholdings cannot be transacted, they do not serve as collateral.

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, $\bar{p}_t$, subject to incurring a fixed cost, ρ. The MSP is announced at the start of the period before any occupational choices are made and is higher than the market price.

The procured crops are redistributed freely among all households as rations, c^{ration}. We assume that the government is willing to purchase any quantity farmers wish to sell, 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.

In the benchmark economy, the price of the intermediate good, p_k includes the input subsidy. The removal of the input subsidy program will increase p_k and affect the farmer's spending on intermediate inputs and occupational choice.

Government expenditure on the MSP and input subsidy is financed by levying a lump sum tax τ on all agents in the economy, which can be interpreted as a tax on the aggregate consumption good. We do not model progressive income tax, as consumption taxes are the primary source of government revenue in India (Piketty & Qian, 2009). The government's budget constraint is specified in Appendix D.2 as part of the competitive equilibrium definition.

3.5 Utility maximization and Occupational choice

An agent with land endowment l 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_n, leading to labour earnings of $z_n w$. To ease notation, we shall denote the state vector (z_a, z_n, a, l) for an agent with sectoral shocks $\{z_a, z_n\}$, asset holding a and landholdings l by $(\mathbf{z}, a, l)$.

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

$$V^w(\mathbf{z}, a, l) = \max_{c_r, c_n, c_s, a'} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}'|\mathbf{z}} V(\mathbf{z}', a', l) \tag{6}$$

subject to:

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

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:

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

subject to:

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

Profits, $\Pi_r(z_a, a, l)$, of a cash crop farmer are derived from the profit maximization exercise subject to a working capital constraint:

$$\Pi_r(z_a, a, l) \quad = \quad \max_{k_r \leq \frac{\phi a}{p_k}} p_r(A z_a)\left[k_r^{\zeta}\, l^{\chi}\right] - (1 + \tilde{r})\, p_k k_r \tag{8}$$

Greater asset holdings directly impact intermediate input use by relaxing the working capital constraint.

Finally, 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 ($\hat{p}_s \in \{p_s, \bar{p}\}$):

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

subject to:

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

Conditional on receiving a price, $\hat{p}_s \in \{p_s, \bar{p}\}$, profits, $\Pi_s(z_a, a, l; \hat{p}_s)$ of a staple crop farmer accounting for the procurement choice and associated cost ρ is:

$$\Pi_s(z_a, a, l; \hat{p}_s) = \max_{k_s \leq \frac{\phi a}{p_k}} \hat{p}_s(A z_a)\left[k_s^{\zeta}\, l^{\chi}\right] - (1 + \tilde{r})\, p_k k_s - \mu(z_a, z_n, a)\rho \tag{10}$$

Consequently, $V^s(\mathbf{z}, a, l) = \max\{V^s(\mathbf{z}, a, l; p_s), V^s(\mathbf{z}, a, l; \bar{p})\}$, implying the procurement choices:

$$\mu(\mathbf{z}, a, l) = 1 \text{ if } V^s(\mathbf{z}, a, l; p_s) \leq V^s(\mathbf{z}, a, l; \bar{p}) \tag{11}$$

$$\mu(\mathbf{z}, a, l) = 0 \text{ if } V^s(\mathbf{z}, a, l; p_s) > V^s(\mathbf{z}, a, l; \bar{p}) \tag{12}$$

Given the timing of sectoral choice in our model, the value function $V(\mathbf{z}, a, l)$ is the maximum between the value of working in non-agriculture and the expected value of working in agriculture, $\tilde{V}^a(\mathbf{z}, a, l)$:

$$V(\mathbf{z}, a, l) = \max\{\tilde{V}^a(\mathbf{z}, a, l), V^w(\mathbf{z}, a, l)\} \tag{13}$$

The expected value function for agriculture is given by:

$$\tilde{V}^a(\mathbf{z}, a, l) = \mathbb{E}\max\{V^s(\mathbf{z}, a, l; \hat{p}_s) + e_s, V^r(\mathbf{z}, a, l) + e_r\} \tag{14}$$

where, e_s and e_r are the additively separable i.i.d. Type-I extreme value taste shocks with scale parameter ν that are associated with growing staple and cash crops, respectively[14].

Conditional on working in agriculture, the probability of being a staple crop farmer is:

$$\sigma(\mathbf{z}, a, l) = \frac{\exp\left(\frac{V^s(\mathbf{z},a,l;\hat{p}_s)}{\nu}\right)}{\exp\left(\frac{V^s(\mathbf{z},a,l;\hat{p}_s)}{\nu}\right) + \exp\left(\frac{V^r(\mathbf{z},a,l)}{\nu}\right)} \tag{15}$$

Finally, one can define the sectoral choice functions:

$$\omega(\mathbf{z}, a) \;=\; 1, \;\; \text{if } V(\mathbf{z}, a, l) = V^w(\mathbf{z}, a, l) \tag{16}$$

$$\omega(\mathbf{z}, a, l) \;=\; 0, \;\; \text{if } V(\mathbf{z}, a, l) = \tilde{V}^a(\mathbf{z}, a, l) \tag{17}$$

We define the agricultural productivity gap as the ratio of non-agricultural labour productivity to agricultural labour productivity:

$$\text{APG} = \frac{y_n}{p_s^* y_s + p_r^* y_r} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}} \tag{18}$$

where p_s^* and p_r^* refer to crop prices in the benchmark economy. We show below that the

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

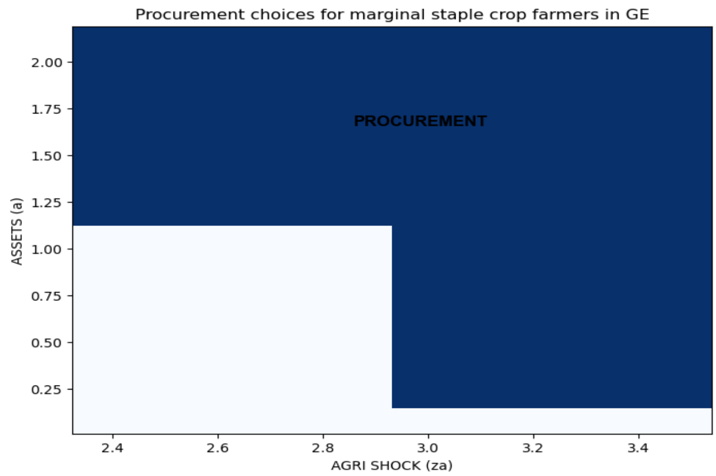
conclusions of the counterfactual exercises are robust to considering an alternate definition of APG based on value-added rather than output[15]. With fixed prices, subsidies influence the APG through two channels: (i) agricultural output via intermediate input intensity, and (ii) shaping individuals' sectoral employment choices (*selection effect*).

Below, we explore the factors behind a farmer's decision to participate in MSP and examine how assets influence cropping and sectoral choices. The mathematical derivations of the input choices are shown in Appendix D.1.

3.5.1 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. This pattern holds regardless of the size of an agent's landholdings. Figure 2 illustrates the procurement choice in blue for staple crop farmers with smallest landholdings. The asset threshold for opting into procurement decreases as farmers' productivity rises.

Figure 2: Procurement choices for staple crop farmers with marginal landholdings



[15] The value-added definition of APG is: $\frac{y_n}{p_s^* y_s + p_r^* y_r - p_k(k_s+k_r)} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}}$. We use the output-based definition of APG as the baseline because the value-added measure is mechanically influenced when analysing input subsidies.

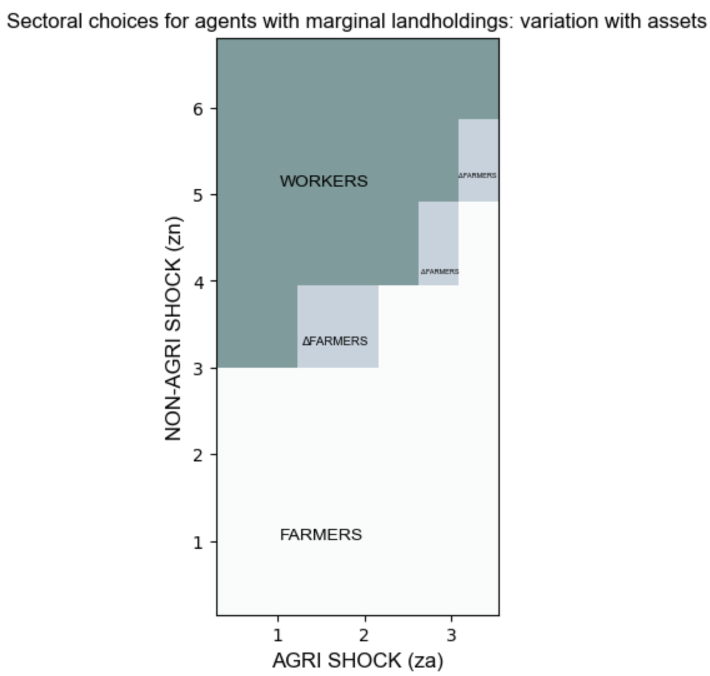
3.5.2 Role of assets in sectoral choices and input usage

We now consider the channels whereby assets influence outcomes like sectoral choice and intermediate input usage, and consequently APG. Asset holdings also influence the welfare gains or losses arising under various policies, which we discuss further in section 5.4.

Asset holdings influence sectoral choices through the working capital constraint, as represented in equation (5). As one would expect, agents with low asset holdings face tighter constraints on intermediate input use, which depresses their returns from agricultural production. Given comparable sectoral productivity draws, these agents are more likely to sort into non-agricultural work.

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 incomplete markets: 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 with marginal landholdings and their variation with assets



Asset holdings can also affect sectoral choices through the fixed cost of operating in the non-agricultural sector. 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 for agents with the smallest landholdings vary with asset holdings[16]. The gray bands labelled 'ΔFARMERS', which represent the transition to the agriculture sector by agents with higher asset holdings, are primarily 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 main factor driving those results.

In conclusion, studying the impact of agricultural subsidies through a dynamic model with assets allows for a richer set of mechanisms to affect the APG than a static model without assets.

3.6 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 government maintains a balanced budget and all markets must clear. The distribution of agents in the economy F evolves as per:

$$TF(\mathbf{z}', a', l) = \int_{\mathbf{z}\times A\times\mathbb{L}} \mathbb{I}_{\{a'(\mathbf{z},a,l)=a'\}} \; \Pi^a(z_a, z_a') \; \Pi^n(z_n, z_n') \; dF(\mathbf{z}, a, l) \quad \forall(\mathbf{z}', a') \in \mathbf{z} \times A \tag{19}$$

Here, $\mathbb{I}_{\{a'(\mathbf{z},a,l)=a'\}}$ is an indicator function that takes the value 1 when an agent with state $(\mathbf{z}, a, l)$ 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 conditions 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.

[16] Appendix Figure A3 shows that the variation in sectoral choice by landholdings for agents with intermediate asset holdings closely resembles Figure 3.

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:

$$Y_{dt} = \alpha + \phi_d + \phi_t + \boldsymbol{\beta}^{-1} \times \mathrm{T}_s \times 1_{\{2016 \leq t \leq 2017\}} + \boldsymbol{\beta} \times \mathrm{T}_s \times 1_{\{t=2019\}} + \varepsilon_{dt} \tag{20}$$

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 treated year 2019 and $\mathbf{1}_{2016 \leq t \leq 2017}$ is a dummy variable that takes value 1 for years before 2018. We exclude 2020 and future periods to ensure our estimates are not driven by the pandemic period, or the anticipation of West Bengal joining the program in 2021. β measures the average treatment of the outcome of interest: the log of the total value of nitrogen, phosphorous and potash fertilizers (see Appendix C for details on the datasets used.).

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%[17,18]. These results highlight

[17] Appendix Figures A4a and A4b shows the estimates using an event-study specification. The insignificant pre-treated effects imply that there were no differences in fertilizer use between the treated and control states.

[18] Appendix Table B1 shows the cash transfer program primarily 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

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 set to 0.05 so that the model matches the observed increase in aggregate intermediate input demand when farmers' cash-on-hand rises by 6.25%. This parameter value is quite close to Buera et al. (2021) ($\phi = 0.08$), who choose it to match an aggregate moment: the external finance to GDP ratio in India.

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.

Other internally calibrated parameters

We internally calibrate 10 other parameters. We describe the moment we target in the data to match them, although all of the moments are jointly targeted in equilibrium.

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

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.

and log non-agricultural income, respectively. The standard deviation and persistence of agricultural shocks are 0.36 and 0.4, 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 0.4 than the agricultural productivity shock, and is also much more persistent (0.78 versus 0.52).

