The Equilibrium Impact of Agricultural Support Prices and Input Subsidies

Pubali Chakraborty [*] Anand Chopra [†] Lalit Contractor [‡]

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Abstract

We study the macroeconomic implications of agricultural subsidies for the agricultural productivity gap and consumer welfare. We examine two tax-financed policies: a support price program for staple crops and intermediate input price subsidies. We develop a dynamic general equilibrium model, where heterogeneous individuals endogenously sort between sectors and crop types, while facing sectoral mobility costs, financial frictions and incomplete asset markets. The benchmark economy is disciplined using Indian data, where both policies are observed. We find that eliminating either policy worsens agricultural productivity relative to non-agriculture, but increases welfare by reducing the tax burden, disproportionately benefiting asset-poor households. Our findings highlight a trade-off between promoting productivity and improving welfare in industrial policy design.

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

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

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[*]Department of Economics, Bates College, Email: pchakraborty@bates.edu

[†]Economics, Management School, University of Liverpool, Email: achopra@liverpool.ac.uk

[‡]**Corresponding Author**. Department of Economics, Ashoka University, Email: lalit.contractor@ashoka.edu.in

1 Introduction

Subsidies in agriculture, often through interventions that affect intermediate input and output prices, are a widely used form of industrial policy, especially in developing countries.[1] Such interventions are typically justified by the large fraction of the workforce employed in agriculture despite persistently low labour productivity within the sector, partly due to limited use of intermediate inputs (Restuccia et al., 2008; Boppart et al., 2023). However, they can encourage lower-productivity farmers to remain in agriculture, generating labour misallocation (Lagakos & Waugh, 2013). Therefore, the aggregate and distributional effects of price-based agricultural interventions are ambiguous and require careful quantitative evaluation.

In this paper, we study two tax-financed agricultural policies: (1) minimum support price (MSP) programs, under which governments procure a share of staple output at pre-announced prices and redistribute it as food rations, and (2) subsidies that lower the price of intermediate inputs used in agriculture. We develop a quantitative general equilibrium framework to evaluate their impact on consumer welfare and the agricultural productivity gap (APG), defined as the ratio of non-agricultural to agricultural labour productivity.[2] The model incorporates financial constraints, incomplete asset markets, and barriers to sectoral mobility, frictions widely observed in developing economies (Restuccia & Rogerson, 2017), generating rich interactions between the drivers of the APG and agriculture subsidies. Individual-level heterogeneity in sectoral productivity, land endowments, and assets enables a careful assessment of the aggregate productivity and welfare consequences of these policies. We discipline the model using data from India, where both policies are implemented, matching key micro and macro moments. Our results highlight a trade-off between productivity and welfare when analysing such policies: removing either intervention lowers agricultural productivity and widens the APG, while improving consumer welfare through a reduced tax burden.

To quantify these mechanisms, we develop a model with two sectors (agriculture and non-agriculture) and two crop types (staples and non-staples), and incomplete asset market. Crop production combines intermediate inputs and land, with farmers facing working capital con-

[1] FAO data show that more than 43 countries implemented some form of output price support in agriculture over the past decade, including the United States and China. Input subsidy programs are common across developing countries and constitute a key component of agricultural budgets, in part because many such economies rely heavily on imported intermediate inputs (Farrokhi & Pellegrina, 2023). For example, Holden (2019) and Jayne et al. (2018) document that such programs account for 14–26 percent of government agricultural spending in African countries.

[2] Our baseline measure of APG is based on sectoral output rather than value-added to prevent a change in the input price to mechanically affect the APG. Reassuringly, conclusions are similar using either measure.

straints when purchasing inputs. Individuals choose their sector-crop type, consumption allocations, and asset position given sectoral productivities, land endowments and asset holdings. Their sector and crop choices are also affected by mobility barriers to non-agricultural employment and idiosyncratic taste shocks between crop types. Staple crop farmers can participate in the MSP program by paying a fixed cost. The government procures staple output from these farmers at above-market prices and redistributes it as free rations to all households, along with partially subsidizing the cost of intermediate inputs for each farmer. The two programs are financed through a lump sum tax on all individuals.[3]

The dynamic structure of the model offers several advantages relative to static frameworks for evaluating agricultural policies. Asset holdings create scope for input subsidies through working capital constraints, as low asset holdings can lead to inefficient input use by farmers (Donovan, 2021). Assets also shape sectoral, cropping, and procurement choices in an environment with incomplete markets, and idiosyncratic productivity and taste shocks. Because government interventions can alter the wealth distribution in equilibrium (Aiyagari, 1994), aggregate productivity responds along margins that are absent in static settings. Finally, welfare effects arising from asset reallocation along the transition between policy changes are absent from static steady-state comparisons (Domeij & Heathcote, 2004).[4]

The model is calibrated using Indian data, combining quasi-experimental evidence with macroeconomic statistics. To identify the working capital constraint, we use a natural experiment in which a government cash transfer to landowning farmers increase their intermediate input use. We calibrate the persistence and variance of sector-specific productivity shocks to match estimates from individual panel data. The fixed cost of procurement is chosen to match the 23 percent share of staple crop production procured by the government, capturing the observed scale of the MSP program.[5] We validate the model by showing it reproduces several untargeted patterns in both aggregate and micro-level data, including key moments of the income distribution.

Before evaluating the effects of the policies on productivity, we highlight the main drivers of the APG in our calibrated model. Barriers to entering the non-agricultural sector are a key

[3]According to IMF Government Finance Statistics data from 2000 to 2017, 54 percent of Indian tax revenue was generated through consumption taxes, while only 11 percent came from individual labour income taxes. Moreover, indirect taxes being the primary source of government revenue holds across developing countries (Bachas et al., 2024), which motivates the assumption of an uniform tax in the model.

[4]Our approach complements recent studies, such as Hsiao et al. (2024), which evaluate welfare effects of agricultural policies using static models.

[5]We set a 33 percent reduction in input prices to match the empirical input subsidy expenditure to GDP ratio.

determinant, as eliminating them reduces the APG by 18 percent. Eliminating working capital frictions in input purchases raises their use by 23 percent and reduces the APG by 8.6 percent. Reducing the variance of taste shocks also lowers the APG by increasing crop prices and intermediate input use. Other features, such as the fixed cost of MSP program participation, have limited impact on the APG.[6]

We conduct counterfactual experiments using the calibrated model to quantify the impact of each policy under fixed prices and in general equilibrium, removing one policy while keeping the other in place. Each subsidy influences the APG through opposing forces. Under fixed prices, their removal raises the APG by dampening intermediate input use, while lowering APG through a reduction in farmers' profits and agricultural employment, thereby distorting occupational choices (the *selection effect*). In general equilibrium, prices and lump sum taxes adjust in response to individual decisions, potentially dampening or even reversing these effects.

In the first exercise, we show that eliminating the MSP program, including the distribution of rations, while retaining the input subsidy, increases the APG in general equilibrium. To understand this result, we first examine the effects under fixed prices. Removing the MSP lowers the attractiveness of staple farming and the agriculture sector, raising non-agricultural employment by 2.3 percentage points. APG falls by 3 percent, partially offset by a decline in intermediate input use. In general equilibrium, higher consumption demand is met by the increased market supply of staple crops not procured by the government, leaving crop prices unchanged. Consequently, the non-agricultural employment share falls by 0.2 percentage points, while agricultural productivity declines, resulting in a 0.36 percent increase in the APG relative to the benchmark. To our knowledge, this is the first study to investigate the general equilibrium effects of government interventions through agricultural output prices.

In the second exercise, we find that eliminating the input subsidy program (a 33 percent increase in input prices), while keeping the MSP in place, raises the APG by 8.5 percent in general equilibrium. Under fixed prices, intermediate input demand falls by nearly 31 percent, leading to a 2.8 percentage point decline in agricultural employment. In general equilibrium, this employment response reverses as crop prices rise due to lower supply and higher demand stemming from the reduced tax burden on households. Higher prices partially offset the decline in input use and induce substantial labour reallocation, with agricultural employment

[6]Incomplete asset markets also affect the APG; Mongey and Waugh (2024) show that discrete choice economies are inefficient in such environments.

increasing by 2.2 percentage points. While this reallocation raises non-agricultural labour productivity by 2.5 percent, the net decline in input use reduces agricultural productivity by 5.4 percent.[7] Overall, the rise in APG is driven by both labour reallocation and input intensity, operating through channels distinct from those under MSP removal.

We next assess the welfare consequences of removing either policy, accounting for transition dynamics from the benchmark to the new counterfactual stationary equilibrium. We find that both policies reduce consumer welfare, measured in consumption-equivalent units, driven primarily by the tax burden they impose. The lump sum tax amounts to nearly 5 percent of GDP in the benchmark economy with both programs in place. Welfare increases by 1 percent and 1.5 percent when the MSP program and the input subsidy program are removed, respectively. Moreover, welfare gains are at least 80 percent larger for asset-poor households than for asset-rich households. Beyond the direct increase in disposable income, the lower tax burden leads to more staple crops being sold to the government and, consequently, more staple crops available as free rations. This channel accounts for part of the additional welfare gains from removing input subsidies, particularly among asset-poor households.

To assess the importance of the tax burden and its incidence in shaping welfare effects, we consider counterfactuals in a benchmark economy with progressive taxation. In this economy, at least half of government revenue is raised through an income tax on non-agricultural workers. Relative to the lump-sum tax benchmark, welfare gains from removing either policy are attenuated but remain positive. This suggests that while greater tax progressivity can modulate the welfare effects of agricultural programs, the overall tax burden is likely the primary determinant of welfare outcomes. Consistent with this interpretation, we show that cash transfers to non-agricultural workers — similar to the migration subsidies studied in Lagakos et al. (2023) — simultaneously raise welfare and the APG.

Finally, we validate key model predictions using reduced-form evidence from India. In particular, a policy-induced increase in fertilizer prices confirms the predicted decline in crop output and rise in crop prices following a reduction in input subsidies. We also exploit a natural experiment involving an increase in support price, unrelated to productivity, to demonstrate a positive relationship between support prices on both staple output and intermediate input

[7] The price of the intermediate input is assumed to be exogenous in line with other studies (Donovan, 2021). Allowing input prices to vary in general equilibrium 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 more productive farmers (Basurto et al., 2020), which we do not consider in our model, then their removal would dampen agricultural productivity more than our estimates.

use. This is consistent with the model's predictions of removing MSP under fixed prices.

To summarize, agricultural price subsidies can create a trade-off between productivity indicators and consumer welfare.[8] The quantitative effects of removing either policy appear modest in part because they do not directly affect the main drivers of the APG in the Indian context, such as sectoral mobility and land frictions. Our counterfactual results also highlight the importance of evaluating policies within a general equilibrium framework (Muralidharan & Niehaus, 2017), as implications under fixed prices differ both quantitatively and qualitatively from the effects when prices adjust.

This paper contributes to multiple strands of literature. First, we contribute to the literature on the consequences of price support policies. To our knowledge, we are the first to study the impact of price support policies on the APG and welfare in a quantitative general equilibrium model. Existing studies typically abstract from equilibrium feedback between prices, fiscal adjustments, and occupational choice (Alizamir et al., 2018; Garg & Saxena, 2022; Lichtenberg & Zilberman, 1986).

We also contribute to the literature on fertilizer subsidies. Our dynamic framework enables a comprehensive welfare evaluation of such subsidies by accounting for transition dynamics, which cannot be captured by recent studies using static models (Bergquist et al., 2019; Diop, 2022; Garg & Saxena, 2022; Ghose et al., 2023). Our paper complements recent studies by Brooks and Donovan (2025) and Mazur and Tetenyi (2025), who also examine input subsidies using a dynamic general equilibrium model with financial frictions. We contribute to this literature by showing that agricultural output subsidies and in-kind government transfers reduce the need for input subsidies, as part of the welfare gains from eliminating input subsidies is attributable to these programs. Social programs with in-kind transfers, common in 90% of low-income countries (World Bank, 2014), would also diminish the role of transaction costs considered in Mazur and Tetenyi (2025).[9] Thus, the analysis of agricultural policies should include their interaction with social insurance programs.

