Support prices, Input subsidies, and Misallocation in Agriculture

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Abstract

In this paper, we study the implications of agricultural price support programs, which offer a minimum price to farmers of certain crops, and input price subsidies for occupational choices and the resulting misallocation of talent across sectors. We develop a dynamic general equilibrium model with multiple sectors: agriculture and non-agriculture and multiple crops: staples and cash crops. The government procures staple crops at predetermined prices and distributes them as free rations. Agents differ by their productivity and asset holdings and make occupational and cropping choices. The model is calibrated to the Indian economy. Preliminary results suggest that the removal of the minimum support price policy reallocates labor from the agricultural sector (both cash and staple production) to the non-agricultural sector, thereby substantially increasing non-agriculture and aggregate output in the economy. Consumer welfare falls because of a combination of loss of free rations from the government and higher market price of staples. A reduction of the intermediate input price subsidy leads to a proportional increase in the equilibrium output prices for crops, thereby keeping employment shares and aggregate output fairly unchanged in equilibrium but with a fall in consumer welfare.

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

Keywords: misallocation, agriculture, price support policy, subsidies, general equilibrium

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1 Introduction

Agricultural productivity in developing countries is low, yet their agricultural sector continues to employ a majority of their labor force[1]. Since Caselli (2005), several authors have argued that the sizable difference in living standards between developed and developing economies could be understood to a large extent by focusing on the causes of relatively low agricultural productivity in the low-income countries (Adamopoulos & Restuccia, 2014; Donovan, 2021).

Given the importance of agriculture in developing economies, policymakers in these countries have rolled out various policies designed to assist farmers, often by directly influencing crop input and sale prices[2]. While the aim of the former group of policies is to ease access to inputs, the latter group of policies enables farmers to hedge against *ex-post* shocks to sale prices. This is valuable to farmers as it provides an indirect form of insurance, with direct crop insurance being either unavailable or not demanded (Giné & Yang, 2009; Mobarak & Rosenzweig, 2013; Karlan, Osei, Osei-akoto, & Udry, 2014). However, these policies that distort prices can distort the allocation of inputs both within the agricultural sector and across sectors, which in turn affects aggregate productivity[3]. In this paper, we study the implications of input price subsidies and price floors both empirically and through the lens of a general equilibrium macroeconomic model, which is calibrated to the Indian economy. Using counterfactual exercises, we quantify the effect of these policies on sectoral misallocation and their impact on consumer welfare.

We first discuss the empirical findings that motivate our project. Our first exercise studies the impact of a policy change in 2009 in India on area cultivated and production. This policy deregulated the prices of fertilizers that deliver potassium and phosphorous nutrients. In particular, we use a difference-in-difference analysis and find that districts that utilized fertilizers relatively more intensively before 2009 experienced a bigger reduction in total area cultivated and production post-deregulation, both in the aggregate and for staple and cash crops. The second exercise looks at the impact of minimum support prices (MSP) on cropping choices and production. The experience of Rajasthan, a northern Indian state that discontinued the

[1]See Figures A1 and A2 in the Appendix

[2]Bangladesh, Brazil, Myanmar, Egypt, India, Indonesia, Mali, Pakistan, and Zambia, among other countries (World Bank Agricultural Distortions Database) had price support programs in place. The FAO finds that 27% of the 81 developing countries surveyed had price supports in place as of January 1, 2008. Ramaswami (2019) estimated that input subsidies to power, fertilizer, irrigation, and credit in India together comprised 1.5% of GDP in 2017-18. Holden (2019) reviews the input subsidy programs in Africa.

[3]Focusing specifically on the sorting of labor across sectors, Lagakos and Waugh (2013) argues that heterogeneous workers select into the agricultural sector even if they might be more productive in other sectors of the economy.

MSP and associated government procurement program for rice in 2008, is analyzed. Using district-level data from 1994-2016 in a difference-in-difference analysis, we find that when the government of Rajasthan had a procurement program in place prior to 2009, farmers increased rice plantation area and production by a larger magnitude as the MSP price increased. We extend this analogy to a national setting and use variation in the procurement of rice and wheat by state governments in the previous period. We again find that as MSP rises, production and the share of area under cultivation of that crop rises more in states where procurement was higher in the previous period. Thus, we conclude that farmers respond strongly to changes in input and output subsidies.

We use these insights to develop a dynamic general equilibrium model with two sectors (agriculture and non-agriculture) and two crops (staples and cash). All agents are heterogeneous with respect to their relative productivity in each occupation and their asset holdings and, at the start of each period, decide which sector to work in and which crop to grow if they choose to stay in the agricultural sector. Farmers face idiosyncratic risk in terms of the market price that they receive for their crops and are subject to a collateral constraint. Staple crops are protected by a minimum support price policy wherein they can be procured by the government at a fixed price and then distributed freely as rations to all farming households. Both crops are subject to subsidies in input prices. Farmers earn profits, and workers earn wages in the non-agricultural sector, which they then use to make consumption-saving decisions.