Table 2: Internally calibrated parameters

Parameter	Value	Target/Source	Data	Model
Standard dev. of agricultural prod. shock σ_a	0.36	Variance of log crop harvest (ICRISAT VLS)	1.02	1
Standard dev. of non-agri shock σ_n	0.4	Variance of log non-agri income (ICRISAT VLS)	0.47	0.443
Persistence of agri prod. shocks ρ_a	0.52	First order auto-covariance of log harvest (ICRISAT VLS)	0.63	0.72
Persistence of non-agri prod. shocks ρ_n	0.78	First order auto-covariance of log non-agri income (ICRISAT VLS)	0.27	0.278
Subsistence requirement $\bar{c}$	0.01	Agricultural employment share in 2003 (RBI India KLEMS)	57.1%	58%
Fixed cost of procurement ρ	0.1127	Mean share of staple crops procured in 2000-09 (RBI)	26%	23%
Fixed cost of operating in non-agriculture ξ	0.52	Agricultural productivity gap in 2003 (RBI India KLEMS)	4.24	4.17
Working capital constraint ϕ	0.05	$\frac{\Delta(\sum_j k_j)}{\Delta\text{Income}}\vert_{\Delta\text{Income}=6.25\%}$	8.5%	6.57%
Scale parameter ν	0.8	Share of staple crop farmers (IHDS-I)	65.9%	57.3%
Share of agents with small landholdings	0.7	Share of farmers with small landholdings (Agricultural Census, 2010-11)	67%	64.1%
Share of agents with marginal landholdings	0.2	Share of farmers with marginal landholdings (Agricultural Census, 2010-11)	18%	22.8%

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)[19]. The fixed cost of procurement, ρ, is chosen to match the mean share of staple crops procured in the decade between 2000 and 2009, which is 26%. The operating cost associated with the non-agricultural sector, ξ, is chosen in order to match the APG of 4.24.

Finally, we allow for land endowments to take one of three values of $\mathbb{L} = \{1, \frac{1.42}{0.39}, \frac{3.61}{0.39}\}$. These grid points are chosen to match the average landholdings (in hectares) of *marginal* (less than

[19] IHDS-I is a nationally representative data that contains detailed questions on the types and value of crops grown. Appendix Figure A6 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.

1 hectare), *small* (between 1 and 2 hectare) and a weighted average of *semi-medium* (between 2 and 4 hectares) and *medium* (between 4 and 10 hectares) farmers, based on the 2010-11 Agricultural Census. The marginal farmers' average landholdings (0.39 hectares) are normalised to one. The shares of agents with marginal and small landholdings, $\{G_{l_0}, G_{l_1}\} = \{0.7, 0.2\}$, are estimated to match the empirical shares of farmers with marginal and small landholdings of 67% and 18%, respectively. Using three grid-points for landholdings provides a parsimonious representation of the empirical distribution in India, without substantially expanding the dimensionality of the state space.

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 agricultural production function parameters ζ and χ, which capture the intermediate input and land expenditure shares respectively, are both chosen to be 0.2, following Bolhuis et al. (2021).

Government expenditure on the input subsidy is calibrated to be equal to 1.25% of GDP, as discussed in Section 2. 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. Since, the Indian government subsidizes inputs, the intermediate price of $p_k = 1.56$ includes the implicit input subsidy. Lastly, the support price $\bar{p}$ is set to be $1.07 * p_s$, based on the empirical ratio of MSP to price received by farmers[20]. Combined, the two subsidies are

[20] We use the nationally representative Land and Livestock Holding Survey of 2018 (NSS 77$^{\text{th}}$ Round) to determine the price received by the farmer for rice or wheat. Price received is equal to the average value divided by the quantity sold. Appendix Figure A5 shows the distribution of price received to support price. Chatterjee et al. (2020)

financed through a lump-sum tax equivalent to 5% of GDP in the benchmark economy.

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 at the household level about the relationship between asset holdings and both intermediate input usage and harvest value. 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 exercise. First, the implied aggregate saving rate of the economy equals 25.4%, which is quite close to the 23.2% saving rate in 2004. Furthermore, our model replicates the pattern of saving rates being lower for agricultural than non-agricultural workers observed in household-level data reasonably well, with the non-agricultural saving rate being perfectly matched. This suggests that our choice of $\beta = 0.96$ generates empirically consistent savings behaviour. The model matches the transition rates from staple to cash crops and agriculture to non-agriculture sectors quite well. Finally, the model closely replicates the empirical income distribution of the bottom 10% and 50%, as reported in the World Inequality Database (WID) for the year 2005 (Chancel et al., 2022). This validates the calibration of the sectoral productivity shocks.

Table 3: Non-targeted moments

Moment	Source	Data	Model
Aggregate saving rate	World Bank	23.2%	25.4%
Agricultural saving rate	IHDS-I	15.9%	22.2%
Non-agricultural saving rate	IHDS-I	29.4%	29.76%
Transition rate between agriculture and non-agri sectors	ICRISAT VLS	6.41%	11.65%
Transition rate between staple and cash crop farmers	ICRISAT VLS	14.7%	13.83%
Income share of top 10%	WID	45.48%	27%
Income share of bottom 50%	WID	18.39%	21.4%
Income share of bottom 10%	WID	1.27%	1.95%

also reports that market price can fall below the support price in regions with low procurement of grains.

4.3.2 Relationship between assets, intermediate input usage and harvest value

We estimate the relationship between asset holdings and both intermediate input use and harvest value using model simulations and empirical 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 are run using data for households in periods where they choose the agricultural sector. We follow Donovan (2021) to obtain these relationships using the ICRISAT VLS data. Lagged asset holding is the primary independent variable instead of current to limit issues of reverse causality. We regress lagged asset holdings on intermediate input expenditure and harvest value, while controlling for village and year dummies, village-level time trends, and household characteristics (number of adult men, adult women and kids in the household, and gender, education, age and age squared of the household head) in the empirical regressions.

Appendix Table B2 demonstrates that the model successfully replicates the strong positive association between asset holdings and both input expenditure and harvest value in the data. Financial frictions and taste shocks in the model are key in generating the positive association between assets and input expenditure, which in turn positively relates with production.

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. We then proceed to by conducting a counterfactual exercise wherein we evaluate the equilibrium outcomes after eliminating the input price subsidy. Finally, we discuss the welfare implications of removing these programs.

5.1 Role of frictions and preferences

Note that the APG is defined as $\frac{y_n}{p_s^* y_s + p_r^* y_r} \frac{\text{Employment}_{\text{agri}}}{\text{Employment}_{\text{non-agri}}}$. 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	$\rho = 0$	$\phi = 1$	$\xi = 0$	$\theta = 1$	$\nu = 0.3$	$\{\chi, \zeta\} = \{0.1, 0.3\}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Share of non-agriculture workers	42.9%	42.6%	43.6%	46.9%	56%	47.4%	42.1%
Share of staple crop farmers in agriculture	57.3%	59.5%	57.1%	57.7%	50%	59.3%	58.6%
Share of staple crops procured	23.25%	100%	22.6%	55.35%	10.5%	32.5%	28.8%
Intermediate input usage	0.0487	0.0503	0.06	0.067	0.021	0.052	0.0756
Agricultural productivity gap	4.17	4.17	4.09	3.41	3.8	3.19	5.46
Labour productivity of non-agri sector†	3.53	3.55	3.43	3.3	2.89	3.77	3.69
Labour productivity of agricultural sector*	0.845	0.853	0.9	0.969	0.763	0.89	0.675
Labour productivity of cash crop sector	0.878	0.885	0.915	1	0.771	0.92	0.70
Labour productivity of staple crop sector	0.905	0.91	0.977	1.036	0.852	0.953	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 $\frac{p_r^* Y_r + p_s^* Y_s}{\text{Agricultural employment share}}$

First, 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 0.1127. Column (2) of Table 4 indicates that this leads to all staple crops being procured, raising the share of staple farmers in agriculture; while also leading to a marginally lower employment share of the non-agricultural sector. The influx of staple crop farmers drives down staple crop prices by 3%, while cash crop prices are raised slightly. Intermediate input usage rises slightly as all staple crop farmers avail of the support price, while cash crop farmers also earn a higher revenue. Higher intermediate input usage raises the labour productivity of agriculture. Non-agricultural labour productivity is also raised slightly, driven by the slightly lower non-agricultural employment share. Overall, removing the fixed cost of procurement has little effect on the APG.

We then consider the role of the working capital constraint. Eliminating this constraint, we find in Column (3) of Table 4 that intermediate input consumption by farmers rises, which raises the production of both crops and lowers their equilibrium prices. Together with the decline in the agricultural employment share, this leads to an increase in agricultural labour productivity. Labour productivity in the non-agricultural sector falls, driven mainly by the higher employment share in that sector. The APG falls by 1.92%.

Next, we drop the fixed cost associated with operating in the non-agricultural sector. Column (4) of Table 4 shows that the employment share of agriculture drops significantly (by 4 pp). Consequently, crop prices rise by around 50%, and a majority of staple producers choose procurement. Higher crop prices raise revenue and intermediate input usage. As one would expect, the sizeable drop in agricultural employment raises agricultural (staple and cash crop) labour productivity, while non-agricultural labour productivity falls significantly, leading to a 18.2% 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. Column (5) reports the results from this exercise. The higher elasticity of substitution lowers the agricultural employment share significantly (13.1 pp) due to higher demand for the cheaper non-agricultural good. The lower demand for agriculture goods results in significantly reduced crop prices, intermediate input use and agricultural productivity. The resulting decline in agricultural profitability, combined with the difficulty of affording the fixed cost of procurement, reduces the share of staple crop farmers within agriculture. Non-agricultural labour productivity also falls, driven mainly by the increase in the non-agricultural employment share. Overall, the APG declines relative to the benchmark by around 9%. The other preference parameters have limited effect on APG. Appendix Table B3 shows that removing the subsistence requirement or adjusting the staple and cash crop consumption shares to align with observed household expenditure patterns in India have little effect on the APG relative to the benchmark economy.

In order to assess the role of intra-temporal risk, we reduce the standard deviation of the taste shocks (ν). The results are reported in column (6). A decrease in the volatility of the taste shock lowers the expected value of agriculture, thereby reducing the agricultural employment share by 4.5 pp and share of cash crop farmers within agriculture by 2 pp. This results in a rise in crop prices, which encourages greater input use and increases agricultural productivity. The share of staple crop farmers rises slightly relative to the benchmark, driven by the higher crop prices leading to a greater ability of staple farmers to avail of the support price program, conditional on choosing agriculture. In equilibrium, APG decreases by 23.5%.

Finally, we reduce the importance of land in agricultural production by lowering the elasticity parameter χ in the agricultural production function to 0.1 from its benchmark value of 0.2. We adjust the elasticity parameter for the intermediate input, ζ, to be equal to 0.3 from its benchmark value of 0.2. These results are reported in column (7). As might be expected, raising the importance of the intermediate input in crop production raises intermediate input usage by 55% from its benchmark level. While sectoral employment shares are largely unchanged, we find that the agricultural productivity falls significantly by 20% from its benchmark value. This is driven by a decline in agricultural production relative to its benchmark value. By diminishing the importance of land, farmers need to use more of the intermediate input in order to produce crops, but are limited by their asset holdings due to the borrowing constraint they face. While crop prices do rise significantly to incentivize crop production, the overall effect is a rise in the APG by 30.9% relative to the benchmark.

In conclusion, we find that intra-temporal risk, the elasticity of substitution, the fixed cost of operating in the non-agricultural sector and the elasticity of agricultural production with respect to land are important factors in understanding the APG. A key point to note is that the quantitative effect of these frictions is conditional on the skill distribution. For example, Appendix Table B3 shows that reducing the sectoral productivity standard deviations to 0.1 nearly halves the APG relative to the benchmark. The reduction in the high values of individual productivity combined with the dampened precautionary motive has a significant effect on sectoral productivities and employment. Thus, other frictions would have an even bigger role in an economy with a high APG and a concentrated skill distribution.

5.2 Counterfactual exercise: removing the MSP

Table 5 displays the quantitative results obtained from removing the support price program (and hence the distribution of free rations) when prices are kept fixed (Column 2), and when prices can adjust in general equilibrium (GE) (Column 3); alongside equilibrium outcomes in the benchmark specification (Column 1).

Under fixed prices, the removal of the MSP reduces the staple farmers' profits and expected value from farming for staple and cash crop farmers. This leads to a modest labour reallocation of 2.3 pp towards the non-agricultural sector. Note that the higher benchmark equilibrium staple crop price (due to subsistence requirements for staple crop consumption and the higher expenditure share on staple than cash crops) still makes staple crop farming relatively profitable, particularly when the agent must compensate for the loss of rations through purchases at fixed market prices. Higher employment in the non-agricultural sector boosts non-agricultural output, resulting in higher aggregate real output. The overall quantitative effects are small under fixed prices, as the salience of the program is limited (the government procures 23% of the staple output in the benchmark equilibrium).