Finally, this study contributes to the macroeconomic development literature on the sources of large productivity gaps across countries. Low input intensity is widely recognized as a key

[8]Policymakers may also justify such policies on additional grounds, for instance to support farm incomes during periods of excess aggregate supply and low crop prices. We show that even in such states, when the MSP program would seem very attractive, equilibrium outcomes differ little with and without the MSP in place. The limited procurement share of the Indian government substantially dampens the program's potential stabilizing role.

[9]In contrast to Mazur and Tetenyi (2025), 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. We discuss the reasons for these differences in greater detail in Section 5.5.4.

factor driving these gaps (Boppart et al., 2023; Caunedo & Keller, 2021; Restuccia et al., 2008), particularly low intermediate input use (Donovan, 2021; McArthur & McCord, 2017; Pietrobon, 2024). Input misallocation, including the worker selection effect (Adamopoulos et al., 2024; Lagakos & Waugh, 2013), further exacerbates productivity differences across nations (Restuccia & Rogerson, 2017).[10] In this paper, we complement the literature by disentangling the roles of selection and input intensity in shaping the effects of these agricultural policies on the APG.

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 percent 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 percent and 1.5 percent for agriculture and non-agriculture, respectively. Yet, crop insurance take-ups are quite low, suggesting that asset markets are incomplete.[11]

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

[10] Various institutions and policies contribute to such misallocation, including labour market institutions (Donovan et al., 2023; Donovan & Schoellman, 2023; Herrendorf & Schoellman, 2018; Lagakos et al., 2023), financial market institutions (Buera et al., 2011), land market institutions (Adamopoulos et al., 2024; Manysheva, 2022; Chen et al., 2023), and spatial frictions (Chatterjee, 2023), among others.

[11] Fewer than 10 percent of agricultural households hold any form of crop insurance (2019 Land and Livestock Survey)

(Moscona, 2023). Monari (2002) finds that Indian farmers pay less than 10 percent of the actual cost of electricity generation. Additionally, about 40 percent 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 percent of GDP between 2000 and 2019. Given the extensive price regulation by the government, we shall assume that input prices are fixed in the model and input subsidies amount to 1.25 percent of GDP in the benchmark economy.

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. In practice, rice and wheat account for the bulk of procurement (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 predetermined 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.[12] Thus, in the model we will assume that there is no uncertainty with regard to the support price for the farmer.

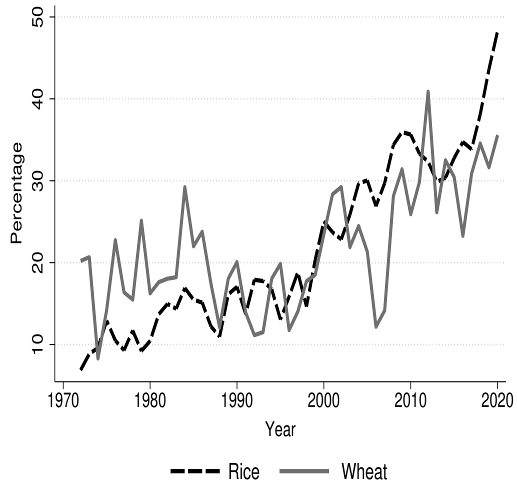
Second, farmers face barriers to access the MSP program. In recent years, the government has procured around 25 percent of national rice and wheat output (Figure 1a). Furthermore, delays in procurement after harvest and payments imply that the richer farmers are more likely to access the MSP. Figure 1b shows that farmers with higher production levels were more likely to take advantage of the MSP program.[13] 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

[12]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.

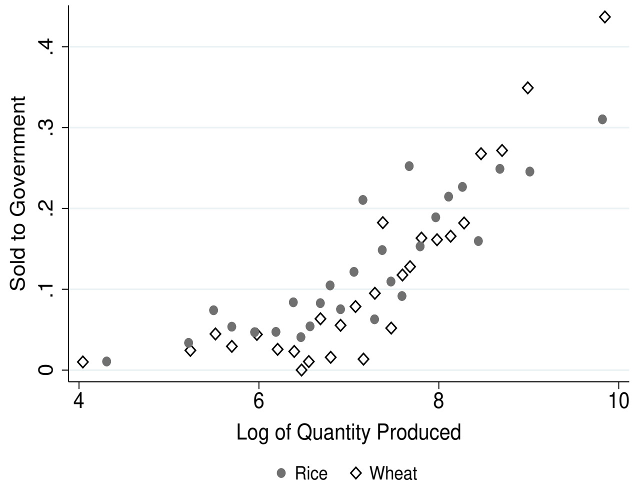
[13]Some of this variation is explained by variation in procurement at state-level due to political cycles and local-level procurement infrastructure. But, this pattern holds even after controlling for state fixed effects, as shown in Appendix Figure A2a. Furthermore, we demonstrate that this pattern remains consistent when measuring a farmer's wealth by land area rather than output (Appendix Figure A2b).

production.

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. Data on procurement and output comes from the Reserve Bank of India's Handbook of Indian Statistics. The figure on the right shows a binscatter of the fraction of farmers selling to a government agency against 30 quintiles of the log of total quantity produced. Both variables come from the Land and Livestock Survey (77^{th} NSS Round). Appendix C provides more details on the datasets used.

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 percent of household rice and wheat consumption (Gadenne, 2020).[14] We integrate these features into a general equilibrium model in Section 3 and conduct various counterfactual exercises to analyze the effects of agricultural input and output price subsidies.

3 Model

There are two sectors in the economy: agriculture and non-agriculture. Farmers can produce staple or non-staples crops, with the former being eligible for the government's support price program discussed below. Time is discrete and continues forever. The non-agricultural good serves as the numeraire, and its price is normalized to 1 $\forall t$. The prices of the staple (s) and non-staples 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

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

affect their sectoral and cropping choices. Individuals inelastically supply one unit of labour.[15] All agents have a fixed endowment of land (their *landholdings*), which they cannot adjust due to land market frictions.[16] 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 the consumption of the three goods:

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

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).[17]

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

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 (e.g. Aiyagari (1994)). Individuals cannot borrow to finance consumption, i.e., $a_t \in A = [0, \bar{a}]$.

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

[16] 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 percent of farms reporting renting in or renting out land.

[17] This is similar to the preference specification in Donovan (2021), setting $\theta = 1$.

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.[18]

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 farmers' spending on intermediate inputs and occupational choices.

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 consump-

[18]In nearly every quantitative exercise conducted below, we find that the amount of staple crops procured coincides with rations disbursed, i.e. there are no market sales of staple crops procured in excess of rations.

tion good. We do not model a 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 non-staple 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 non-staple crop:

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

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 non-staple 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 affect optimal 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 ($\hat{p}_s \in \{p_s, \bar{p}\}$):

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

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:

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

In turn, $V^s(\mathbf{z}, a, l) = \max\{V^s(\mathbf{z}, a, l; p_s), V^s(\mathbf{z}, a, l; \bar{p})\}$, 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 of 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 non-staple crops, respectively.[19]

[19] 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: $\tilde{V}^a(\mathbf{z}, a, l) = \nu \log \left\{ \exp\left(\frac{V^s(\mathbf{z}, a, l; \hat{p}_s)}{\nu}\right) + \exp\left(\frac{V^r(\mathbf{z}, a, l)}{\nu}\right) \right\}$

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 (APG) as the ratio of non-agricultural labour productivity to agricultural labour productivity:

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

where p_s^* and p_r^* refer to crop prices in the benchmark economy. We show below that the conclusions of the counterfactual exercises are robust to considering an alternate definition of the APG based on value-added rather than output.[20] 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*).

It is straightforward to see that keeping everything else constant, either subsidy increases profits and thereby demand for intermediate inputs. The mathematical derivations of the input choices are shown in Appendix D.1. Moreover, either subsidy increases profits and on the margin encourages an individual to work in the agriculture sector relative to the non-agriculture sector. However, these choices are influenced by the decision to participate in the MSP and asset holdings. Below, we explore the factors behind a farmer's decision to participate in MSP and examine how assets influence cropping and sectoral choices.

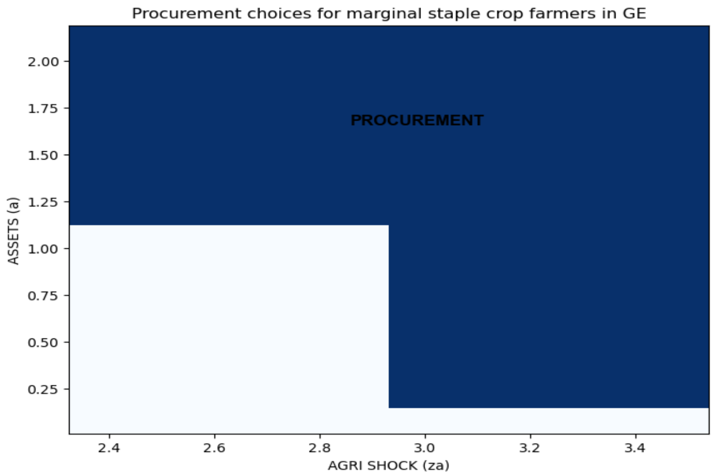
3.5.1 Procurement choice

As discussed above, 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

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

price, taking into account the fixed cost of procurement. Moreover, staple crop farmers with higher productivity or assets face fewer constraints and are more likely to earn higher profits. Figure 2 illustrates the procurement choice in blue for staple crop farmers with smallest landholdings, though the following pattern holds regardless of the size of an agent's landholdings. Farmers with greater assets or higher productivity are more likely to participate in the MSP program, consistent with the empirical pattern shown in Figure 1b.

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



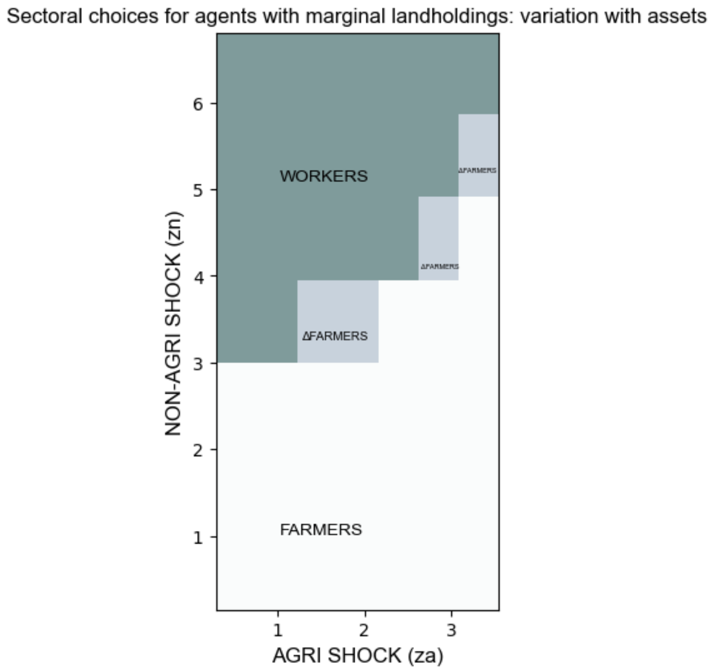
3.5.2 Role of assets in sectoral choices and input usage

We now consider the channels whereby assets influence outcomes like sectoral choice and intermediate input usage, and consequently the 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.[21] 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 main-

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

tains 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 provides a complete definition of the stationary equilibrium.[22]

4 Calibration

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

4.1 Internally calibrated parameters

Working capital constraint estimation

To pin-down the working capital constraint parameter ϕ, we bring to bear a permanent income transfer program in India that increased investment in intermediate inputs (fertilizers). The Pradhan Mantri Kisan Samman Nidhi (PMKSN) policy promises a perpetual cash transfer to landowning farmers of Rs 6000 (equivalent to 6.25 percent 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

[22] Appendix section D.3 describes the computational approach employed to solve for the stationary equilibrium and the transitions exercises associated with policy changes.