We calibrate the stationary distribution of the benchmark model to the Indian economy[4] in the presence of both price support policies and input subsidies. To quantify the role of each policy, we then conduct two counterfactual experiments. In the first exercise, the procurement option is not available as insurance against price shocks for staple crop producers, thereby leading to an absence of free staples for all farmers. In the second exercise, the input price subsidy is reduced, which leads to higher costs and tighter credit constraints for all crop producers. Our general equilibrium framework allows us to quantify the effect of these policies not only on the production choices and subsequent consumption-savings decisions of households but also accounts for sectoral reallocation through changes in the resulting equilibrium prices.

[4] Based on the 2018 Economic Survey of India, over half of the Indian workforce is employed in agriculture. However, agriculture accounts for under 20% of Indian GDP. Agriculture production has also been volatile. Growth in agricultural production and yield have experienced respective standard deviations of 7.9% and 6.2% since 1960 (Ghosh & Vats, 2022). This has prompted government policies, such as minimum support prices and input subsidies, that have been aimed at protecting against downside risk and boosting farmer incomes more generally.

We find that in the absence of the minimum support price, lower expected profits incentivize staple crop producers to relocate to other sectors. This results in a fall in the relative output price for cash crops and a rise for staple crops, partially offsetting the decrease in expected profits for staple crop farmers. This propels further reallocation of labor from cash crops towards the non-agricultural sector. In equilibrium, the employment shares of both cash and staple crop production fall. Thus, the output in the non-agricultural sector increases, which compensates for the decline in agricultural output, leading to an increase in the aggregate output of the economy. When input subsidies are reduced, effectively increasing the price of the intermediate input, the value of being a farmer reduces through lower expected profits and incentivizes the poor farmers at the margin to move to the non-agricultural sector. While the demand for all goods falls due to the income effect, the negative effect on supply leads to higher output prices in equilibrium, which offsets the initial decline in expected profits. Thus, in equilibrium, employment shares remain unchanged, aggregate output increases marginally, and the resulting quantity of both cash and staple crops produced are lower with higher market prices.

While investigating the welfare implications of these policies, we find that the removal of the minimum support price policy results in lower consumer welfare due to a combination of the absence of free rations, higher uncertainty, and higher market prices for staples. As an alternative policy, if the government expenditure on procurement is instead utilized to make income transfers to all households in the absence of an MSP, there are welfare losses, but their magnitudes are lower. Similarly, if the government expenditure on procurement were utilized to make in-kind transfers of staples to all households in the absence of an MSP (constituting a form of rations disbursal), then welfare losses are considerably lowered. A reduction in input price subsidies also results in welfare losses as the market prices for both crops rise. Even if households are compensated by lump-sum transfers that are equivalent to the amount saved by the lowering of these subsidies, welfare losses are not eliminated even though they are quantitatively smaller.

Our paper contributes to the vast literature that explores the effect of various distortions on misallocation (Hsieh & Klenow, 2009; Restuccia, Yang, & Zhu, 2008; Adamopoulos & Restuccia, 2014). The analytical framework employed builds on the quantitative literature on agricultural misallocation, e.g., Adamopoulos and Restuccia (2014, 2020) and Donovan (2021). Unlike the 'indirect' wedge-based approach employed in Adamopoulos and Restuccia (2014), we explicitly model distortions to prices received by farmers and subsidies to farm input prices. Donovan (2021) also uses a general equilibrium model to study misallocation in the agricultural sector.

However, the focus of their paper is on the role of incomplete markets in the presence of agricultural risk, which leads to low input utilization. In contrast, we study the effect of agricultural policies on sectoral allocation and its effect on aggregate productivity.

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

2 Empirical Evidence

Input and output subsidies affect farmers' choices in the Indian context given the low productivity and farm size (Bolhuis, Rachapalli, & Restuccia, 2021). We will discuss the institutional context and the implications of two types of subsidies given by the Government of India (GOI): (1) fertilizer subsidy and (2) minimum support price.