Table 5: Comparison of equilibrium outcomes upon removal of MSP

	Benchmark	No MSP (fixed prices)	No MSP (GE)
	(1)	(2)	(3)
Aggregate Quantities			
Aggregate Output, $\sum_j p_j Y_j$	1.997	2.016	1.989
Real Output†, $\sum_j p_j^* Y_j$	1.997	2.028	1.989
Non-agricultural Good, y_n	1.514	1.559	1.507
Cash Crop, y_r	0.214	0.2	0.216
Staple Crop, y_s	0.296	0.295	0.294
Rations, c^{ration}	0.069	0	0
Intermediate input demand, $k_s + k_r$	0.0487	0.047	0.0484
Capital demand, k_n	4.59	4.72	4.552
Labour productivity of non-agri sector‡	3.53	3.45	3.53
Labour productivity of agricultural sector	0.845	0.85	0.842
Labour productivity of cash crop sector	0.878	0.9	0.878
Labour productivity of staple crop sector	0.905	0.904	0.899
Tax, τ	0.0977	0.0977	0.025
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	0.889	0.889	0.889
Staple Crop, p_s	0.987	0.987	0.987
Support Price, $\bar{p}$	1.056	-	-
Interest rate, r	0.0122	0.0122	0.0126
Wage, w	1.168	1.168	1.166
Employment Shares			
Non-agricultural Sector	0.429	0.452	0.427
Cash Crop Farmers	0.244	0.222	0.246
Staple Crop Farmers	0.327	0.326	0.327

Note: †p^* represents prices in the benchmark
‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

In general equilibrium (column 3), staple crop prices are influenced by two offsetting forces. On the one hand, the increased market supply of staple crops – previously purchased by the government – exerts downward pressure on prices. On the other hand, the reduction in the tax burden (from 4.89% to 1.26% of GDP) boosts aggregate demand across all goods, putting upward pressure on prices. On net, these opposing forces offset each other completely, leaving crop prices unchanged.

The increase in household consumption and corresponding decline in savings raises the equilibrium interest rate, thereby decreasing capital demand in the non-agricultural sector. However, due to complementarities between capital and labour, the lower overall capital usage reduces the marginal product of labour, leading to a decline in labour demand and a slight reduction in wages.

Since crop and factor prices do not adjust significantly, there is minimal labour reallocation across occupations. The fall in agricultural employment keeping prices fixed is offset by an increase in the attractiveness of agriculture because agents become less risk-averse in GE. The lower tax burden raises agents' net worth, and note that conditional on receiving similar sectoral productivity shocks, less risk-averse individuals are more likely to select the riskier agricultural sector. The overall value of production, $\sum_j p_j y_j$, and real output are lower as the production of the two crops doesn't rise enough to offset the reduction in capital demand and size of the government budget.

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 is unchanged with the removal of the MSP program, as the fall in non-agricultural production is offset by the reduced employment share of that sector. The labour productivity of the cash crop sector is unchanged, as the slightly higher production of that crop balances the higher employment share of cash crop farmers when the support price is removed. The labour productivity of the staple crop sector falls by 0.67%, due to lower intermediate input use leading a slight increase in APG by 0.39%.

In conclusion, eliminating the MSP leads to an increase in the APG by reducing intermediate input use and agricultural productivity. However, the quantitative effects are small due to the limited salience of the MSP program and MSP not directly targeting the drivers of the APG.

5.3 Counterfactual exercise: removing the input subsidy

Table 6 displays the quantitative results obtained from eliminating the input subsidy when prices are kept fixed (Column 2) and when prices adjust in general equilibrium (GE) (Column 3) alongside equilibrium outcomes in the benchmark specification (Column 1). Removing the input subsidy corresponds to raising the input price by around 33%.

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 rises by 33%, intermediate input usage falls by around 31% from its benchmark value, which lowers the production of

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

	Benchmark	No subsidy (fixed prices)	No subsidy (GE)
	(1)	(2)	(3)
Aggregate Quantities			
Aggregate Output, $\sum_j p_j Y_j$	1.997	2.279	2.003
Real Output†, $\sum_j p_j^* Y_j$	1.997	2.01	1.946
Non-agricultural Good, y_n	1.514	1.574	1.472
Cash Crop, y_r	0.214	0.189	0.209
Staple Crop, y_s	0.296	0.269	0.291
Rations, c^{ration}	0.0689	0.0485	0.074
Intermediate input demand, $k_s + k_r$	0.0487	0.0334	0.0395
Capital demand, k_n	4.59	4.77	4.494
Labour productivity of non-agri sector‡	3.53	3.44	3.62
Labour productivity of agricultural sector	0.845	0.8	0.799
Labour productivity of cash crop sector	0.878	0.833	0.829
Labour productivity of staple crop sector	0.905	0.853	0.855
Tax	0.0977	0.0977	0.0879
Input price	1.56	2.072	2.072
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	0.8896	0.8896	0.9955
Staple Crop, p_s	0.987	0.987	1.11
Support Price, $\bar{p}$	1.056	1.056	1.187
Interest rate, r	0.0122	0.0122	0.0113
Wage, w	1.168	1.168	1.173
Employment Shares			
Non-agricultural Sector	0.429	0.457	0.407
Cash Crop Farmers	0.244	0.227	0.252
Staple Crop Farmers	0.327	0.315	0.341

Note: $\dagger p^*$ represents prices in the benchmark
$\ddagger$Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

both crops by around 10%. The lower ensuing profit margins for farmers lead to an increase in non-agricultural employment of 2.8 pp. 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. The fall in supply of agricultural goods mandate an upward adjustment in crop prices to incentivize crop production: the reduction in intermediate input usage is partly compensated by adding more agents in the agricultural sector in order to boost crop production. The lower tax burden of around 10%

increases households' cash-on-hand and boosts demand for both the cash crop and the non-agricultural good. Market demand for staple crops actually falls, due to a 7.4% increase in the ration disbursed[21].

The significant rise in staple and cash crop prices (by around 12%) compensate for the higher intermediate input prices, leading to a labour reallocation towards the agriculture sector by 2.2 pp, although the reduction in intermediate input usage lowers crop production.

The falling employment share of the non-agricultural sector lowers capital demand in spite of lower interest rates relative to the benchmark. Wages rise as a consequence of reduced labour supply to the non-agricultural sector. Overall, the decline in non-agricultural good production outweighs the slight increase in agricultural production. Hence, real output, computed using benchmark equilibrium prices, declines by 2.5%.

The reduced employment share of the non-agricultural sector dominates the decline in non-agricultural production, leading to higher non-agricultural labour productivity by 2.5%. Labour productivity in the cash and staple crop sectors decline by around 5.4% because the increase in employment share is not matched by a commensurate increase in agricultural production due to lower intermediate input use. Taken together, the APG rises by 8.5% both due to the fall in non-agricultural employment and agricultural intermediate input use.

Our qualitative findings are not primarily driven by the magnitude of the input price increase. Even partial reductions in input subsidies – reflected in input price increases of 13% and 20%, compared to a 33% increase under complete removal – increase the APG, as shown in Appendix Table B4.

In conclusion, removing either policy reduces agricultural productivity and increases the APG. Furthermore, APG also rises if we had computed it using the value-added approach rather than the output approach. APG using the value-added approach rises by 0.3% and 10.6% when the MSP policy and the input subsidy policy are removed, respectively. Lastly, removing both policies simultaneously also reduces agricultural productivity and increases APG, as shown in Appendix Table B5. The decline in agricultural productivity is slightly smaller in the counterfactual where both policies are removed, compared to the scenario with only the input subsidy withdrawn. This is because the removal of the MSP and rations program increases market de-

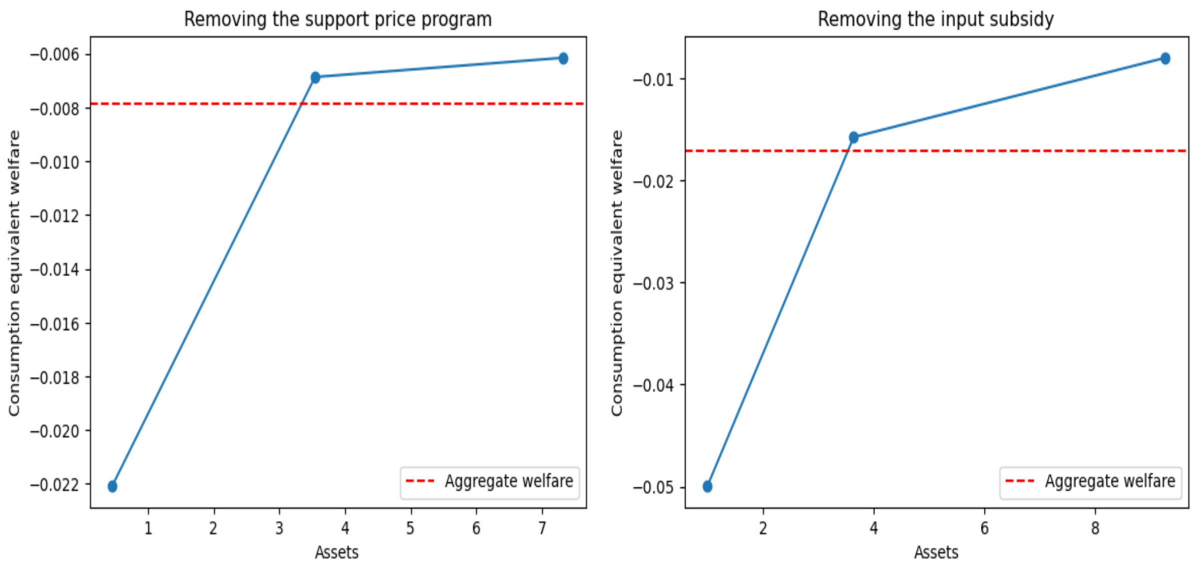
[21] The lower tax burden increases the share of crops that the farmers sell to the government. However, we fix rations to not exceed 30% of household staple crop consumption to be consistent with the policy in India. The amount procured by the government in excess of rations is sold on the market, which limits the rise in government expenditure.

mand and price of the staple crop, which partially offsets the productivity loss in agriculture.

5.4 Welfare

We next investigate the effect of each subsidy policy on welfare. We define an aggregate consumption equivalent measure of welfare based on Buera and Shin (2011). The welfare cost is expressed in units of permanent consumption compensation necessary to make the average individual indifferent between the status quo (the benchmark stationary equilibrium) and the counterfactual equilibrium. Additionally, we compute the welfare measure for three asset levels (low, medium, and high). Appendix Section D.3 provides details about the definition.

Figure 4: Welfare losses by asset levels



(a) Removal of MSP

(b) Removal of input subsidy

Figures 4a and 4b depict that the removal of both policies result in welfare gains for individuals at each asset level. Consider first the increase in welfare from the removal of the MSP policy, which is 0.8% across all households. Note that removing the MSP has negligible effect on crop prices. The boost in cash-on-hand due to a lower tax burden is more than the loss of staple rations, leading to welfare gains for all households. The lower tax burden disproportionately benefits households with lower asset holdings, resulting in a 1.6 pp difference in welfare gains between the low- relative to the high-asset groups.

The removal of the input subsidy leads to a 1.7% increase in welfare across all agents (Figure 4b). The removal of the subsidy increases crop prices by around 12%. However, the lower tax burden increases consumption, in turn leading to an increase in welfare. Furthermore, the lower tax burden allows more staple farmers to afford paying the cost of selling staple produce to the government. This leads to more rations being distributed by the government (an increase of 7.4% relative to the benchmark ration received). Lastly, welfare gains for low-asset households are significantly higher than those for high-asset households.

We also compare welfare gains by land endowments rather than by asset holdings. Appendix Figures A7a and A7b show that welfare gains are higher for households with lower land-holdings when the support price is removed, but the pattern is reversed when the input subsidy is removed. This is driven by the fact that agents with high land holdings are typically farmers, who benefit from higher crop prices and lower taxes. Lastly, we also consider welfare gains by occupation (Appendix Table B6). A consistent pattern emerges across both counterfactuals: welfare gains are higher for staple and cash crop farmers than non-agricultural workers[22]. As crop prices outpace wage growth in both counterfactual scenarios, farmers experience larger income and welfare gains relative to non-agricultural workers. Appendix Figures A8a and A8b affirm that these patterns hold across all asset levels.

5.5 Discussion

Overall, our findings reveal that removing either policy hurts agricultural productivity and amplifies the APG, but boosts welfare. We next examine the robustness of these findings under alternative tax-financing schemes, compare our results with related literature, and explore alternative policies that avoid the trade-off between productivity enhancement and welfare.

5.5.1 Robustness of model counterfactual results

A key factor driving the demand for non-agriculture good following the lower tax-burden is due to a risk aversion (θ) of 2, or elasticity of substitution ($1/\theta$) equal to 1/2. We dampen the risk-aversion channel by considering a unit elasticity of substitution (θ) = 1. Appendix Table B7 shows that the selection effect of removing the input subsidy is almost fully offset. Employment shares do not change, but agricultural productivity falls by around 10% due to lower input use. Non-agricultural productivity remains unchanged implying a rise in APG of 10.9%, which is close to our baseline finding.