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 later periods to ensure our estimates are not driven by the COVID-19 pandemic period or the anticipation of West Bengal's entry into 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 percent.[23,24] These results highlight the presence of financial frictions that limit the use of intermediate input use in the Indian context. The parameter ϕ in the working capital constraint is 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 percent. This parameter value is quite close to the estimate of $\phi = 0.08$ by Buera et al. (2021) for India.

Other internally calibrated parameters

We internally calibrate 10 other parameters. We describe the data moment we target to best estimate each of the parameters, although all 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

[23] 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.

[24] 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 Pradesh to use fertilizer (extensive margin), while Ghosh and Vats (2022) shows the beneficial impact on input usage on more versus less treated areas through a continuous difference-in-differences specification.

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

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

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

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, adult men, village and year. These factors explain 34 percent and 40 percent of the total variation in log agricultural harvest 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).

The subsistence requirement, $\bar{c}$, and the operating cost associated with the non-agricultural sector, ξ, are chosen in order to match the 2003 agricultural employment share of 57.4 percent and an APG of 4.24. The scale parameter ν associated with the crop taste shocks is chosen to match the staple crop farmer share of 65.9 percent obtained from the first wave of the Indian Human Development Survey (IHDS-I).[25] 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 percent.

[25]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 percent of area devoted to staple crop farming are defined as staple crop farmers.

Table 2: Internally calibrated parameters

Parameter	Value	Target/Source	Data	Model
Standard dev. of agricultural prod. shock σ_a	0.36	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%

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 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 in the model, $\{G_{l_0}, G_{l_1}\} = \{0.7, 0.2\}$, are estimated to match the empirical shares of farmers with marginal and small landholdings of 67 percent and 18 percent, 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 non-staple 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. We discuss below that using India-specific staple and non-staple crop consumption shares does not substantially change outcomes in the benchmark model. θ, the risk-aversion coefficient, which is also inverse of the elasticity of substitution across crops, is set at 2. We set the discount factor to $\beta = 0.96$, a standard value 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, α, is set at a standard value of 0.67. 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 percent 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 $1.07 \times p_s$, based on the empirical ratio of MSP to price received by farmers.[26] Combined, the two subsidies are financed through a lump sum tax equivalent to 5 percent 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.

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

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 percent, which is quite close to the 23.2 percent saving rate in 2004. Furthermore, our model replicates the empirical pattern of saving rates being lower for agricultural households than non-agricultural households, 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 rate of households from staple to non-staple crops and agriculture to non-agriculture sectors quite well. Finally, the model closely replicates the empirical income distribution of the bottom 10 percent and 50 percent, 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 non-staple 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%

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 assets to limit issues of reverse causality. We regress intermediate input expenditure and harvest value on lagged asset holdings, 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, years of 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 consider the role of the input subsidy 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 $\frac{y_n}{p_s^* y_s + p_r^* y_r} \times \frac{\text{Employment}_{\text{agriculture}}}{\text{Employment}_{\text{non-agriculture}}}$. 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.

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 eliminate the fixed cost, ρ, compared to the 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 percent, while non-staple crop prices are raised slightly. Intermediate input usage rises slightly as all staple crop farmers avail of the support price, while non-staple crop farmers also earn a higher revenue. Higher intermediate

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	3.81	3.41	3.8	3.77	5.46
Labour productivity of non-agri sector†	3.53	3.55	3.43	3.3	2.89	3.36	3.69
Labour productivity of agricultural sector*	0.845	0.853	0.9	0.969	0.763	0.89	0.675
Labour productivity of non-staple 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 $\frac{p_r^* Y_r + p_s^* Y_s}{\text{Agricultural employment share}}$

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. After eliminating this constraint, Column (3) of Table 4 shows that farmers increase their use of intermediate inputs, leading to higher production of both crops and a decline in 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. Overall, the APG falls by 8.6 percent.

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 percent, and a majority of staple producers choose to sell to the government. Higher crop prices raise revenue and intermediate input usage. As one would expect, the sizeable drop in agricultural employment raises agricultural (staple and non-staple crop) labour productivity, while non-agricultural labour productivity falls significantly, leading to a 18.2 percent 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) driven by 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 selling to the government, 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 percent. The other preference parameters have limited effect on the APG. Appendix Table B3 shows that removing the subsistence requirement or adjusting the staple and non-staple 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 percentage points and share of non-staple crop farmers within agriculture by 2 percentage points. 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 9.6 percent.

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 percent from its benchmark level. While sectoral employment shares are largely unchanged, we find that the agricultural productivity falls significantly by 20 percent 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 financial frictions. While crop prices do rise significantly to incentivize crop production, the overall effect is a rise in the APG by 30.9 percent relative to the benchmark.

In conclusion, we find that intra-temporal risk, the elasticity of substitution, the working capital constraint, 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 linked to the sectoral productivity 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 productivity 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 staple farmers' profits and expected value from farming for staple and non-staple crop farmers. This leads to a modest labour reallocation of 2.3 percentage points 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 non-staple 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 percent of the staple output in the benchmark equilibrium).

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 percent to 1.26 percent 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

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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple Crop Farmers	0.244	0.222	0.246
Staple Crop Farmers	0.327	0.326	0.327

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

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 non-staple crop sector is unchanged, as the slightly higher production of that crop balances the higher employment share of non-staple crop farmers when the support price is removed. The labour productivity of the staple crop sector falls by 0.67 percent, due to lower intermediate input use leading a slight increase in APG by 0.39 percent.

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 the fact that MSP does not directly target 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 percent.

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 percent, intermediate input usage falls by around 31 percent from its benchmark value, which lowers the production of both crops by around 10 percent. The lower ensuing profit margins for farmers lead to an increase in non-agricultural employment of 2.8 percentage points. This boosts capital demand and non-agriculture output, resulting in higher real output.

The quantitative results under general equilibrium are listed in Column 3 of Table 6. A fall in the supply of agricultural goods mandates an upward adjustment in crop prices to incentivize crop production: the reduction in intermediate input usage is partly compensated by

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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple Crop Farmers	0.244	0.227	0.252
Staple Crop Farmers	0.327	0.315	0.341

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

adding more agents in the agricultural sector in order to boost crop production. The lower tax burden of around 10 percent increases households' cash-on-hand and boosts demand for both the non-staple crop and the non-agricultural good. Market demand for staple crops actually falls, due to a 7.4 percent increase in the ration disbursed.[27]

[27]The lower tax burden increases the share of crops that the farmers sell to the government. However, we fix rations to not exceed 30 percent 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.

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

The falling employment share of the non-agricultural sector lowers capital demand and 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 percent.

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 percent. Labour productivity in the non-staple and staple crop sectors decline by around 5.4 percent 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 percent both due to the fall in non-agricultural employment and agricultural intermediate input use.

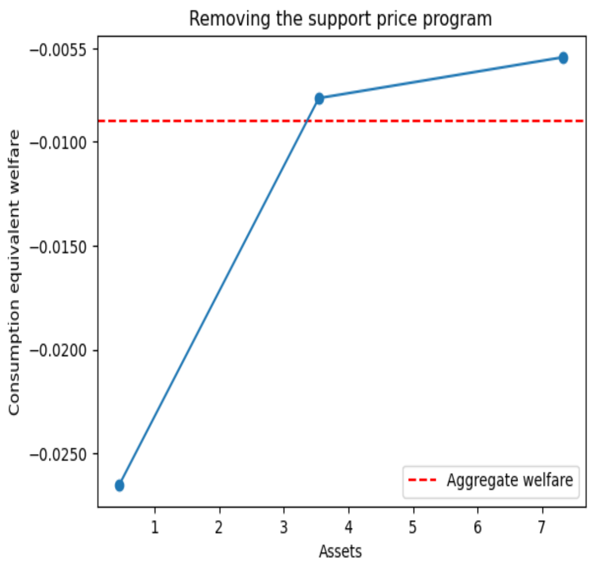
Our qualitative findings are not primarily driven by the magnitude of the input price increase. Even partial reductions in input subsidies – reflected in input price increases of 13 percent and 20 percent, compared to a 33 percent increase under complete removal – increase the APG, as shown in Appendix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

In conclusion, removing either policy reduces agricultural productivity and increases the APG. Furthermore, the APG also rises using the value-added definition rather than the output-based measure. APG using the value-added approach rises by 0.3 percent and 10.6 percent when the MSP policy and the input subsidy policy are removed, respectively. Lastly, removing both policies simultaneously also reduces agricultural productivity and increases the 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 demand and price of the staple crop, which partially offsets the productivity loss in agriculture.

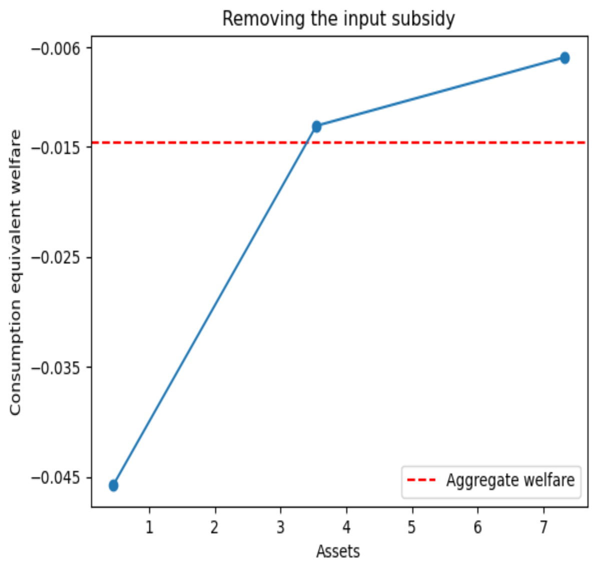
5.4 Welfare

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, accounting for the transition path to that counterfactual equilibrium.[28] Hence, we compute the welfare change associated with a policy reform (either removing the MSP or the input subsidy), fully accounting for dynamics associated with the transition from the benchmark stationary equilibrium towards the new stationary equilibrium associated with the policy change. Additionally, we also compute this welfare measure for three asset levels (low, medium, and high). Appendix Section D.4 provides details about the welfare measure.

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 results in welfare gains for individuals at each asset level. Consider first the increase in welfare from the removal of the MSP policy, which is around 1 percent across all households. Note that removing the MSP has a limited effect on crop prices, with staple crop prices rising slightly initially and then falling to baseline levels, following the removal of the MSP, as the reduced tax burden boosts demand enough to eventually offset the increased supply of formerly procured staple crops to the mar-

[28]Appendix E discusses a particular transition exercise associated with a one-time shock to agricultural TFP.

ket. The boost in cash-on-hand due to a lower tax burden outweighs 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 2 percentage points difference in welfare gains between the low- relative to the high-asset groups.

The removal of the input subsidy leads to a 1.5 percent increase in welfare across all agents (Figure 4b). The removal of the subsidy increases crop prices steadily along the transition path, resulting in a nearly 12 percent rise in crop prices in the resulting counterfactual stationary equilibrium. 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 percent 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 landholdings when the support price is removed, but the pattern is mixed 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; while agents with intermediate land holdings may not always choose to be farmers, and hence their welfare gains are attenuated by the higher price of their consumption basket. 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 non-staple crop farmers than non-agricultural workers.[29] 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

[29]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 along the transition path.

alternative policies that avoid the trade-off between productivity enhancement and welfare.