2.1 Fertilizer subsidies

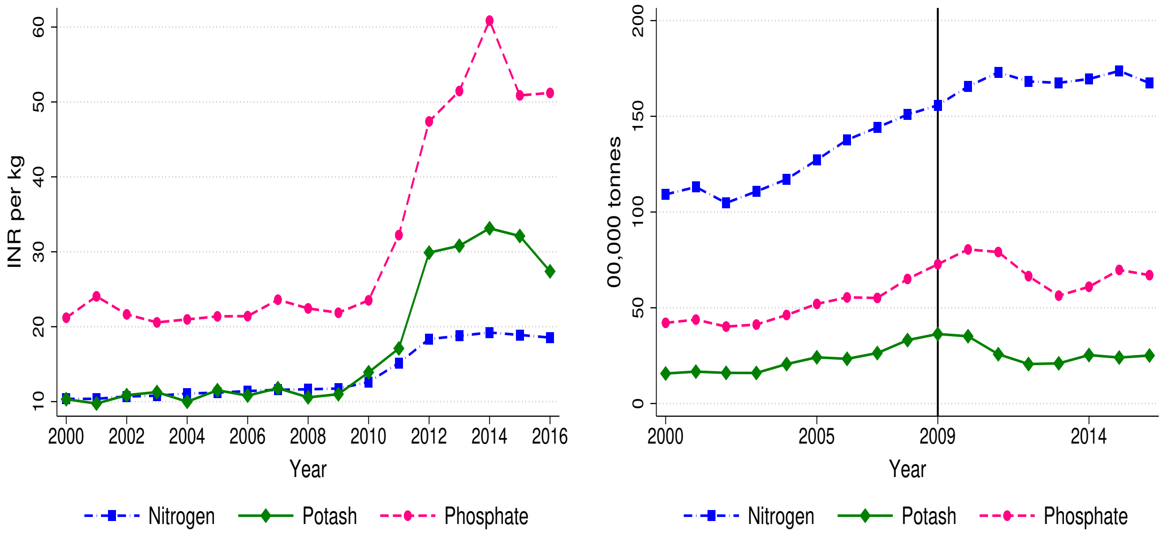
Fertiliser subsidies were introduced during the Green Revolution period in India. The government controlled the retail price at which fertilizers were sold to the farmers and also compensated manufacturers for the difference in the cost of production and retail price. The subsidies are mostly applied to urea, diammonium phosphate (DAP) and muriate of potash (MOP) which primarily deliver nutrients nitrogen (N), phosphate (P) and potassium (K) respectively. Comparing the international and the Indian retail price, the subsidy on a bag of urea, DAP and MOP was 89%, 61% and 29% respectively in 2022.[5] The government decontrolled retail prices in 1991 as part of the economic liberalization and structural adjustment program and further in 2010.

In 2010, the government delinked the international price of P and K fertilizers from its cost of production and allowed the fertilizer manufactures control over the retail prices as part of the Nutrient Based Subsidy Scheme. The price of urea continues to be regulated by the Government. We compute the mean fertilizer price per hectare that farmers paid each year from 2004-2014 using the Cost of Cultivation Survey.[6] Figure 1a shows that fertilizer prices of

[5]Source: https://govtschemes.in/fertilizer-subsidy-scheme-2022#gsc.tab=0

[6]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.

Figure 1: Fertilizer price and consumption over time



(a) Price of N, P and K

(b) Consumption of N, P and K

phosphate and phosphorous rose significantly post 2010. On the other hand, the price of urea rose a bit in 2011 and 2012 but then flattened in spite of the sharp increase in the international market (Bansal & Rawal, 2020). The increase in prices lead to a fall in national consumption of P and K fertilizers but not urea after 2009 as seen in figure 1b.[7] We show in Appendix figure A3 using an event-study analysis that the use of P and K fertilizers fell at the district level too.

We use the change in policy as a quasi-natural experiment to understand the role of input subsidy on the agricultural output. The fertilizer subsidy is applicable nationally but depending on the extent of fertilizer use across districts, some districts would be more exposed to the policy change than others. We use the variation in fertilizer usage before 2010, to estimate the effect of the change in fertilizer prices on agricultural land use and production. The regression specification we employ is the following:

$$Y_{dt} = \beta_0 + \boldsymbol{\beta}_1 \log\left(\text{Fertilizer Usage Intensity}_d\right) * \mathbf{1}_{t>2009} + \phi_d + \mathbf{1}_{t>2009} + \varepsilon_{dt} \tag{1}$$

where Y_{dt} is log area or log production in district d at time t, ϕ_d is district fixed effect, $\mathbf{1}_{t>2009}$ is a dummy variable that takes value 1 for years after 2009 and log Usage Intensity$_d$ is the log of average fertilizer use from 2004-2009 in a district.[8] ε_{dt} is the mean zero random error term and standard errors are clustered at the district level. β_1 is the coefficient of interest capturing

[7]Source: Fertilizer Association of India

[8]Results are unchanged if we used year fixed effects instead of post 2009 dummy variable.

the effect of the change in fertilizer subsidy on differentially exposed districts. Fertilizer Usage Intensity is constructed by taking a weighted average across years 2004 to 2009 of phosphate and potash fertilizer used with total area sown as weighs.[9]

We use data on cropped area (thousand hectare) and value of output (rupees per thousand tonne) for years 2004 to 2016 of 16 crops in 20 major Indian states from the ICRISAT district-level panel data. We classify the crops into two categories, staple and cash crops. Staples include cereals (rice, wheat, pearl millet, sorghum, maize, finger millet, barley) and pulses (chickpea and pigeonpea) whereas cash crops include oil crops (castor seed, groundnut, linseed, rape mustard, sesame) and other commercial crops (sugarcane, cotton).