[22] Note that the welfare measure characterizes agents by their occupation in the benchmark economy. If agents sort into a different occupation in the counterfactual exercises as incomes change, this is accounted for when computing the welfare gains.

A potential concern is that we may overstate the welfare gains from policy removal, since the tax burden of these programs falls on all individuals in the benchmark. While labour income tax in India is progressive, it constitutes only a small share of total tax revenue, as previously noted. To address this concern, we consider an alternative economy in which at least half of the tax revenue is raised through a labour income tax on non-agricultural workers that is capped at a rate of 3%. Appendix Table B8 shows that our qualitative conclusions are broadly unchanged: removal of either policy improves welfare, while not improving agricultural productivity. Thus, our results remain robust to alternative methods of financing the subsidies.

5.5.2 Comparison of model results with literature

The most closely related study, Mazur and Tetenyi (2023), also finds that removing input subsidies reduces agricultural productivity while improving welfare. However, in contrast to their results, we find that a reduction in input subsidies *increases* the APG through a fall in the non-agricultural employment share.

While the model environment in their paper differs from ours in several respects, the key distinction lies in the type of friction driving the APG – specifically, a transaction cost associated with staple crop purchases[23]. This friction raises the relative cost of purchasing staples compared to producing them, leading to a high proportion of unproductive staple farmers and, consequently, a large APG. 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)[24]. Furthermore, consistent with the predictions of our model, Diop (2022) finds an increase in migration to urban areas following the introduction of a large-scale input subsidy program in a different setting (Zambia). Overall, this highlights the impact of policies and their external validity crucially depends on the types of frictions driving the APG.

[23]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 model does not feature crop-specific taste shocks.

[24]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).

5.5.3 Welfare-enhancing and APG improving policies

The results so far strongly indicate that reducing the tax burden is important to increasing welfare. Additionally, our results in Section 5.1 suggest that reducing barriers to work in the non-agriculture sector is a crucial driver of the APG. To encourage movement out of agriculture and boost the APG, we consider a conditional cash transfer that individuals choosing the non-agriculture sector can avail, similar to the migration subsidies examined in Bryan et al. (2014) and Lagakos et al. (2023).

We consider an economy with no agricultural subsidy, but rather a lump sum transfer from farmers to individuals who choose to work in non-agriculture of 0.06. Appendix Table B9 shows that such a policy increases the non-agricultural employment share by around 1.5 pp relative to the benchmark and raises the APG by around 0.45%. Welfare also improves slightly due to the lower tax burden in the counterfactual relative to the benchmark of 0.0977. The increase in welfare is small as some gains are offset by higher prices and loss of rations. Though the gains in welfare and APG are modest, this exercise illustrates that policies encouraging transition out of agriculture while simultaneously lowering the tax burden can jointly enhance welfare and reduce the APG.

6 Empirical validation of model counterfactuals

In this section, we present empirical evidence that supports the model's predictions. We begin by examining the effects of a reduction in input subsidies, followed by analysing the impact of the 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 the 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. Following Garg and Saxena (2022), we use a continuous difference-in-differences (DiD) framework to analyze the effect of the policy.

$$\begin{aligned} Y_{dt} &= \alpha + \phi_d + \phi_t + \boldsymbol{\beta} \times \text{Treatment intensity}_d \times \text{Post}_t \\ &+ \boldsymbol{\beta}^{-1} \times \text{Treatment intensity}_d \times \text{Pre}_t + \gamma X_{dt} + \varepsilon_{dt} \end{aligned} \tag{21}$$

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[25]. 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[26].

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[27]. Staple crops includes cereals and pulses, whereas cash crops includes oilseeds, fibre crops, sugarcane and tobacco.

Column 1 of Table 7 shows that agricultural output fell more in areas that experienced a greater reduction in fertilizer subsidy. This result is consistent with studies in other countries analysing the impact of fertilizer subsidies on agriculture (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[28]. Lastly, the insignificant coefficients associated with the pre-treatment periods and treatment intensity

[25] 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.

[26] Appendix Figures A9a and A9b 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.

[27] 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.

[28] Appendix Table B10 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 A10 and A11 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.

imply a lack of meaningful pre-trends in output between high and low fertilizer use areas.

Table 7: Effect of fertilizer deregulation on agricultural production

Dependent variables: Log Output			
	All (1)	Cash Crops (2)	Staple Crops (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 8 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[29]. 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[30].

The empirical results align with the model's predictions that a reduction in input subsidy raises prices of agriculture goods in GE. However, the empirical and model implied change in outcomes from an increase in input price are not directly comparable, as the β in a continuous DiD setting does not capture the *level* treatment effect as in the model (Callaway et al., 2024).

6.2 MSP

We will use two factors in our empirical approach to test the effect of higher price support on agricultural output. First, farmers know the support price, as it is announced at the start of the cultivation season. Second, the quantity procured by the government varies at the state level.

[29] 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.

[30] Appendix Figure A12 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.

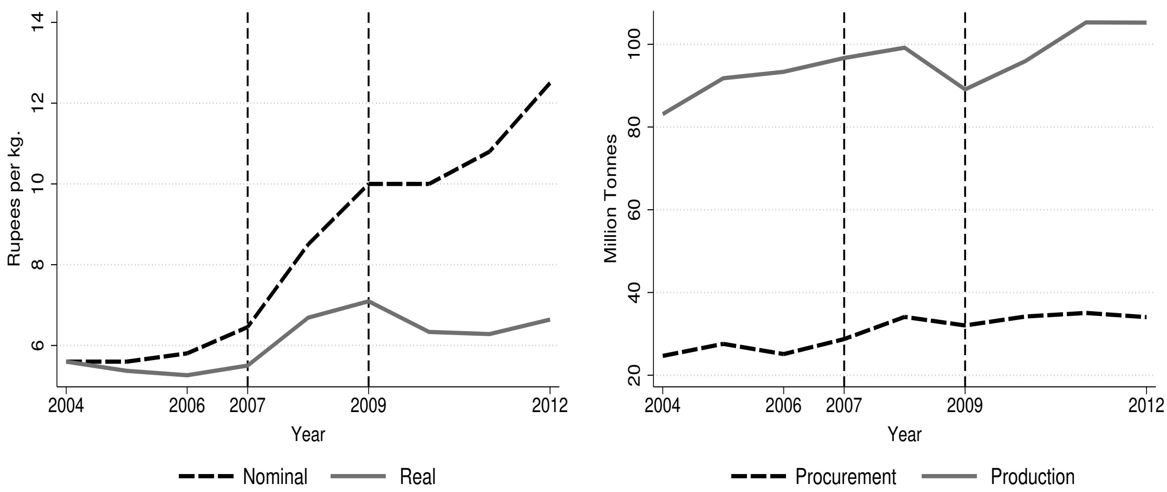
Table 8: Effect of fertilizer deregulation on agricultural prices

Dependent variables: Log Price			
	All (1)	Cash Crops (2)	Staple Crops (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% and 10% levels, respectively.

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 rice 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 A13 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, whereas a state like West Bengal procures less than 7% of its output even though it contributes to around 17% of India's rice production[31].

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

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

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[32,33]. We control for the logarithm of annual rainfall and logarithm of irrigated area to account for trends by district and year that can influence agricultural production.

Table 9 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 B11 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 B11 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).

[31]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.

[32]We drop Tamil Nadu and Rajasthan because their procurement policy changed substantially during this period.

[33]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 9: 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. ** represents the statistical significance at the 5% level.

7 Conclusion

This article examines the productivity and welfare consequences of policies that provide output subsidies for staple crops and intermediate 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 price subsidies for the agricultural sector that are financed through taxes. Our results indicate that these policies impact the APG through distinct channels: *selection* and intermediate input use. Eliminating either policy hurts agricultural productivity and increases the APG. Removing the policy dampens intermediate input use and increases agricultural employment in GE. Counterfactual exercises reveal that welfare gains arise from abolishing the programs due to lower tax burden on individuals. The quantitative effects are small when eliminating the MSP due the limited salience of the program and its limited direct effect on key drivers of the APG. Overall, this study highlights that agricultural policy interventions can create tensions between productivity improvements and welfare gains.

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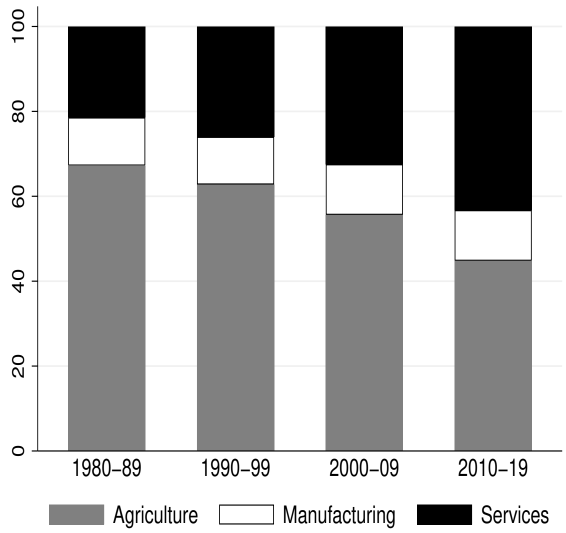
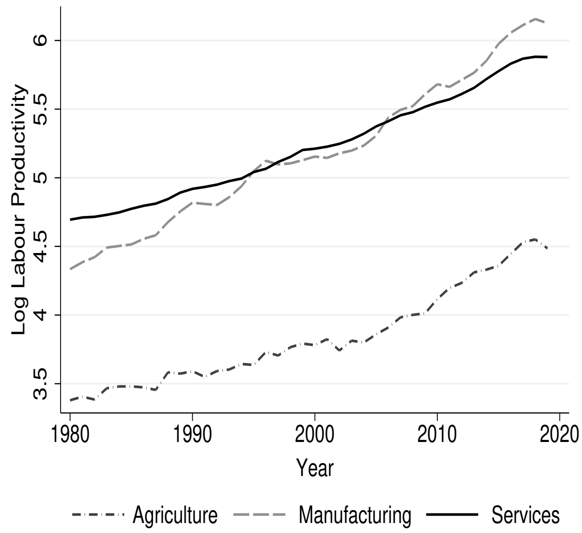
Appendix