5.5.1 Tax burden vs incidence

While labour income tax in India is progressive, it constitutes only a small share of total tax revenue, as previously noted. To assess the importance of the tax burden and its incidence in shaping welfare effects, we consider counterfactuals in a benchmark economy with progressive taxation. In this alternative economy, 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 percent. Appendix Table B7 shows that even under this financing scheme, welfare improves when each policy is removed; however, the magnitude of the gains reduces relative to the benchmark. This highlights that higher tax progressivity can dampen some of the negative effects of agricultural subsidies.

The results so far strongly indicate that reducing the tax burden is important for 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 lower the APG, we consider a conditional cash transfer that individuals choosing the non-agriculture sector can avail of, 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 net redistributive 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 percentage points relative to the benchmark and lowers the APG by around 0.45 percent. 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 gain in welfare and decline in 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.

5.5.2 The support price program and food security

An argument in favour of the support price program might be its role in facilitating food security in the face of aggregate fluctuations. In appendix E, we consider a transitory positive shock to agricultural productivity, which would tend to drive down market prices of both crops. The support price program should be especially attractive in such a scenario, tending to offset the negative impact of a lower market price on the choice to cultivate staple crops, and hence on staple crop production. However, we find that aggregate staple crop production is quite similar following the transitory agricultural TFP shock, regardless of whether or not the support price program is offered to farmers. Hence, consistent with the limited impact of the support price program on equilibrium outcomes that we noted in section 5.2, we find a limited role for the support price program in fostering food security.

5.5.3 Robustness of model parameters

A key factor driving the demand for the 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 B8 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 percent due to lower input use. Non-agricultural productivity remains unchanged, implying a rise in APG of 10.9 percent, which is close to our baseline finding.

5.5.4 Comparison of model results with literature

The most closely related study to ours, Mazur and Tetenyi (2025), also finds that removing input subsidies reduces agricultural productivity. 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.[30] 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. While this channel might be important for Malawi, it is unlikely to be relevant in the Indian context, where the government provides staple foods as in-kind transfers to households, thereby reducing farmers' incentives to produce staple crops

[30] Mazur and Tetenyi (2025) permit non-staple 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.

(Gadenne, 2020).[31] 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 illustrates the dependence of findings about policy impact and their external validity on the types of frictions driving 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 non-staple 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 percent 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.

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

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

[31] This mechanism would also be less applicable in many other developing countries, as 44 percent of safety net recipients in the world benefit from in-kind transfers (Honorati et al., 2015).

the fertilizer use at the district level to minimize the influence of areas with extremely large or small fertilizer use.[32] 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.[33]

The main outcomes of interest are output and price of staple and non-staple crops. The Ministry of Agriculture and 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.[34] Staple crops includes cereals and pulses, whereas non-staple 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 non-staple and staple crops fell by similar magnitude in areas more exposed to the policy, respectively.[35] Lastly, the insignificant coefficients associated with the pre-treatment periods and treatment intensity imply a lack of meaningful pre-trends in output between high and low fertilizer use areas.

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 non-staple crops.[36] 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 non-staple 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

[32] 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.

[33] 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.

[34] 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.

[35] 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 non-staple 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.

[36] 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. Non-staple crops include oilseeds, sugarcane and cotton and rest are classified as staple crops.

Table 7: Effect of fertilizer deregulation on agricultural production

Dependent variables: Log Output			
	All (1)	Non-staple 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.

the treatment effect. Hence, the conclusions of our empirical findings remain valid.[37]

The empirical results align with the model's predictions that a reduction in input subsidy raises prices of agricultural goods. 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 our model (Callaway et al., 2024).

Table 8: Effect of fertilizer deregulation on agricultural prices

Dependent variables: Log Price			
	All (1)	Non-staple 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.

6.2 MSP

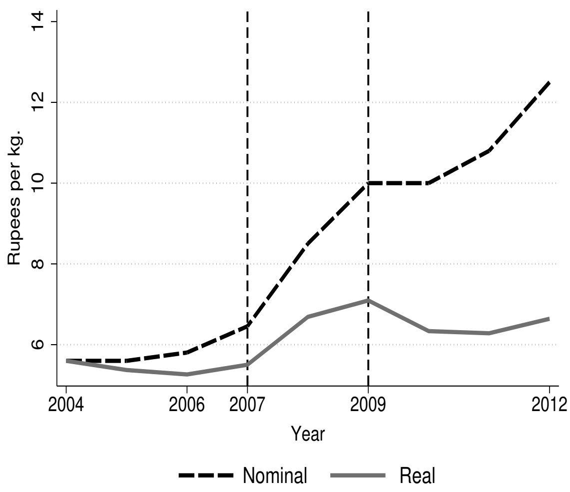
We will use two factors in our empirical approach to test the effect of higher price support on agricultural output. First, farmers know the support price, as it is announced at the start of the

[37] Appendix Figure A12 shows the event study estimates of all, non-staple 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.

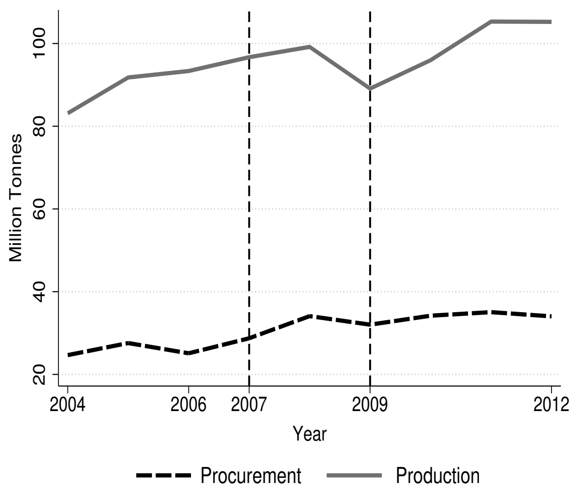
cultivation season. Second, the quantity procured by the government varies at the state level.

Before 2007, though the support price of rice in nominal terms was rising, the support price in real terms had stagnated (Figure 5a). But, the over reliance on imports during the global spike in international food prices (De Hoyos & Medvedev, 2011) and the falling stock 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, this correlation 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 the local government's 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 percent of rice output is procured by the government in states like Punjab and Haryana, whereas a state like West Bengal procures less than 7 percent of its output even though it contributes to around 17 percent of India's rice production.[38]

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

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

[38]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.

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.[39,40] To reduce omitted-variable bias relating to potentially confounding factors across districts and over time, we control for the logarithm of annual rainfall and logarithm of irrigated area at the district level.

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 percent higher procurement share, increased output and area sown of rice by 2 percent and 1 percent, 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 (Chatterjee et al., 2024; Krishnaswamy, 2018) and the model's predictions that output price subsidy induces greater output of that crop through higher employment and intermediate input use.[41]

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.

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

[40] 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).

[41] Our empirical strategy complements the approach in Chatterjee et al. (2024) and Krishnaswamy (2018). Chatterjee et al. (2024) uses examines the effect of greater procurement on agricultural output for the states of Punjab and Madhya Pradesh. Krishnaswamy (2018) uses variation in price and productivity to argue that the response of output and employment to MSP is stronger given a positive rainfall shock than a negative rainfall shock. In contrast, we investigate the effect of higher MSP using variation in government procurement.

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 either policy dampens intermediate input use and increases agricultural employment due to adjustments in output prices. Counterfactual exercises reveal that welfare gains arise from abolishing the programs due to a 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. Studying the optimal design of MSP and fertilizer subsidies within a rich framework like ours presents an important avenue for future research.

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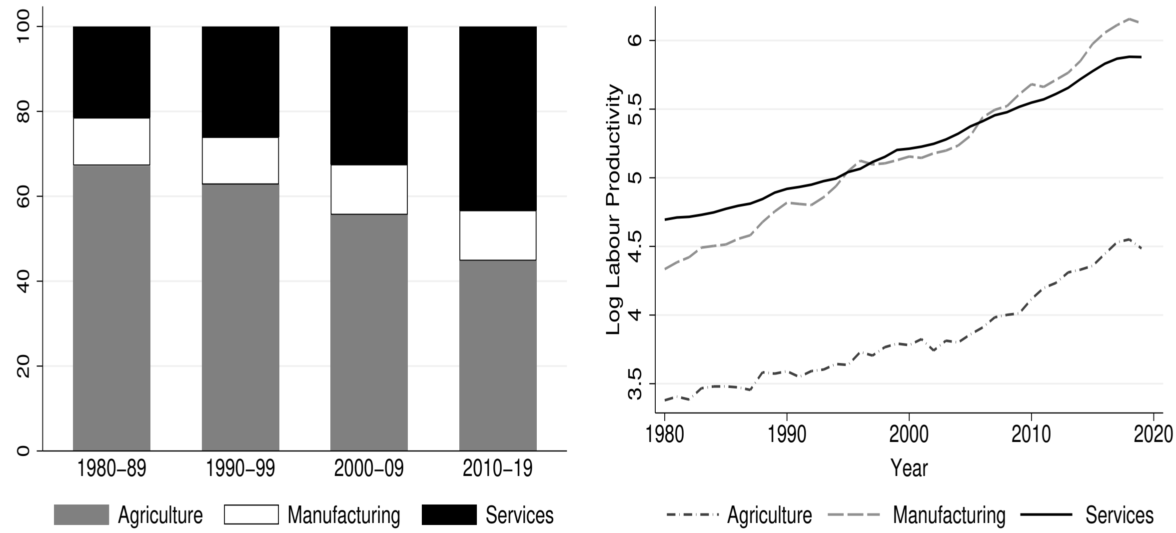
Appendix

A Additional Figures

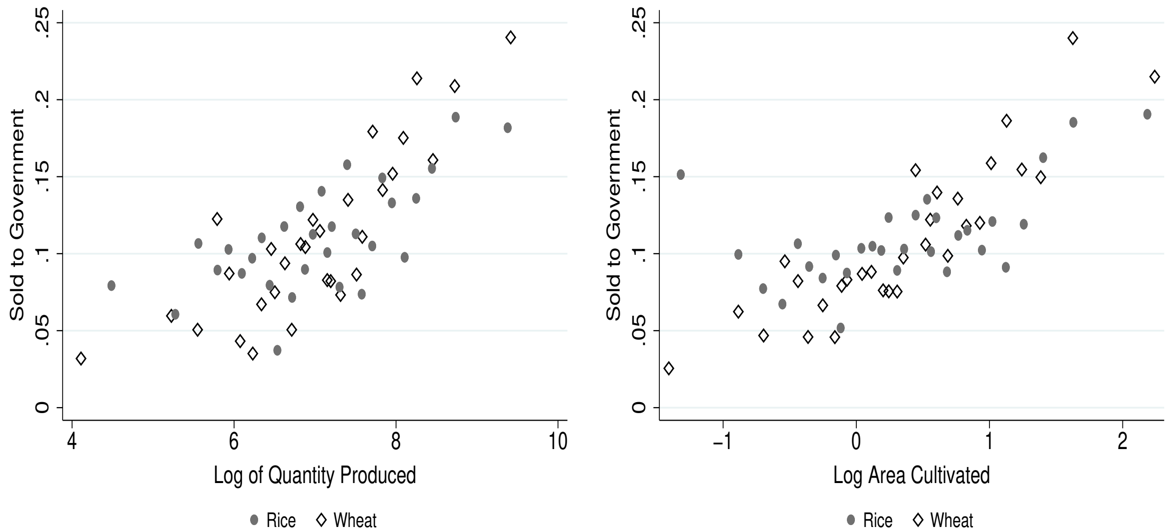
Figure A1: Employment shares and labour productivity in India by sectors



(a) Employment Shares (b) Labour Productivity

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

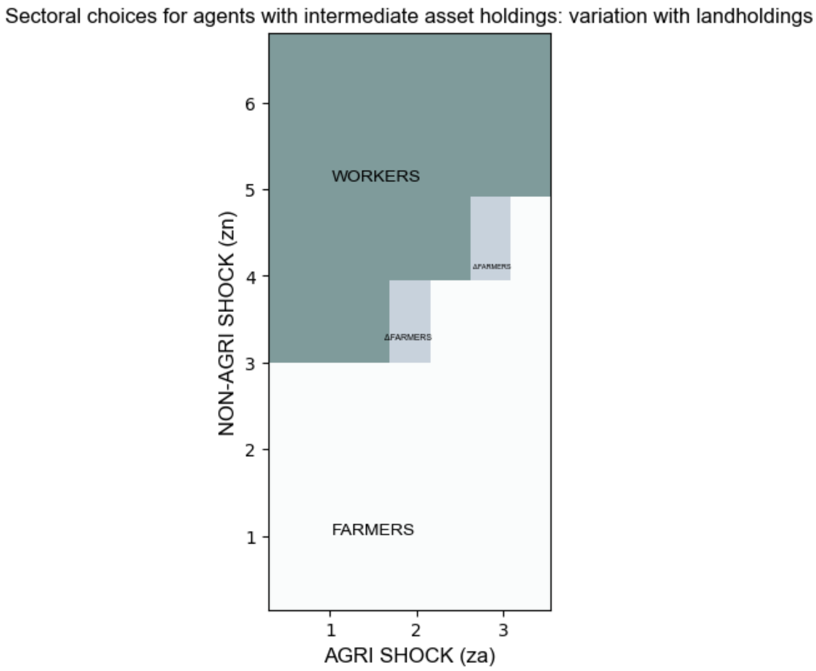
Figure A2: Incomplete penetration of MSP: controlling for state fixed effects



(a) Log quantity produced (b) Log area cultivated

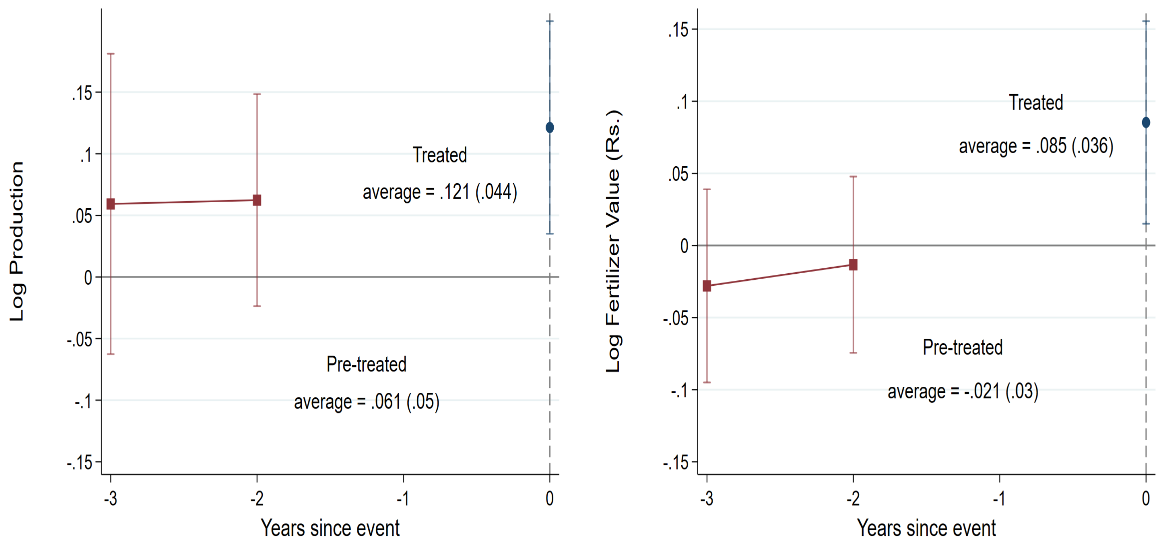
Note: The y-axis is an indicator variable taking the value 1 if output sold to a government agency. The x-axis is log quantity produced and log total area cultivated for left- and right-hand side, respectively. Both plots control for state dummies and use 30 quintiles for each crop. The figure uses the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

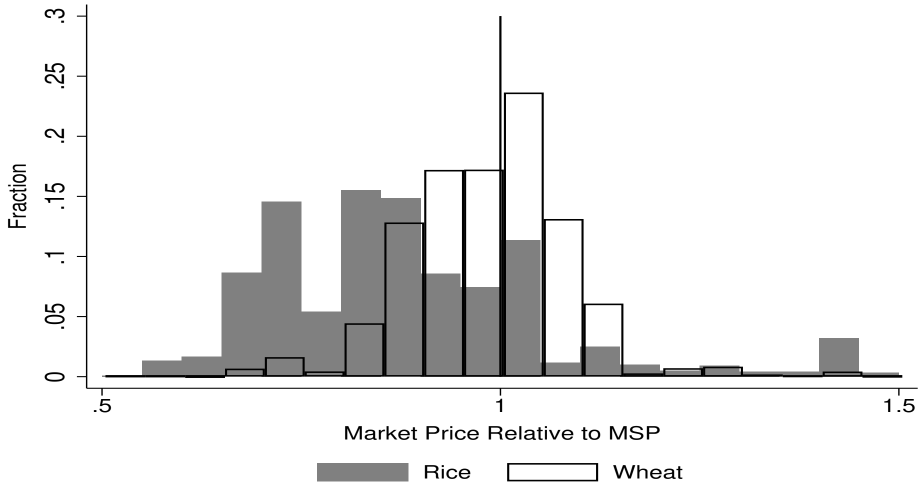
Figure A4: Effect on log output and log fertilizer consumption to cash transfer program



(a) Output (b) Fertilizer

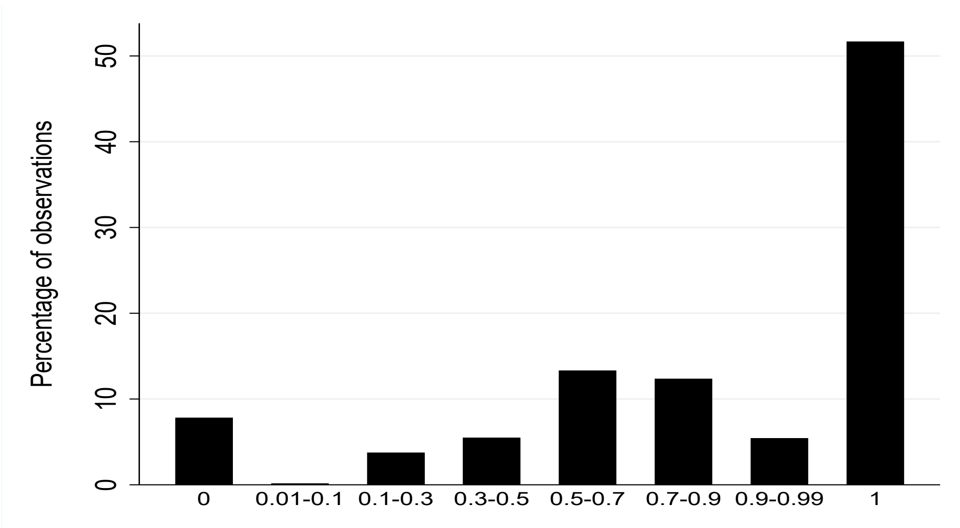
Note: Figure reports treatment and pre-treatment effect averages and 95% confidence intervals in response to the cash transfer program. Standard errors in parentheses are clustered at the district level.

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



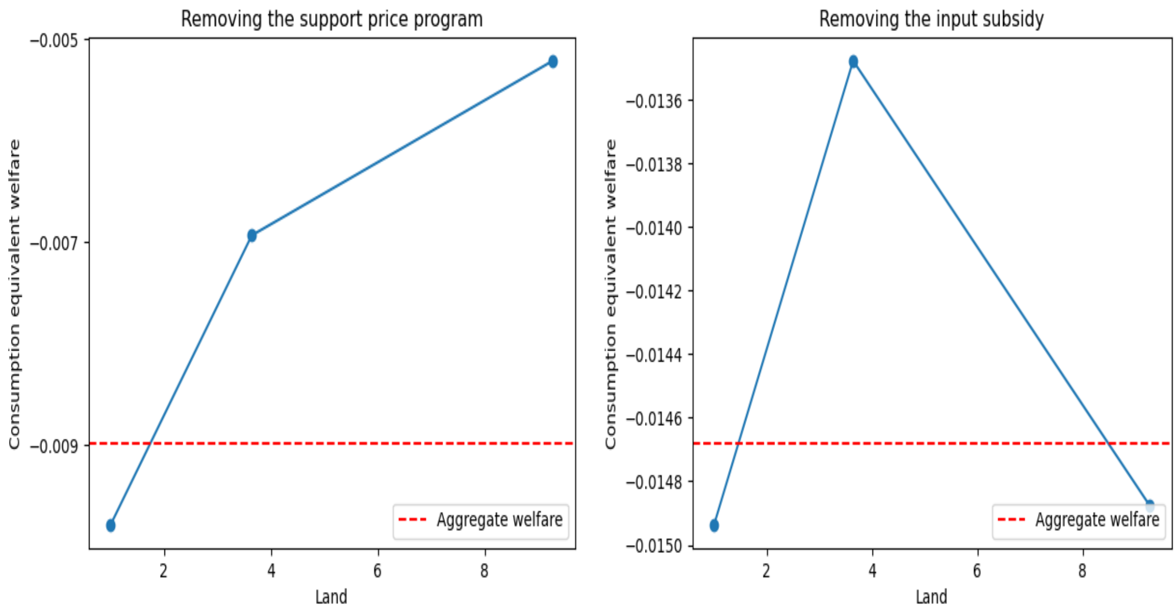
Note: The market price a farmer receives is computed as the ratio of the total value of crop divided by quantity sold. Data comes from the Land and Livestock Survey (77th NSS Round). See Appendix C for more details on sample selection.

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



Note: Data on share of land for each crop comes from the 2004-05 wave of the India Human Development Survey. Staple crops include cereals, pulses, potatoes and sweet potato.