A Additional Figures

Figure A1: Employment shares and labour productivity in India by sectors



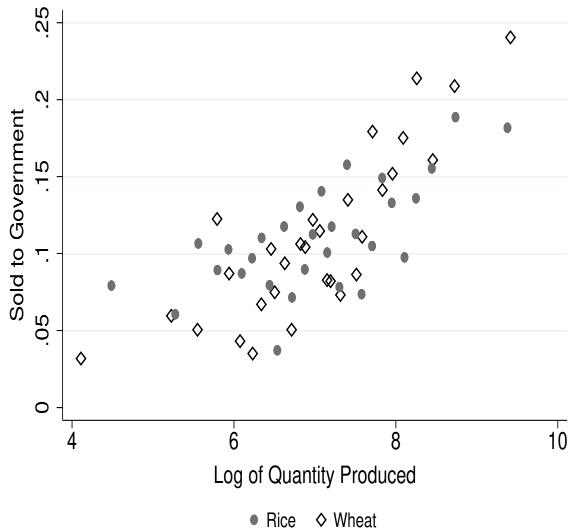
(a) Employment Shares



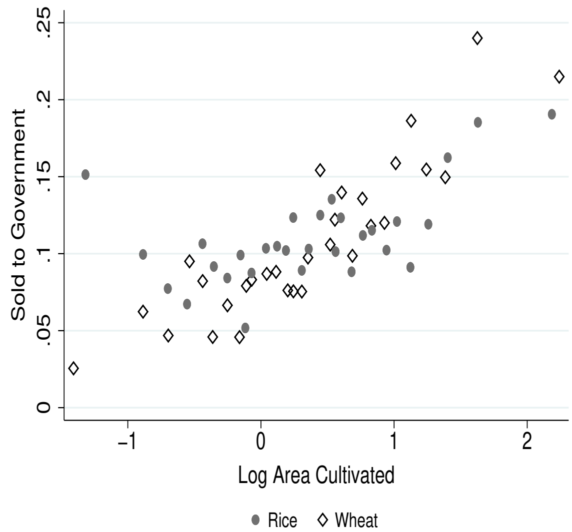
(b) Labour Productivity

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

Figure A2: Incomplete penetration of MSP: controlling for state fixed effects



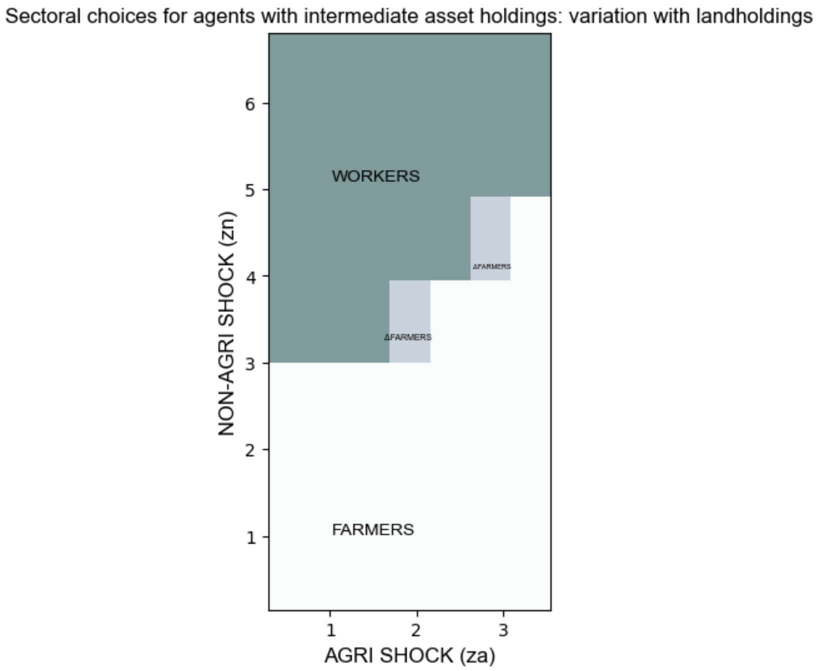
(a) Log quantity produced



(b) Log area cultivated

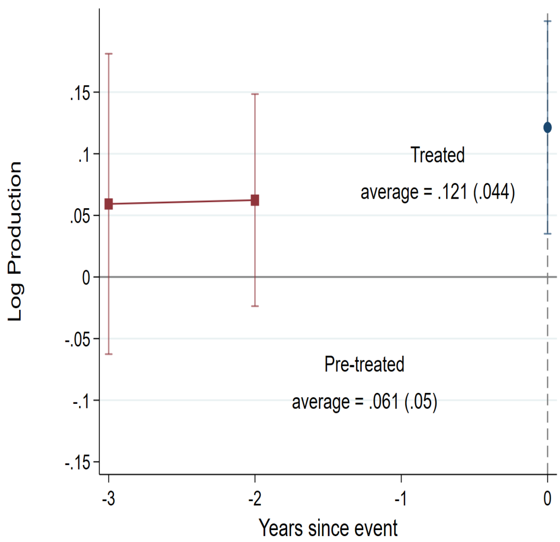
Note: The y-axis is an indicator variable taking the value 1 if output sold to a government agency. The x-axis is log quantity produced and log total area cultivated for left- and righ-hand side, respectively. Both plots control for state dummies and use 30 quintiles for each crop. The figure uses the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

Figure A3: Sectoral choices for agents with intermediate assets and their variation with landholdings

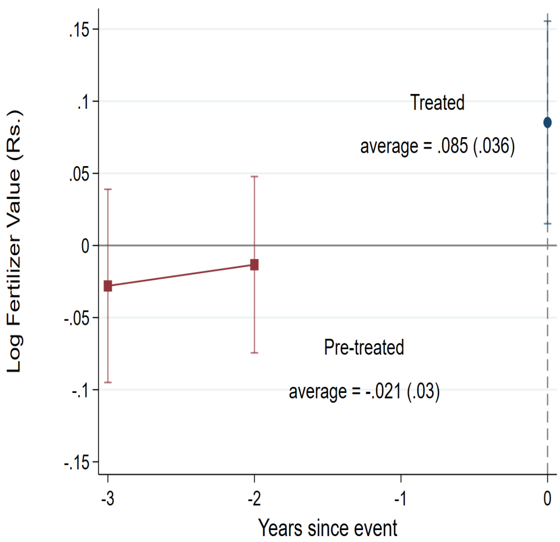


Note: Sectoral choices compared across agents with small and medium landholdings.

Figure A4: 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 A5: Distribution of market price of rice and wheat to MSP

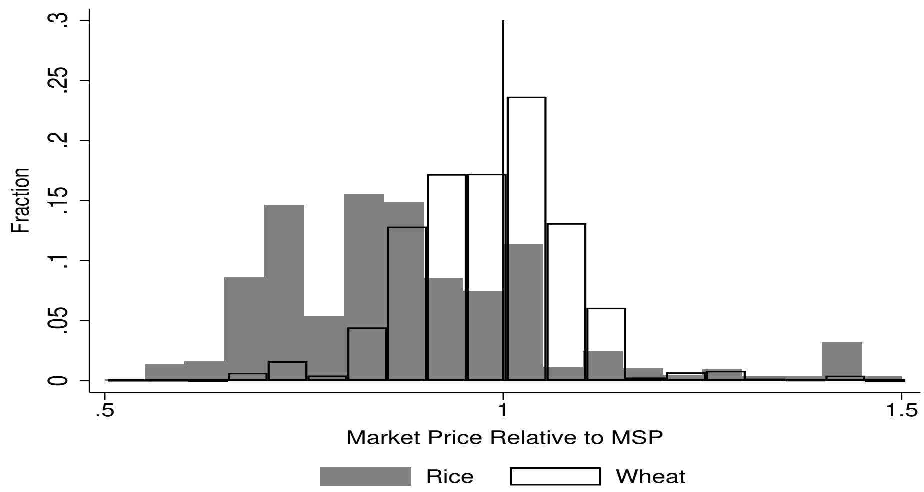


Figure A6: Distribution of the share of area devoted to staple crops

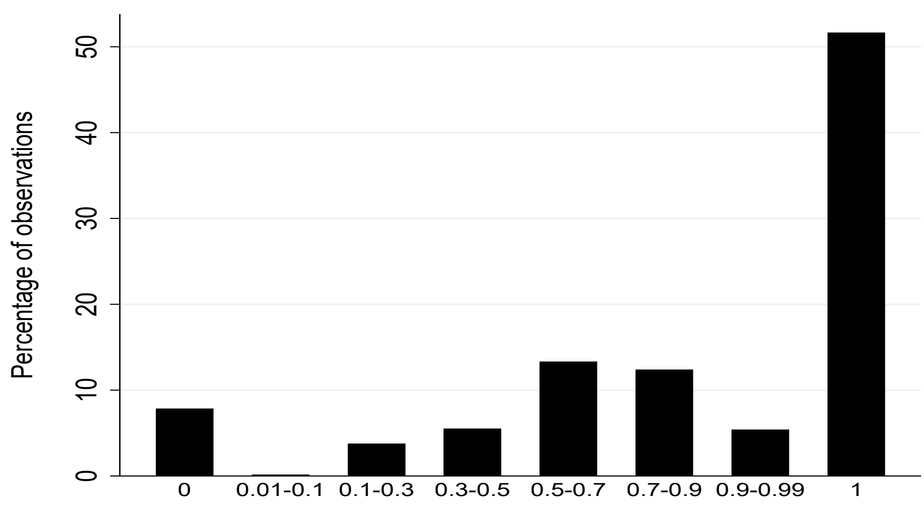
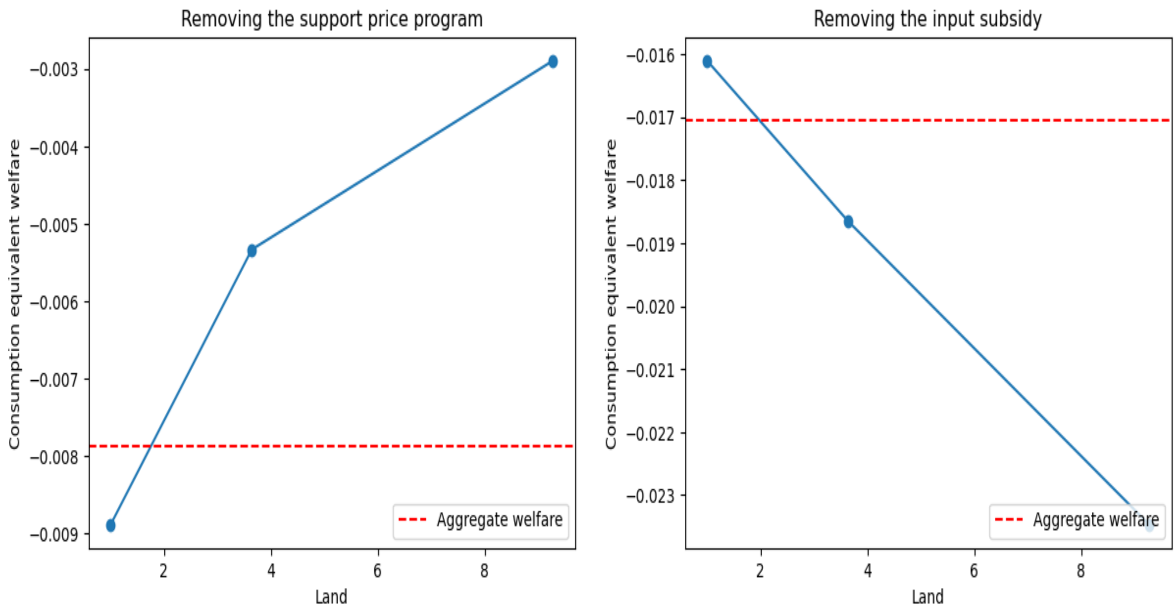


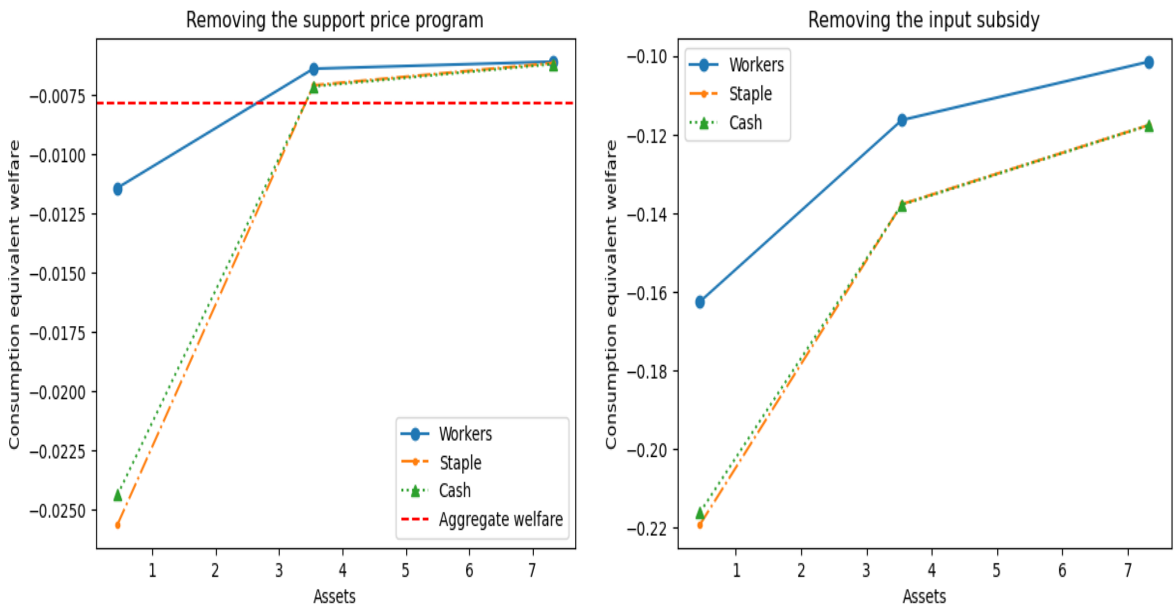
Figure A7: Welfare losses by landholdings



(a) Removal of MSP

(b) Removal of input subsidy

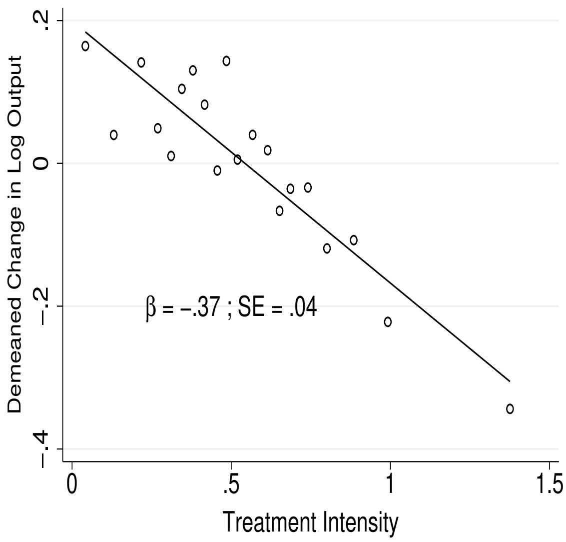
Figure A8: Welfare losses by asset levels and occupations