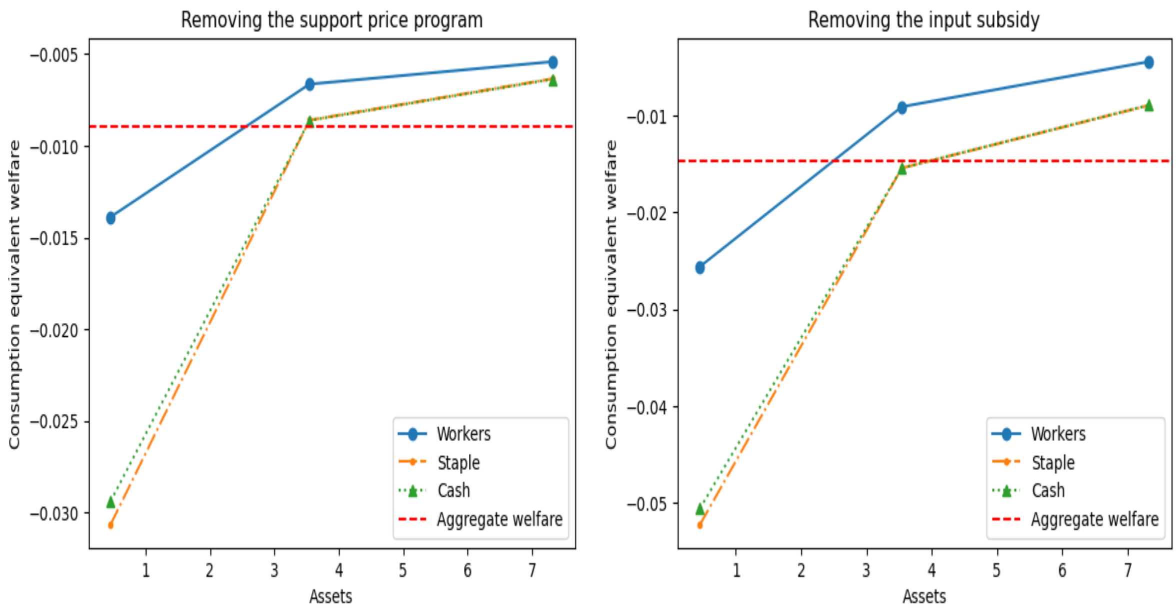
Figure A7: Welfare losses by landholdings



(a) Removal of MSP

(b) Removal of input subsidy

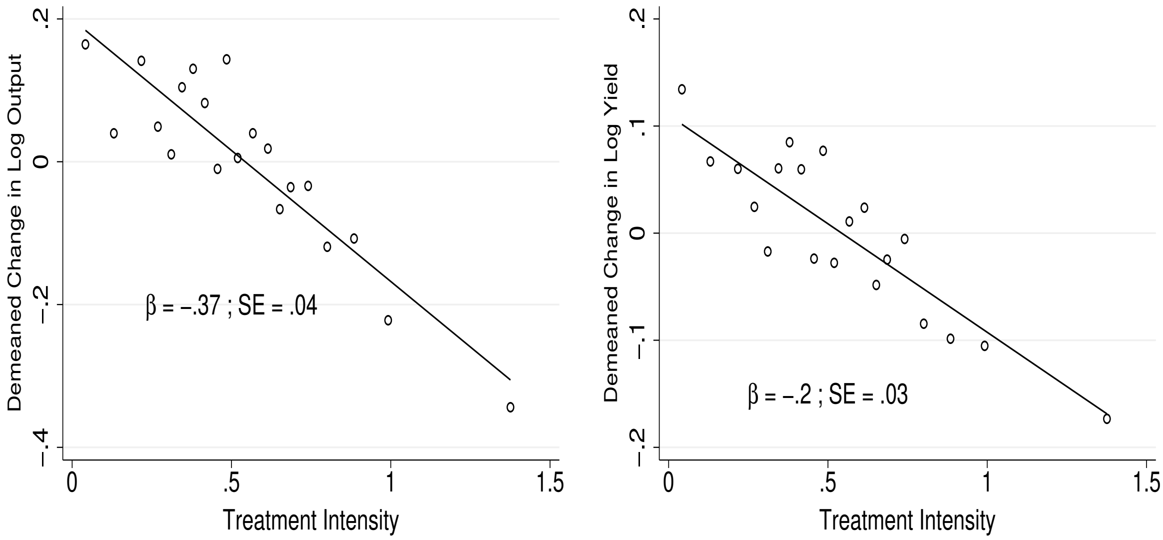
Figure A8: Welfare losses by asset levels and occupations



(a) Removal of MSP

(b) Removal of input subsidy

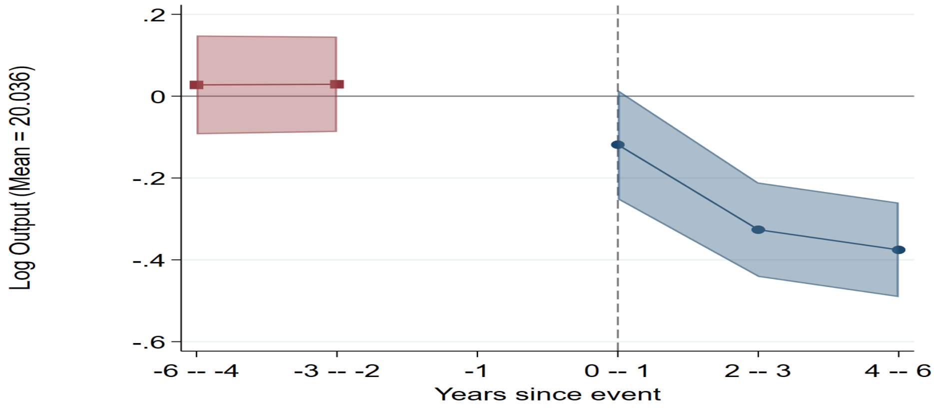
Figure A9: Binscatter of change in agricultural production and yield before and after the policy by quantiles of treatment intensity



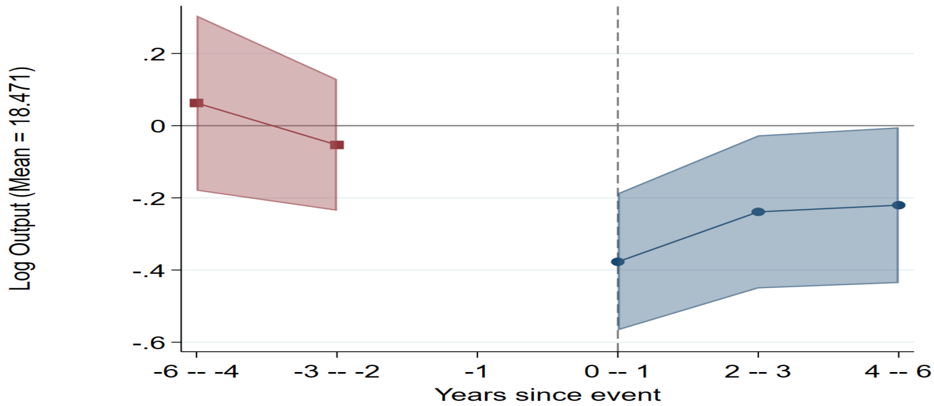
(a) Production (b) Yield

Note: The figure shows the change in the mean of the dependent variable before and after the policy for 20 quintiles of fertilizer treatment intensity. Standard errors are clustered at the district level.

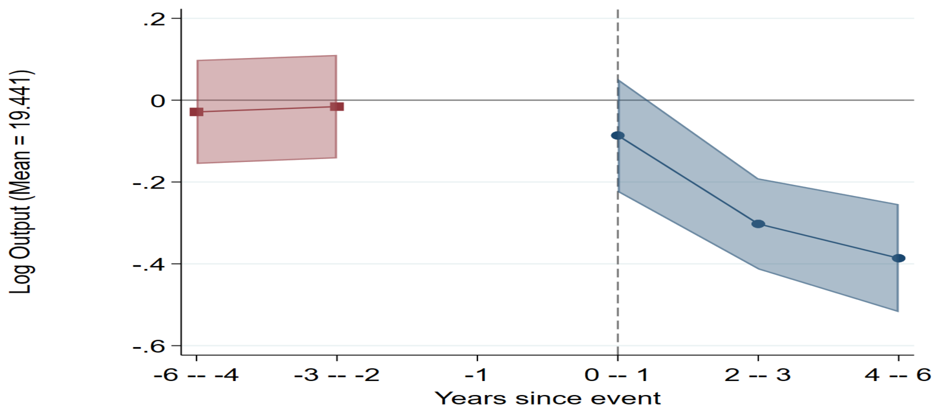
Figure A10: Effect of fertilizer price deregulation on agriculture output



(a) All



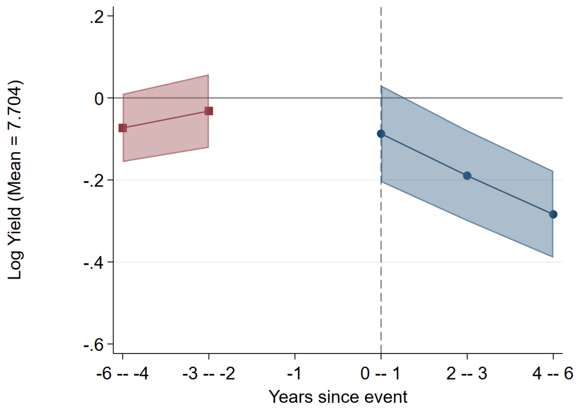
(b) Non-staple



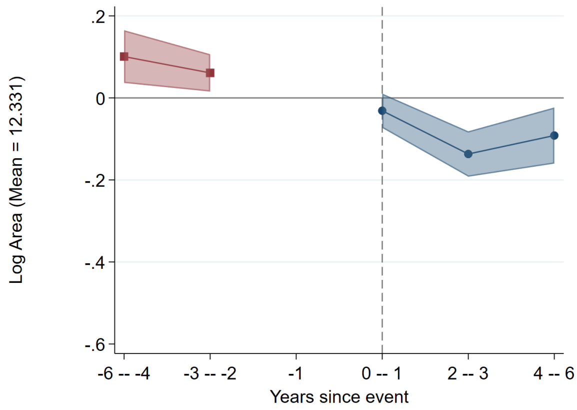
(c) Staple

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.

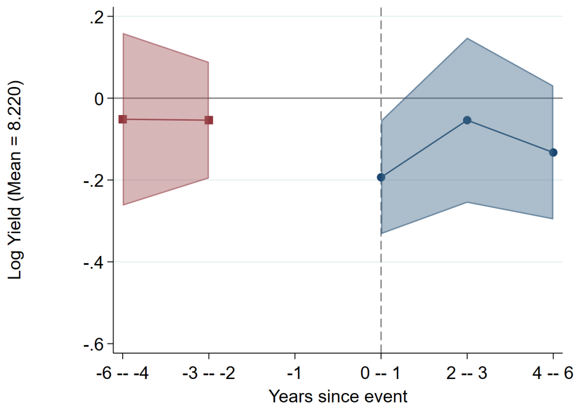
Figure A11: Effect of fertilizer price deregulation on agriculture yield and area



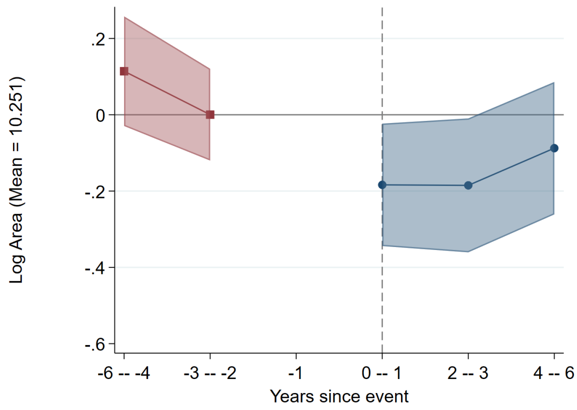
(a) All: Yield



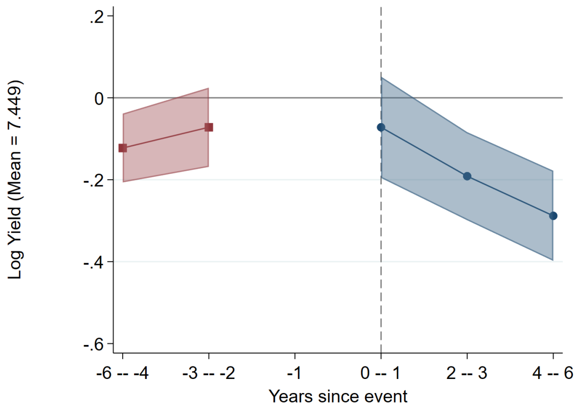
(b) All: Area



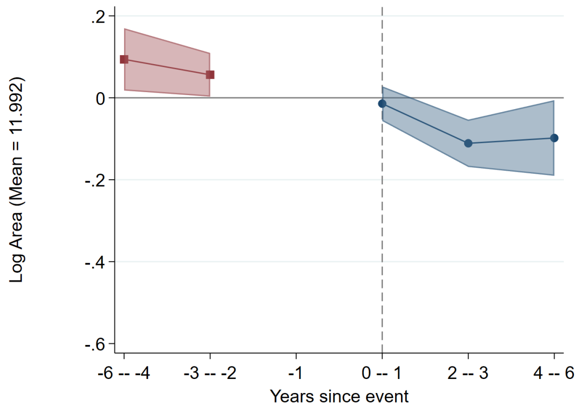
(c) Non-staple: Yield



(d) Non-staple: Area



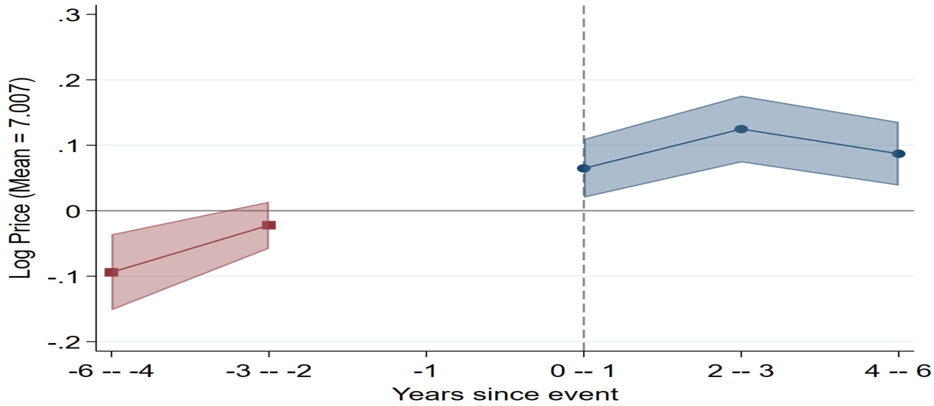
(e) Staples: Yield



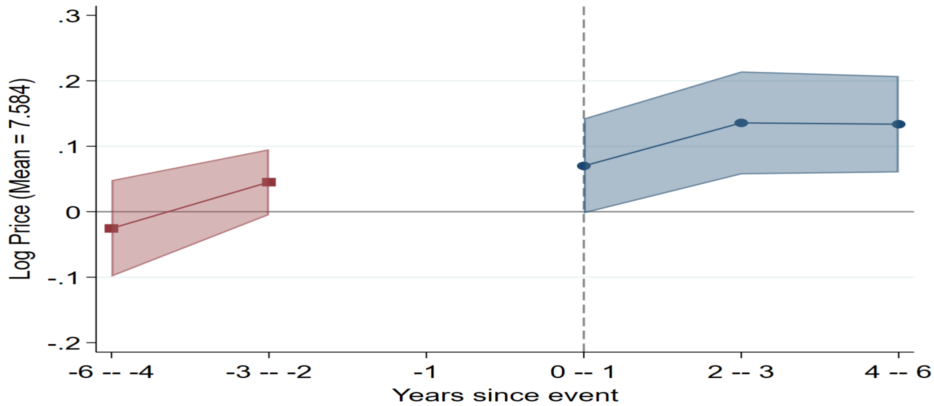
(f) Staples: Area

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.

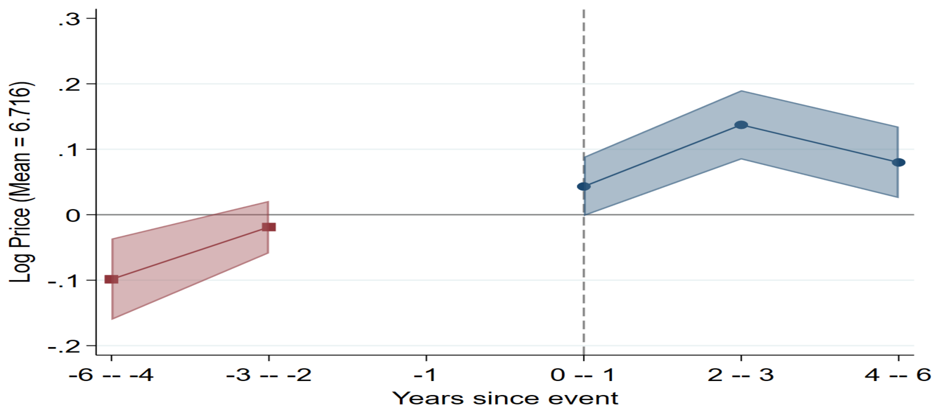
Figure A12: Effect of fertilizer price deregulation on agriculture prices



(a) All



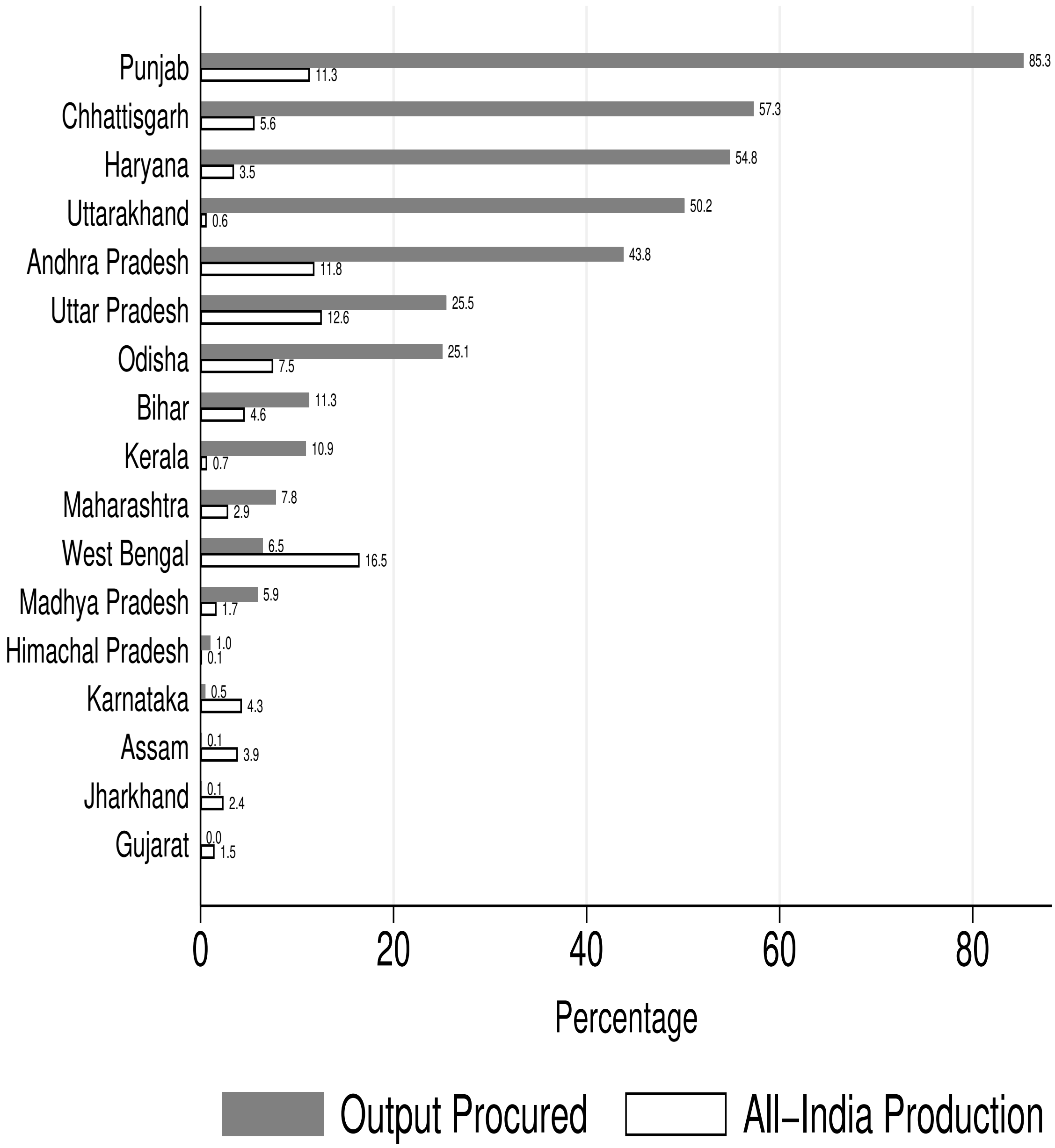
(b) Non-staple



(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



Note: Data on rice production and procurement under the MSP program for each state comes from IndiaStat.

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 non-staple 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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple Crop Farmers	0.244	0.239	0.25	0.252
Staple Crop Farmers	0.327	0.341	0.332	0.341

Note: †p^* represents prices in the benchmark

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

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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple Crop Farmers	0.244	0.246	0.252	0.255
Staple Crop Farmers	0.327	0.327	0.341	0.335

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

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

Group	No MSP (1)	Higher p_k (2)
Workers	–0.7%	–0.95%
Staple crop farmers	–1.06%	–1.9%
Non-staple crop farmers	–0.97%	–1.72%

Table B7: 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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple 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 B8: 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
Non-staple 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 non-staple 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
Non-staple 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
Non-staple Crop Farmers	0.22	0.221
Staple Crop Farmers	0.22	0.221

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

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

	Benchmark	Redistributive transfers
	MSP & input subsidy	No MSP & no input subsidy
	(1)	(2)
Aggregate Quantities		
Aggregate Output, $\sum_j p_j Y_j$	1.997	2.1
Real Output† , $\sum_j p_j^* Y_j$	1.997	1.9977
Non-agricultural Good, y_n	1.514	1.529
Non-staple Crop, y_r	0.214	0.207
Staple Crop, y_s	0.296	0.287
Rations, c^{ration}	0.0689	0
Intermediate input demand, $k_s + k_r$	0.0487	0.0416
Capital demand, k_n	4.59	4.685
Labour productivity of non-agri sector‡	3.53	3.47
Labour productivity of agricultural sector	0.845	0.835
Labour productivity of non-staple crop sector	0.878	0.778
Labour productivity of staple crop sector	0.905	0.878
Tax*	0.0977	0.06
Input price	1.56	2.072
Prices		
Non-agricultural Good (normalized)	1	1
Non-staple Crop, p_r	0.8896	1.09
Staple Crop, p_s	0.987	1.208
Support Price, $\bar{p}$	1.056	-
Interest rate, r	0.0122	0.011
Wage, w	1.168	1.175
Employment Shares		
Non-agricultural Sector	0.429	0.44
Non-staple Crop Farmers	0.244	0.237
Staple Crop Farmers	0.327	0.323
Average consumption equivalent welfare		
Welfare**	-	-0.9%

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

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

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

$**$ Welfare measure is the average consumption equivalent welfare gain (if negative) associated with moving from the benchmark equilibrium to a counterfactual without support prices and the input subsidy, accounting for the transition path.

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

Dependent variables: Log Yield or Log Area			
	All (1)	Non-staple 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.[42] We focus on the states: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand and West Bengal. Quantity of all crops is converted into tonne.[43] We ignore the composite crop groups in the analysis as prices for these groups are not available. We do not include fruits, vegetables and spices as the data is quite sparse. We exclude data for cowpea as data is not available for all years. Finally, we exclude urad and khesari crops from the analysis as farm price for these crops was unavailable during the pre-treatment periods (2004-2009). This leaves us with 32 crops which we use in our analysis.

We also categorize the crops into staple and non-staple crops.