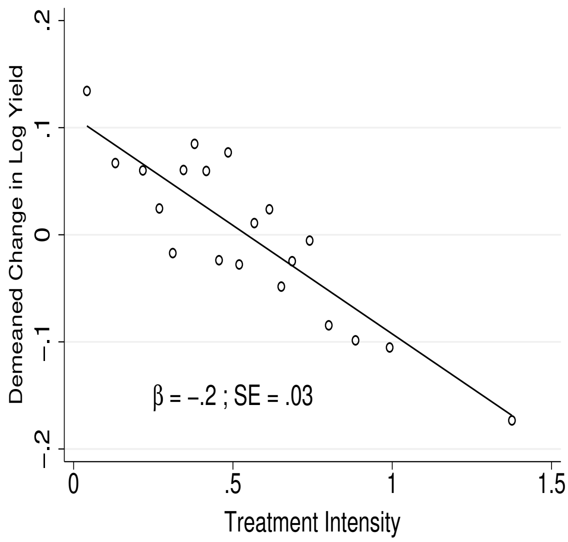
(a) Removal of MSP

(b) Removal of input subsidy

Figure A9: Binscatter of change in agricultural production and yield before and after the policy by quantiles of treatment intensity

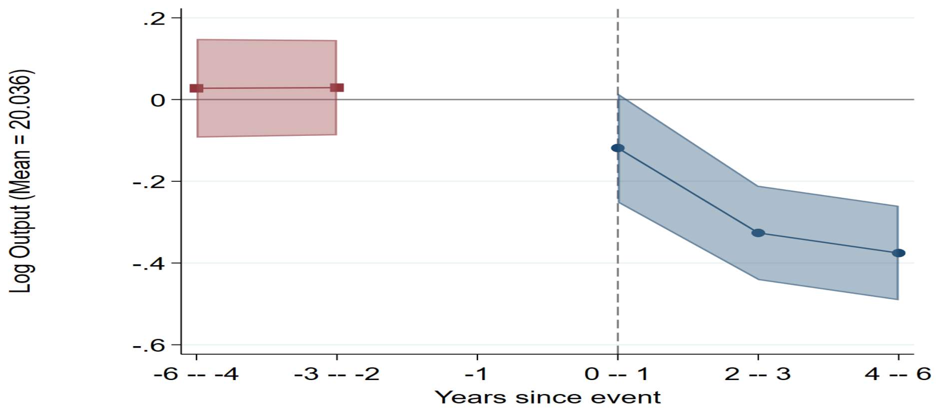


(a) Production

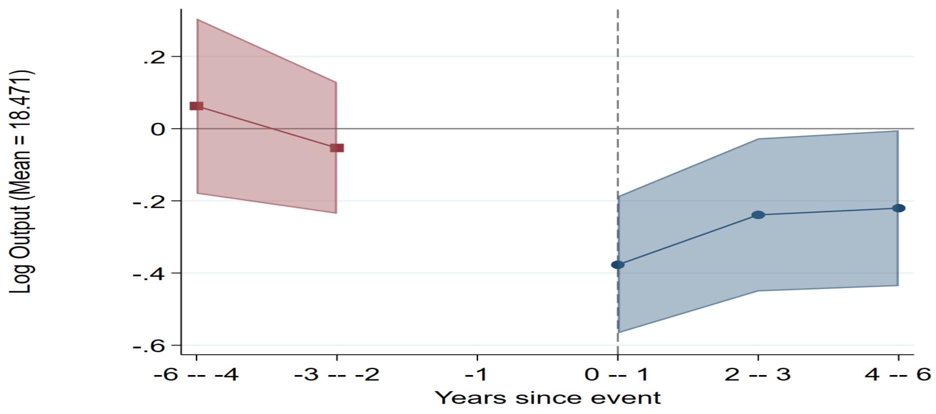


(b) Yield

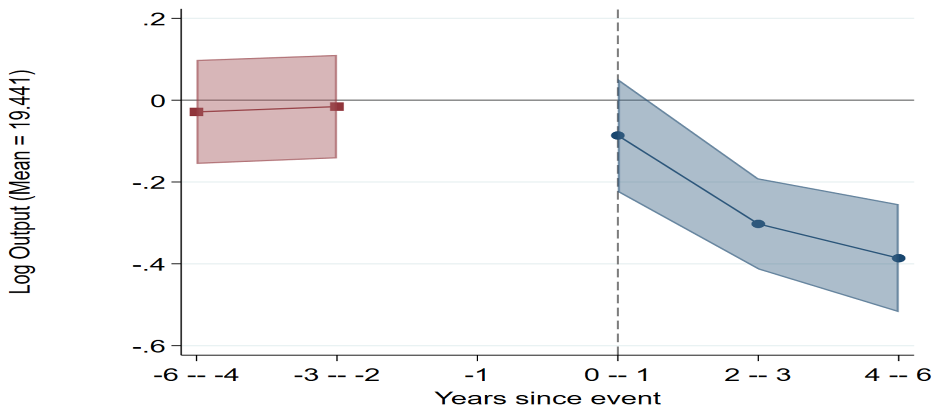
Figure A10: Effect of fertilizer price deregulation on agriculture output



(a) All



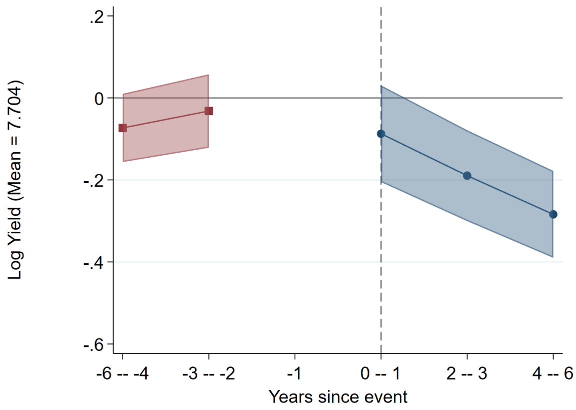
(b) Cash



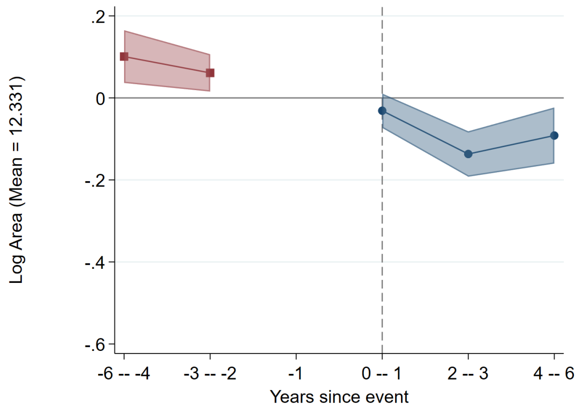
(c) Staples

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.

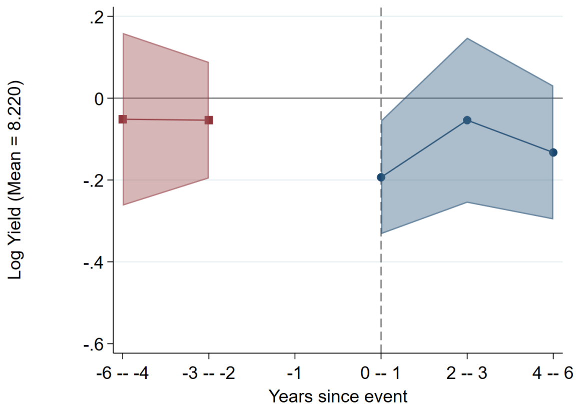
Figure A11: Effect of fertilizer price deregulation on agriculture yield and area



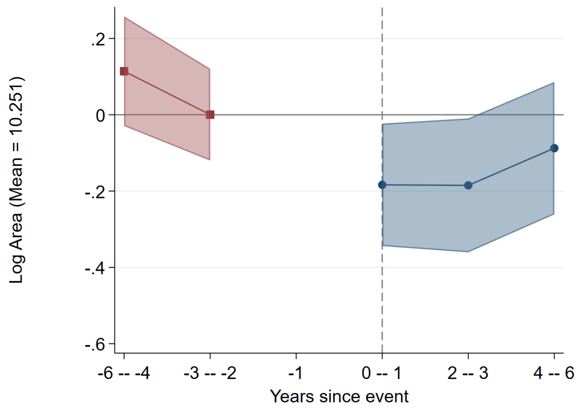
(a) All: Yield



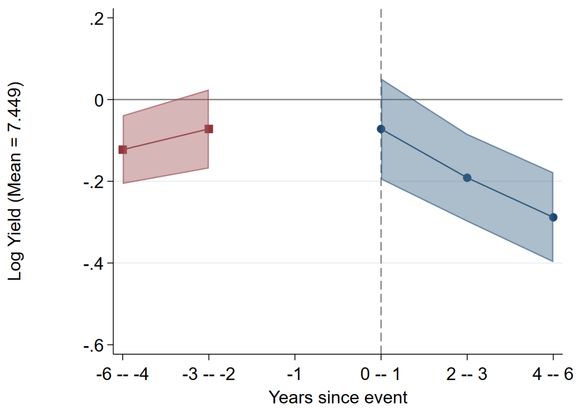
(b) All: Area



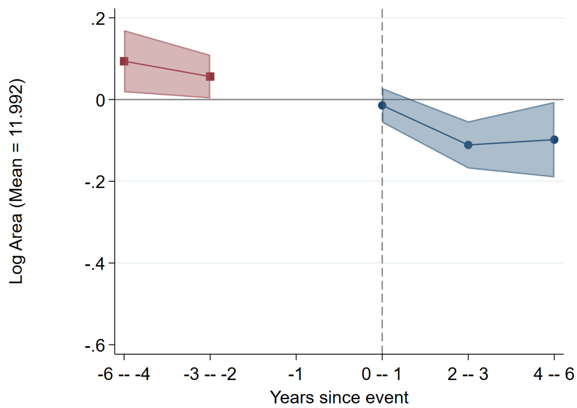
(c) Cash: Yield



(d) Cash: Area



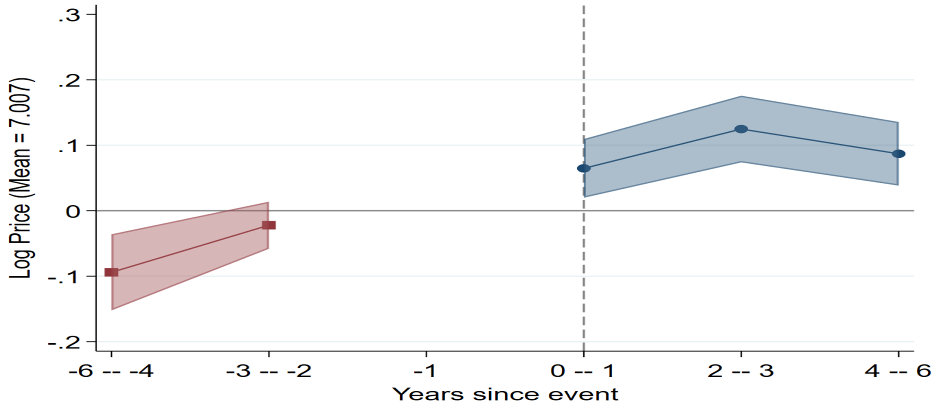
(e) Staples: Yield



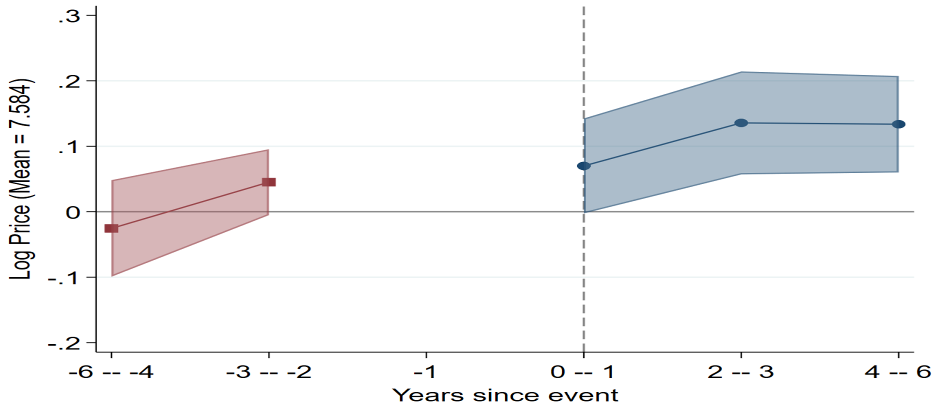
(f) Staples: Area

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.