Table C1: List of staple and non-staple crops

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

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

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

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

For the MSP exercise in Section 6.2, we drop districts that had zero area under rice cultivation for all years in the sample (2004-2009). Moreover, we drop Tamil Nadu and Rajasthan from the analysis because there was a stark difference in its procurement policy during this period. Tamil Nadu procured less than 10 percent of its rice output before the treatment periods, but doubled it post the implementation of the policy. On the other hand, Rajasthan procured 15 percent 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 77th Round)

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

CMIE States of India

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

India Human Development Survey

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

We focus on the 19 major Indian States while computing any statistic from the IHDS dataset. When estimating the variance of crop harvest, we winsorize the top and bottom 1 percent 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 non-staple 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:

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

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

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

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 non-staple 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:

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

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 non-staple 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:

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

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

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 non-staple crop farmers' intermediate input choices:

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

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 non-staple 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:

$$k_s(z_{at}, a_t, l) = \mu(z_a, z_n, a, l) \times k_s(z_{at}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times k_s(z_{at}, a_t, l; p_{st}) \tag{D.14}$$

$$y_s(z_{at}, a_t, l) = \mu(z_a, z_n, a, l) \times y_s(z_{st}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times y_s(z_{at}, a_t, l; p_{st}) \tag{D.15}$$

$$\Pi_s(z_{at}, a_t, l) = \mu(z_a, z_n, a, l) \times \Pi_s(z_{at}, a_t, l; \bar{p}) + \left(1 - \mu(z_a, z_n, a, l)\right) \times \Pi_s(z_{at}, a_t, l; p_{st}) \tag{D.16}$$

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

   (a) non-staple 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, following Gadenne (2020). 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:

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

(c) Asset market:

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

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

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

(e) Non-agricultural sector: this clears by Walras' law, noting that all fixed costs are denominated in units of the non-agricultural good and that one unit of the intermediate input is produced by transforming p_k units of the non-agricultural good:

$$\begin{aligned}\int_{\mathbf{z}\times A\times\mathbb{L}} c_n(\mathbf{z},a,l)\;dF(\mathbf{z},a,l) = Y_n - \int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\sigma(\mathbf{z},a,l)\big)\big(1-\omega(\mathbf{z},a,l)\big)\;p_k k_r(z_a,a,l)\;dF(\mathbf{z},a,l)\\ -\int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\omega(\mathbf{z},a,l)\big)\sigma(\mathbf{z},a,l)\;p_k k_s(z_a,a,l)\;dF(\mathbf{z},a,l) - \rho\int_{\mathbf{z}\times A\times\mathbb{L}} \big(1-\omega(\mathbf{z},a,l)\big)\sigma(\mathbf{z},a,l)\;\mu(\mathbf{z},a,l)\;dF(\mathbf{z},a,l)\\ -\xi\int_{\mathbf{z}\times A\times\mathbb{L}} \omega(\mathbf{z},a,l)\;dF(\mathbf{z},a,l)\end{aligned}\tag{D.22}$$

2. The distribution F evolves as per:

$$TF(z_a',z_n',a',l) = \int_{\mathbf{z}\times A\times\mathbb{L}} \mathbb{I}_{\{a'(\mathbf{z},a,l)=a'\}}\;\Pi^a(z_a,z_a')\;\Pi^n(z_n,z_n')\;dF(\mathbf{z},a,l)\quad \forall(z_a',z_n',a')\in\mathbf{z}\times A\tag{D.23}$$

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 percent of GDP) are financed through

lump sum taxes τ on all agents:

$$\tau = 0.0125*\left(y_n+\int_{\mathbf{z}\times A\times\mathbb{L}}(1-\sigma(\mathbf{z},a,l))(1-\omega(\mathbf{z},a,l))\ y_r(z_a,a,l)\ dF(\mathbf{z},a,l)+\int_{\mathbf{z}\times A\times\mathbb{L}}\sigma(\mathbf{z},a,l)(1-\omega(\mathbf{z},a,l))\ y_s(z_a,a,l)\ dF(\mathbf{z},a,l)\right)$$
$$+\bar{p}*\left(\int_{\mathbf{z}\times A\times\mathbb{L}}\mu(\mathbf{z},a,l)\ \sigma(\mathbf{z},a,l)(1-\omega(\mathbf{z},a,l))\ y_s(z_a,a,l)\ dF(\mathbf{z},a,l)\right)$$
$$-ps*\left(\int_{\mathbf{z}\times A\times\mathbb{L}}\mu(\mathbf{z},a,l)\ \sigma(\mathbf{z},a,l)(1-\omega(\mathbf{z},a,l))\ y_s(z_a,a,l)\ dF(\mathbf{z},a,l)\ -\ \psi C_s\right)*\ \mathbb{I}_{C_s^{\text{procured}}>\psi C_s} \tag{D.24}$$

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 Computational approach

We briefly discuss the computational approach we employ to solve the stationary equilibrium of the model and then obtain the transition path to a new stationary equilibrium following a policy change.

We discretize the sectoral productivity processes following Tauchen (1986), and use a seven state grid. The assets grid has 81 grid points. Our results are robust to increasing the size of both sectoral productivity and asset grids. As noted in section 4, the landholdings grid takes three values.

We compute the stationary equilibrium of the model as follows. We solve for the value and policy functions using value function iteration, while the distribution is updated using relevant policy functions as per equation (D.23). We compute excess demand in the asset, staple and non-staple crop markets defined in section D.2, and update prices using the bisection method until excess demand in each market is close enough to zero based on a tolerance criterion.

In appendix E below, we discuss the transition path following a one-time shock to agricultural TFP. The algorithm to obtain the transition path to a new stationary equilibrium associated with a policy change is to solve for the perfect foresight path following an unanticipated policy change, with markets clearing for assets and the two crops in each period as well as endogenously obtaining the period-wise rations and consumption tax rates.

D.4 Welfare

D.4.1 Aggregate welfare

We first define aggregate social welfare in the benchmark stationary equilibrium as:

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

This measures aggregate social welfare under the 'veil of ignorance', i.e. social welfare computed by a planner who weights every agent in the stationary distribution equally.

In the main counterfactual exercises, corresponding to removing the support price or input subsidy programs, we compute an analogous aggregate social welfare measure that also accounts for transition dynamics. Specifically, we solve for the transition path of an economy moving from the benchmark stationary equilibrium to the stationary equilibrium corresponding to the counterfactual policy (i.e. removing the support price or input subsidy). Denote by $V_{t_0}(\mathbf{z}, a, l)$ the value function of an individual with state $(\mathbf{z}, a, l)$ in the initial period of the transition following the move to the counterfactual policy.

Aggregate social welfare, accounting for transition dynamics, associated with moving to the counterfactual policy, is then:

$$W_{t_0} = \int V_{t_0}(\mathbf{z}, a, l)\; dF^*(\mathbf{z}, a, l) \tag{D.26}$$

Note that we aggregate using the stationary distribution of agents $F^*(\mathbf{z}, a, l)$ in the benchmark stationary equilibrium.

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 going through the transition towards the counterfactual equilibrium:

$$\chi = \left[\frac{W^*}{W_{t_0}}\right]^{\frac{1}{1-\theta}} - 1 \tag{D.27}$$

To obtain the above expression, we scale up subsistence consumption levels $\bar{c}_S$ by χ as well.[44] A negative value for χ would indicate that the average agent is better off going through

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

the transition towards the new stationary equilibrium corresponding to the counterfactual exercise.

D.4.2 Welfare by agent type

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

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

Following the discussion above, one can define social welfare for agents belonging to group j going through a transition away from the benchmark stationary equilibrium towards the stationary equilibrium of an economy with a counterfactual policy (either no support price program or no input subsidy program):

$$W_{t_0}^j = \int V_{t_0}(\mathbf{z}, a, l)\ \mathbb{I}_j^*\ dF^*(\mathbf{z}, a, l) \tag{D.29}$$

As above, we denote by $V_{t_0}(\mathbf{z}, a, l)$ the value of an individual, belonging to group j (hence $\mathbb{I}_j^* = 1$) with state $(\mathbf{z}, a, l)$, in the initial period t_0 of the transition away from the benchmark stationary equilibrium towards the stationary equilibrium under the counterfactual policy. We aggregate across individuals using the stationary distribution of agents $F^*(\mathbf{z}, a, l)$ in the benchmark stationary equilibrium. Further, agents are assigned to a group j based on whether they 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 as they undergo the transition to 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 undergoing the transition towards the counterfactual equilibrium:

$$\chi^j = \left[\frac{W^{j*}}{W_{t_0}^j}\right]^{\frac{1}{1-\theta}} - 1 \tag{D.30}$$

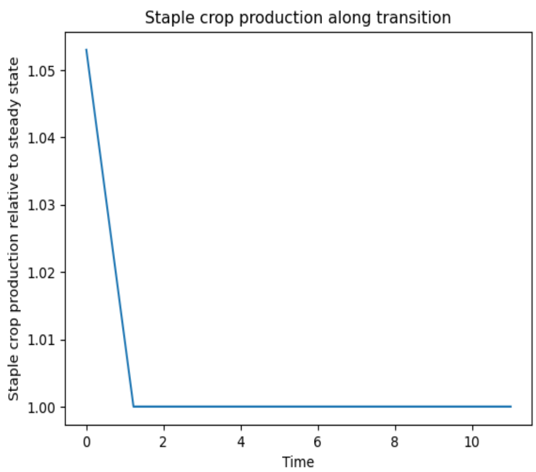
A negative value for χ^j would indicate that agents of group j are better off undergoing the transition towards the new stationary equilibrium corresponding to the counterfactual exercise.

E Transition dynamics following a transitory agricultural productivity shock

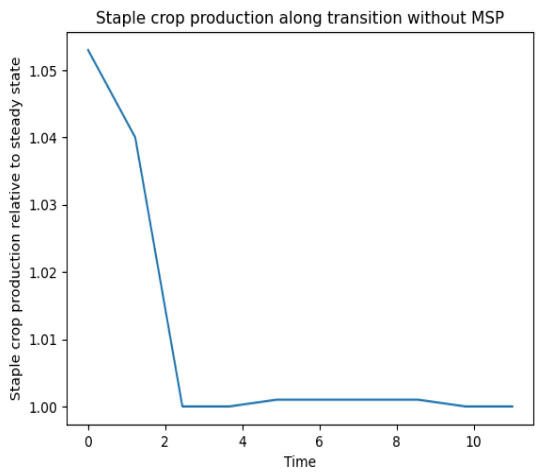
We consider the impact of a temporary (one-time) positive productivity shock on staple crop production. By inducing a glut, and driving down crop prices relative to their baseline equilibrium values, the one-time positive productivity shock could induce staple crop farmers in particular to avail of the support price program, which in turn could boost staple crop production.

Specifically, we shock the stationary equilibrium of the baseline framework with a one-time shock that raises aggregate agricultural TFP, which we denote by A_f, to 1.1 for a single period from its baseline value of 1, following which A_f reverts to 1. We compute transition dynamics by shocking the stationary equilibrium with the one-time agricultural TFP shock separately for the following two cases: (i) the benchmark model with both support price and input subsidy programs; (ii) a model with only the input subsidy program. By comparing total staple crop production following the common one-time agricultural TFP shock in environments with and without the MSP, one can assess the role of the MSP in stabilising staple crop production following a glut.

Figure A14 plots the transition dynamics of staple crop production (relative to its corresponding stationary equilibrium level) in an environment with MSP and input subsidy programs (panel (a)); and in an environment with an input subsidy but without MSP (panel (b)).



(a) Transition dynamics with MSP



(b) Transition dynamics without MSP

Figure A14: Staple crop production along the transition path following a one-time agricultural TFP shock

Interestingly, we observe that staple crop production (relative to steady state) rises nearly identically in the initial period in both cases in response to a positive one-time agricultural productivity shock. We also note that the magnitude of the initial staple crop price decline is also equivalent across the two cases. Hence, the presence of the MSP does not meaningfully affect staple crop production during a period of high staple crop supply (a glut). This is not surprising considering the small impact of the removal of the MSP on equilibrium outcomes that we discussed in section 5.2.