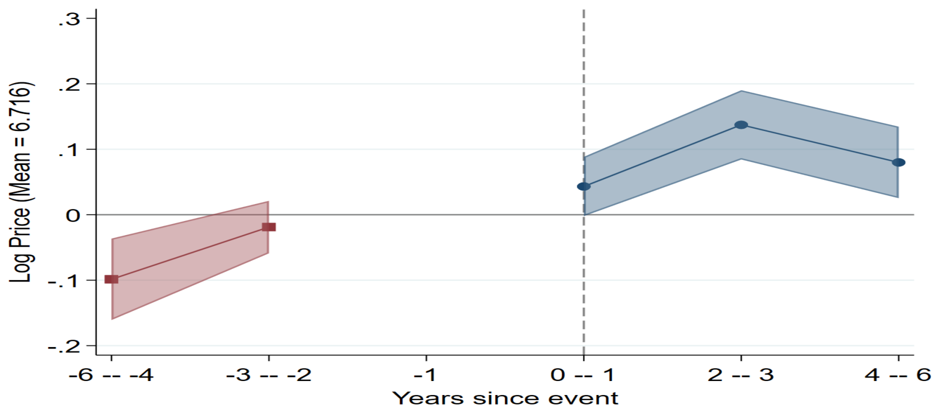
Figure A12: Effect of fertilizer price deregulation on agriculture prices



(a) All



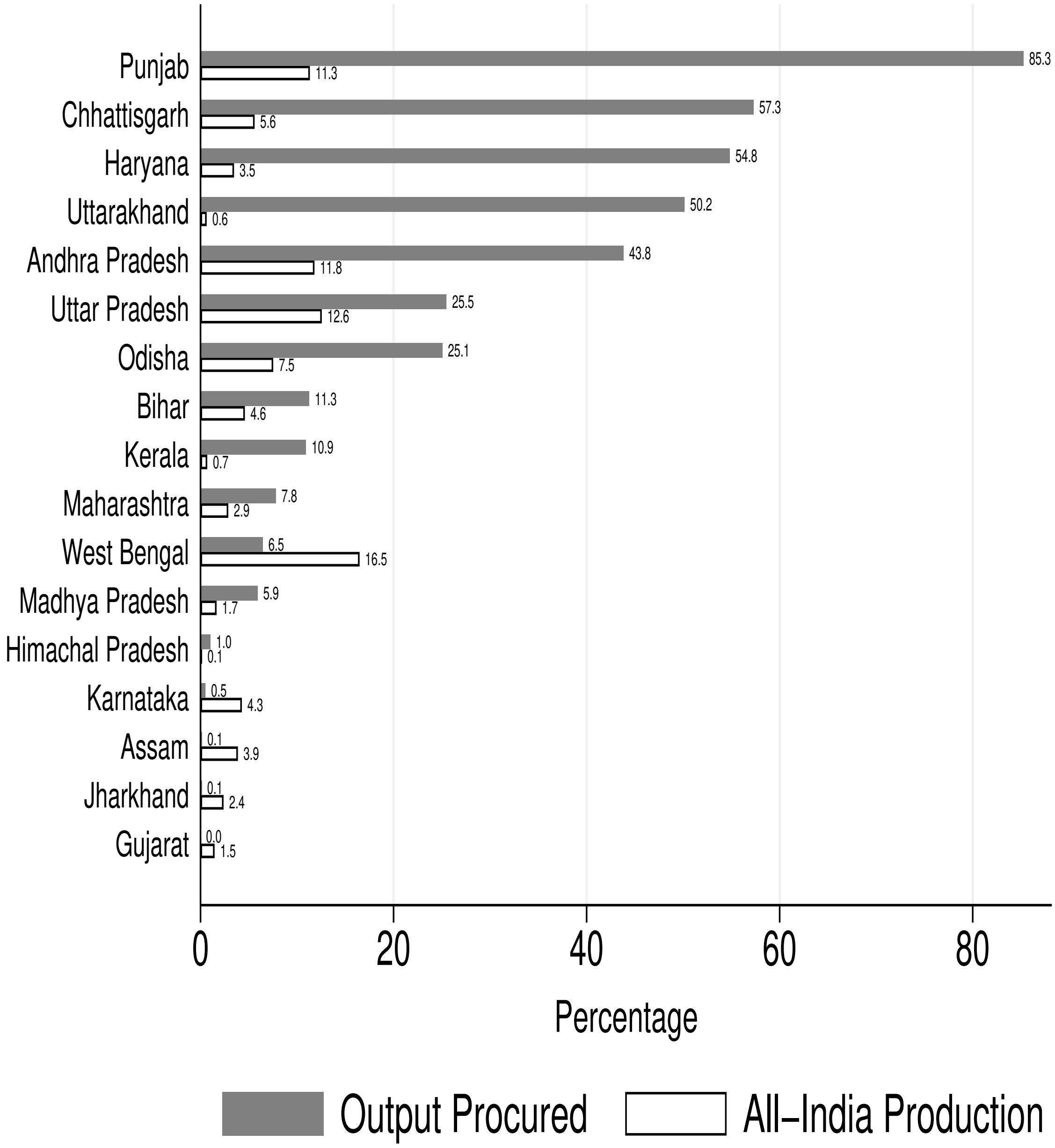
(b) Cash



(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 A13: 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.) (1)	Nitrogen (kg) (2)	Phosphorous (kg) (3)	Potash (kg) (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 (1)	Model (2)	Data (3)	Model (4)
Saving	0.414***	0.568***	0.382***	0.232***
	(0.066)	(0.022)	(0.080)	(0.021)
Observations	2390	n.a.	2390	n.a.
R^2	0.335	0.325	0.334	0.055

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: Change in outcomes with alternate frictions and preferences

Outcome	Benchmark	$\bar{c} = 0$	$\{\phi_s, \phi_r\} =$ $\{0.22, 0.18\}$	$\{\sigma_a, \sigma_n\} =$ $\{0.1, 0.1\}$
	(1)	(2)	(3)	(4)
Share of non-agriculture workers	42.9%	42.7%	36.9%	59.6%
Share of staple crop farmers in agriculture	57.9%	57.1%	52%	60%
Share of staple crops procured	23.25%	23.2%	53.4%	0%
Intermediate input usage	0.049	0.049	0.077	0.03
Agricultural productivity gap	4.17	4.19	4.38	2.33
Labour productivity of non-agri sector†	3.53	3.53	3.895	1.77
Labour productivity of agricultural sector*	0.845	0.843	0.89	0.76
Labour productivity of cash crop sector	0.878	0.876	0.908	0.809
Labour productivity of staple crop sector	0.905	0.903	0.981	0.8

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 $\frac{p_r^* Y_r + p_s^* Y_s}{\text{Agricultural employment share}}$

Table B4: Equilibrium outcomes in benchmark and following input subsidy reduction

	Benchmark (p_k = 1.56)	Low subsidy (p_k = 1.762)	Low subsidy (p_k = 1.865)	No subsidy (p_k = 2.0725)
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output, $\sum_j p_j Y_j$	1.997	2	1.998	2.003
Real Output† , $\sum_j p_j^* Y_j$	1.997	1.976	1.964	1.946
Non-agricultural Good, y_n	1.514	1.497	1.488	1.472
Cash Crop, y_r	0.214	0.204	0.213	0.209
Staple Crop, y_s	0.296	0.302	0.29	0.291
Rations, c^{ration}	0.0689	0.0746	0.07	0.074
Intermediate input demand, $k_s + k_r$	0.0487	0.0445	0.0425	0.0395
Capital demand, k_n	4.59	4.55	4.52	4.494
Labour productivity of non-agri sector‡	3.53	3.559	3.575	3.62
Labour productivity of agricultural sector	0.845	0.827	0.815	0.799
Labour productivity of cash crop sector	0.878	0.854	0.847	0.829
Labour productivity of staple crop sector	0.905	0.886	0.873	0.855
Tax	0.0977	0.0974	0.089	0.0879
Input price	1.56	1.762	1.865	2.072
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	0.8896	0.92	0.955	0.9955
Staple Crop, p_s	0.987	1.046	1.056	1.11
Support Price, $\bar{p}$	1.056	1.12	1.13	1.187
Interest rate, r	0.0122	0.0119	0.0119	0.0113
Wage, w	1.168	1.17	1.17	1.173
Employment Shares				
Non-agricultural Sector	0.429	0.42	0.416	0.407
Cash Crop Farmers	0.244	0.239	0.25	0.252
Staple Crop Farmers	0.327	0.341	0.332	0.341

Note: $\dagger p^*$ 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: Comparison of equilibrium outcomes

	Benchmark	No MSP	No Input subsidy	No MSP and No Input subsidy
	(1)	(2)	(3)	(4)
Aggregate Quantities				
Aggregate Output, $\sum_j p_j Y_j$	1.996	1.989	2.003	1.993
Real Output† , $\sum_j p_j^* Y_j$	1.996	1.989	1.946	1.944
Non-agricultural Good, y_n	1.514	1.507	1.472	1.476
Cash Crop, y_r	0.214	0.216	0.209	0.211
Staple Crop, y_s	0.296	0.297	0.291	0.284
Rations, c^{ration}	0.0689	0	0.074	0
Intermediate input demand, $k_s + k_r$	0.0487	0.0484	0.0395	0.0385
Capital demand, k_n	4.587	4.552	4.494	4.48
Labour productivity of non-agri sector‡	3.53	3.53	3.62	3.595
Labour productivity of agricultural sector	0.845	0.842	0.799	0.795
Labour productivity of cash crop sector	0.878	0.878	0.829	0.83
Labour productivity of staple crop sector	0.905	0.899	0.855	0.85
Tax	0.0977	0.025	0.0879	0
Input price	1.56	1.56	2.072	2.072
Prices				
Non-agricultural Good (normalized)	1	1	1	1
Cash Crop, p_r	0.8896	0.8896	0.9955	0.983
Staple Crop, p_s	0.987	0.987	1.11	1.088
Support Price, $\bar{p}$	1.467	-	1.187	-
Interest rate, r	0.0156	0.0126	0.0113	0.012
Wage, w	1.17	1.166	1.173	1.17
Employment Shares				
Non-agricultural Sector	0.429	0.427	0.407	0.41
Cash Crop Farmers	0.244	0.246	0.252	0.255
Staple Crop Farmers	0.327	0.327	0.341	0.335

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 $\frac{p_j^* Y_j}{\text{Employment share}_j}$

Table B6: Welfare changes under counterfactual policies: variation by type

Group	No MSP	Higher p_k
	(1)	(2)
Workers	−0.7%	−0.96%
Staple crop farmers	−0.89%	−2.3%
Cash crop farmers	−0.81%	−2.1%

Table B7: Equilibrium outcomes following input subsidy removal, with unit elasticity of substitution

	MSP & input subsidy	No subsidy
	(1)	(2)
Aggregate Quantities		
Aggregate Output, $\sum_j p_j Y_j$	1.833	1.833
Real Output†, $\sum_j p_j^* Y_j$	1.955	1.918
Non-agricultural Good, y_n	1.62	1.61
Cash Crop, y_r	0.169	0.154
Staple Crop, y_s	0.188	0.17
Rations, c^{ration}	0.0197	0.0187
Intermediate input demand, $k_s + k_r$	0.021	0.0126
Capital demand, k_n	4.095	4.075
Labour productivity of non-agri sector‡	2.89	2.89
Labour productivity of agricultural sector	0.764	0.689
Labour productivity of cash crop sector	0.77	0.697
Labour productivity of staple crop sector	0.852	0.769
Tax	0.0395	0.0105
Input price	1.56	2.65
Prices		
Non-agricultural Good (normalized)	1	1
Cash Crop, p_r	0.394	0.444
Staple Crop, p_s	0.785	0.889
Support Price, $\bar{p}$	0.839	0.95
Interest rate, r	0.0344	0.0346
Wage, w	1.065	1.064
Employment Shares		
Non-agricultural Sector	0.559	0.557
Cash Crop Farmers	0.22	0.221
Staple Crop Farmers	0.22	0.221

Note: †p^* represents prices in the benchmark equilibrium

‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

Table B8: Comparison of equilibrium outcomes with wage labour income tax and consumption tax

	MSP and Input subsidy	No MSP	No Input subsidy
	(1)	(2)	(3)
Aggregate Quantities			
Aggregate Output, $\sum_j p_j Y_j$	1.948	1.952	1.96
Real Output† , $\sum_j p_j^* Y_j$	1.971	1.975	1.92
Non-agricultural Good, y_n	1.49	1.497	1.443
Cash Crop, y_r	0.208	0.208	0.212
Staple Crop, y_s	0.299	0.296	0.29
Rations, c^{ration}	0.053	0	0.067
Intermediate input demand, $k_s + k_r$	0.046	0.046	0.0383
Capital demand, k_n	4.46	4.48	4.38
Labour productivity of non-agri sector‡	3.54	3.53	3.66
Labour productivity of agricultural sector	0.83	0.83	0.78
Labour productivity of cash crop sector	0.86	0.861	0.813
Labour productivity of staple crop sector	0.89	0.89	0.841
Consumption Tax	0.0485	0	0.0485
Wage income tax rate	0.03	0.0248	0.03
Input price	1.56	1.56	2.086
Prices			
Non-agricultural Good (normalized)	1	1	1
Cash Crop, p_r	0.837	0.837	0.962
Staple Crop, p_s	0.947	0.947	1.073
Support Price, $\bar{p}$	1.013	-	1.148
Interest rate, r	0.0136	0.0136	0.012
Wage, w	1.16	1.161	1.17
Employment Shares			
Non-agricultural Sector	0.421	0.424	0.394
Cash Crop Farmers	0.243	0.242	0.261
Staple Crop Farmers	0.336	0.334	0.345
Average consumption equivalent welfare			
Welfare*	-	-0.065%	-1.4%

Note: For this exercise we consider a combination of income taxes on workers that are capped at a 3% rate and consumption taxes on all agents that amount to government expenditure on the MSP program in the benchmark equilibrium. If government expenditure is below the revenue from a 3% income tax rate on workers, consumption taxes do not apply and the labour income tax rate adjusts.

†p^* represents prices in the benchmark equilibrium

‡Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

* Welfare measure is the average consumption equivalent welfare gain (if negative) associated with moving from the benchmark equilibrium to a counterfactual without support prices or the input subsidy.

Table B9: Comparison of GE outcomes with redistributive transfers to workers

	Benchmark MSP & input subsidy (1)	Redistributive transfers No MSP & no input subsidy (2)
Aggregate Quantities		
Aggregate Output, $\sum_j p_j Y_j$	1.997	2.084
Real Output†, $\sum_j p_j^* Y_j$	1.997	1.998
Non-agricultural Good, y_n	1.514	1.536
Cash Crop, y_r	0.214	0.201
Staple Crop, y_s	0.296	0.287
Rations, c^{ration}	0.0689	0
Intermediate input demand, $k_s + k_r$	0.0487	0.0403
Capital demand, k_n	4.59	4.684
Labour productivity of non-agri sector‡	3.53	3.46
Labour productivity of agricultural sector	0.845	0.832
Labour productivity of cash crop sector	0.878	0.868
Labour productivity of staple crop sector	0.905	0.885
Tax*	0.0977	0.06
Input price	1.56	2.072
Prices		
Non-agricultural Good (normalized)	1	1
Cash Crop, p_r	0.8896	1.05
Staple Crop, p_s	0.987	1.175
Support Price, $\bar{p}$	1.056	-
Interest rate, r	0.0122	0.0115
Wage, w	1.168	1.172
Employment Shares		
Non-agricultural Sector	0.429	0.444
Cash Crop Farmers	0.244	0.232
Staple Crop Farmers	0.327	0.324

Note: $\dagger p^*$ represents prices in the benchmark

$\ddagger$Labour productivity in sector j computed using benchmark equilibrium prices as $\frac{p_j^* Y_j}{\text{Employment share}_j}$

$*$ Taxes in the redistributive transfer case are borne by farmers

Table B10: Effect of fertilizer deregulation on agricultural yield and area

Dependent variables: Log Yield or Log Area			
	All (1)	Cash Crops (2)	Staple Crops (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 B11: Effect of change in support price on intermediate input use

Dependent variables: Log Amount Spent (Rupees)					
	Labour (1)	Seed (2)	Fertilizers (3)	Machine (4)	Others (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[34]. 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[35]. 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).

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

[35] 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)

We aggregate output and yield over crops using prices as weights. 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 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 77$^{\text{th}}$ 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 77$^{\text{th}}$ 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

D Model

D.1 Profit maximization

The profit maximization problem of the representative firm is standard and yields first-order conditions that equate the marginal products of inputs to their factor prices:

$$\max_{n_{nt},k_{nt}} \quad A n_{nt}^{\alpha} k_{nt}^{1-\alpha} - w_t n_{nt} - (\tilde{r}_t + \delta) k_{nt} \tag{D.1}$$

$$w_t = \alpha A k_{nt}^{1-\alpha} n_{nt}^{\alpha-1} \tag{D.2}$$

$$\tilde{r}_t + \delta = (1-\alpha) A k_{nt}^{-\alpha} n_{nt}^{\alpha} \tag{D.3}$$

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 $\{z_{at}, z_{nt}, a_t, l\}$ solves the following:

$$\max_{k_{rt} \leq \frac{\phi a_t}{p_k}} p_{rt}(A z_{at}) \left[k_{rt}^{\zeta} \, l^{\chi} \right] - (1 + \tilde{r}_t) p_k k_{rt} \tag{D.4}$$

Note that the problem above incorporates the working capital constraint, $k_{rt} \leq \frac{\phi a_t}{p_k}$. The optimal unconstrained choice of inputs 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:

$$k_r^u(z_{at}, l) = \left(\frac{\zeta_r A z_{at} p_r l^{\chi}}{p_k (1 + \tilde{r}_t)} \right)^{\frac{1}{1-\zeta}} \tag{D.5}$$

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

$$k_r(z_{at}, a_t, l) = \min\{k_{rt}^u(z_{at}, l), \frac{\phi a_t}{p_k}\} \tag{D.6}$$

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

$$y_r(z_{at}, a_t, l) = (A z_{at}) \left[k_{rt}^{\zeta} \, l^{\chi} \right] \tag{D.7}$$

$$\Pi_r(z_{at}, a_t, l) = p_{rt}(A z_{at}) \left[k_{rt}^{\zeta} \, l^{\chi} \right] - (1 + \tilde{r}_t) p_k k_{rt} \tag{D.8}$$

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 $\{z_{at}, z_{nt}, a_t, l\}$ 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:

$$\max_{k_{st} \leq \frac{\phi a_t}{p_k}} p_{st}(Az_{at})\left[k_{st}^{\zeta}\, l^{\chi}\right] - (1+\tilde{r}_t)p_k k_{st} \tag{D.9}$$

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

$$\max_{k_{st} \leq \frac{\phi a_t}{p_k}} \bar{p}_t(Az_{at})\left[k_{st}^{\zeta}\, l^{\chi}\right] - (1+\tilde{r}_t)p_k k_{st} \tag{D.10}$$

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:

$$k_s^u(z_{at}, l; \hat{p}_{st}) = \Big(\frac{\zeta_s A z_{at} \hat{p}_{st} l^{\chi}}{p_k(1+\tilde{r}_t)}\Big)^{\frac{1}{1-\zeta}} \tag{D.11}$$

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

$$k_s(z_{at}, a_t, l; \hat{p}_{st}) = \min\{k_s^u(z_{at}, l; \hat{p}_{st}), \frac{\phi a_t}{p_k}\} \tag{D.12}$$

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 $\{z_{at}, z_{nt}, a_t, l\}$ and receiving price $\hat{p}_{st}$ is:

$$\Pi_s(z_{at}, a_t, l; \hat{p}_{st}) = \hat{p}_{st}(Az_{at})\left[k_{st}(\hat{p}_{st})^{\zeta}\right] - (1+\tilde{r}_t)\, p_k k_{st}(\hat{p}_{st}) - \mu(z_a, z_n, a, l)\rho \tag{D.13}$$

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

$$\begin{aligned}
k_s(z_{at}, a_t, l) &= \mu(z_a, z_n, a, l) \times k_s(z_{at}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times k_s(z_{at}, a_t, l; p_{st}) && \text{(D.14)}\\
y_s(z_{at}, a_t, l) &= \mu(z_a, z_n, a, l) \times y_s(z_{st}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times y_s(z_{at}, a_t, l; p_{st}) && \text{(D.15)}\\
\Pi_s(z_{at}, a_t, l) &= \mu(z_a, z_n, a, l) \times \Pi_s(z_{at}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times \Pi_s(z_{at}, a_t, l; p_{st}) && \text{(D.16)}
\end{aligned}$$

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:

$$\int_{\mathbf{z}\times A\times\mathbb{L}} c_r(\mathbf{z}, a, l)\; dF(\mathbf{z}, a, l) = \int_{\mathbf{z}\times A\times\mathbb{L}} \left(1 - \sigma(\mathbf{z}, a, l)\right)\left(1 - \omega(\mathbf{z}, a, l)\right)\; y_r(z_a, a, l)\; dF(\mathbf{z}, a, l) \tag{D.17}$$

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

$$c^{\text{ration}} = \min\left\{ c_s^{\text{procured}},\ \psi C_s \right\} \tag{D.18}$$

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

$$\int_{\mathbf{z}\times A\times\mathbb{L}} c_s(\mathbf{z},a,l)\;dF(\mathbf{z},a,l) \;=\; \int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\mu(\mathbf{z},a,l)\big)\;\sigma(\mathbf{z},a,l)\;y_s(z_a,a,l)\;dF(\mathbf{z},a,l) + \mathbb{I}_{c_s^{\text{procured}}>\psi C_s}\times\left(c_s^{\text{procured}}-\psi C_s\right) \tag{D.19}$$

(c) Asset market:

$$\int_{\mathbf{z}\times A\times\mathbb{L}} a^{'}(\mathbf{z},a,l)\;dF(\mathbf{z},a,l) = k_n + \int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\omega(\mathbf{z},a,l)\big)p_k k_j(\mathbf{z},a,l)\;dF(\mathbf{z},a,l) \tag{D.20}$$

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

$$n_n = \int_{\mathbf{z}\times A\times\mathbb{L}} \omega(\mathbf{z},a,l)\;z_n\;dF(\mathbf{z},a,l) \tag{D.21}$$

2. The distribution F evolves as per:

$$TF(z_a', z_n', a', l) = \int_{\mathbf{z}\times A\times\mathbb{L}} \mathbb{I}_{\{a'(\mathbf{z},a,l)=a'\}}\;\Pi^a(z_a,z_a')\;\Pi^n(z_n,z_n')\;dF(\mathbf{z},a,l)\quad \forall (z_a', z_n', a')\in\mathbf{z}\times A \tag{D.22}$$

Here, $\mathbb{I}_{\{a'(\mathbf{z},a,l)=a'\}}$ is an indicator function that takes the value 1 when an agent with state $(\mathbf{z},a,l)$ 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. The distribution F satisfies $\int_{\mathbf{z}\times A} dF(\mathbf{z},a,j) = G_{l_j}$.

3. **Government budget constraint**: Total expenditure by the government on the support price and input subsidy programs (the latter is 1.25% of GDP) are financed through lump-sum taxes τ on all agents:

$$\begin{aligned}\tau = 0.0125*\Bigg(y_n + &\int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\sigma(\mathbf{z},a,l)\big)\big(1-\omega(\mathbf{z},a,l)\big)\;y_r(z_a,a,l)\;dF(\mathbf{z},a,l) + \int_{\mathbf{z}\times A\times\mathbb{L}} \sigma(\mathbf{z},a,l)\big(1-\omega(\mathbf{z},a,l)\big)\;y_s(z_a,a,l)\;dF(\mathbf{z},a,l)\Bigg)\\ &+\bar{p}*\Big(\int_{\mathbf{z}\times A\times\mathbb{L}} \mu(\mathbf{z},a,l)\;\sigma(\mathbf{z},a,l)\big(1-\omega(\mathbf{z},a,l)\big)\;y_s(z_a,a,l)\;dF(\mathbf{z},a,l)\Big)\\ &-ps*\left(\int_{\mathbf{z}\times A\times\mathbb{L}} \mu(\mathbf{z},a,l)\;\sigma(\mathbf{z},a,l)\big(1-\omega(\mathbf{z},a,l)\big)\;y_s(z_a,a,l)\;dF(\mathbf{z},a,l)\;-\;\psi C_s\right)*\;\mathbb{I}_{c_s^{\text{procured}}>\psi C_s}\end{aligned} \tag{D.23}$$

The first term on the RHS is expenditure on the input subsidy, the second term captures government expenditure on procuring staple crops, while the last term captures the revenue earned by the government if procurement exceeds the cap on rations, in which case the surplus is sold on the market.

D.3 Welfare

D.3.1 Aggregate welfare measure

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

$$W^* = \int V^*(\mathbf{z}, a, l)\ dF^*(\mathbf{z}, a, l) \tag{D.24}$$

This measures the welfare of an individual under the 'veil of ignorance', i.e. the welfare calculation of a planner who weights every agent in the stationary distribution equally.

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

$$\hat{W} = \int \hat{V}(\mathbf{z}, a, l)\ dF^*(\mathbf{z}, a, l) \tag{D.25}$$

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

$$\chi = \left[\frac{W^*}{\hat{W}}\right]^{\frac{1}{1-\theta}} - 1 \tag{D.26}$$

To obtain the above expression, we scale up subsistence consumption levels $\bar{c}_s$ by χ as well[36]. A negative value for χ would indicate that the average agent is better off in the new stationary equilibrium corresponding to the counterfactual exercise.

D.3.2 Welfare by agent type

Now, we define the aggregate welfare measure for an agent belonging to a particular group $j \in \{s, r, n\}$:

[36] 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

$$W^{j*} = \int V^*(\mathbf{z}, a, l)\ \mathbb{I}_j^*\ dF^*(\mathbf{z}, a, l) \tag{D.27}$$

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

$$\hat{W^j} = \int \hat{V}(\mathbf{z}, a, l)\ \mathbb{I}_j^*\ dF^*(\mathbf{z}, a, l) \tag{D.28}$$

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:

$$\chi^j = \left[\frac{W^{j*}}{\hat{W^j}}\right]^{\frac{1}{1-\theta}} - 1 \tag{D.29}$$

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.