Table 1: Difference-in-Difference estimates of change in fertilizer subsidy

	Total (1)	Staple (2)	Cash (3)
	A: Area Estimates		
Post * log (Fertilizer Usage Intensity)	-0.0438**	-0.0438 **	-0.0741***
	(0.020)	(0.021)	(0.022)
District FE	Yes	Yes	Yes
Observations	4030	4030	3967
R-Squared	0.988	0.977	0.975
Mean Dependent	5.766	5.515	3.457
Mean Average Usage	6.645	6.645	6.624
	B: Production Estimates		
Post * log (Fertilizer Usage Intensity)	-0.0980***	-0.104***	-0.0926***
	(0.021)	(0.023)	(0.026)
District FE	Yes	Yes	Yes
Observations	4030	4030	3952
R-Squared	0.960	0.945	0.968
Mean Dependent	22.472	22.117	20.449
Mean Average Usage	6.645	6.645	6.614

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1 shows the effect of the fertilizer subsidy on area in Panel A and output in panel B. The first column shows the impact for all crops whereas the second and third column display the results for staple and cash crops respectively. The first column of panel A highlights that

[9]The formula to construct is:

$$\text{Fertilizer Usage Intensity}_d = \frac{1}{6}\sum_{t=2004}^{2009} \frac{p_P F_{Pdt} + p_K F_{Kdt}}{\text{Area Sown}_{dt}} \tag{2}$$

where p_P and p_K are average of annual median prices of phosphorous and potash respectively over 2004-2009 from the Cost of Cultivation Survey.

a district that used fertilizer a unit more experiences a 4% (std. error = 0.02) fall in area employed, consistent with Garg and Saxena (2022). The fall in production is 9.8% (std. error = 0.02) as shown in column (1) of panel B. Furthermore, staple and cash crop area planted falls by 4% and 7.4% respectively in districts that more intensely used fertilizers and consequently, production falls too by around 10% of both crops. To verify that our methodology is not capturing pre-existing differences between districts, we show using an event-study empirical design in Appendix figures A4 and A5 that more versus less exposed areas did not differ in agricultural area employed and production before the policy change. Thus, the removal of input subsidy has a sizeable impact on agriculture production.

2.2 Minimum support price (MSP)

MSP was introduced in India during the time of the Green Revolution to ensure food security and stabilize farmer incomes. It entails the government announcing a price floor for 23 crops at which it commits to buy as much a farmer is willing to sell. In turn, some of the procured crops are distributed to lower income households at near zero prices. The Public Distribution System (PDS) is among the largest food distribution program in the world by covering nearly 800 million individuals in 190 million households.[10]

India has two main sowing seasons: kharif (June to October) and rabi (November to March). The price floor at which the government will procure is announced nationally at the start of each planting season.[11] In practise, most of the government procurement occurs for two crops: rice and wheat. The nominal price at which the government procures (Appendix figure A6a) and the amount of procurement to overall production (Appendix figure A6b) for both these crops has been growing strongly in recent years. But, there exists substantial variation across states and time in the intensity of procurement. Table 2 shows the percentage of rice and wheat which is procured out of total production for selected states. Historically, a significant amount of production is procured in Punjab and Haryana. Although in recent years other states have increased procurement too. Madhya Pradesh procured 30% and 41% of its total rice and wheat output respectively in 2015-16. Telangana and Chhattisgarh procured 80% and 62% respectively of their rice output.

[10]Source: National Food Security Portal

[11]These prices are determined by a combination of government-administered surveys and political considerations.

Table 2: Procurement of Rice and Wheat as % of State Production

	Rice			Wheat		
	1986-87	2000-01	2015-16	1986-87	2000-01	2015-16
Andhra Pradesh	22	58	49	0	0	0
Bihar	0	0	29	0	0	0
Chhattisgarh	N/A	36	62	N/A	0	0
Haryana	44	55	57	46	47	60
Madhya Pradesh	11	18	30	0	7	41
Orissa	3	20	61	0	0	0
Punjab	73	76	69	69	61	64
Rajasthan	0	17	0	3	10	13
Telangana	N/A	N/A	80	N/A	N/A	0

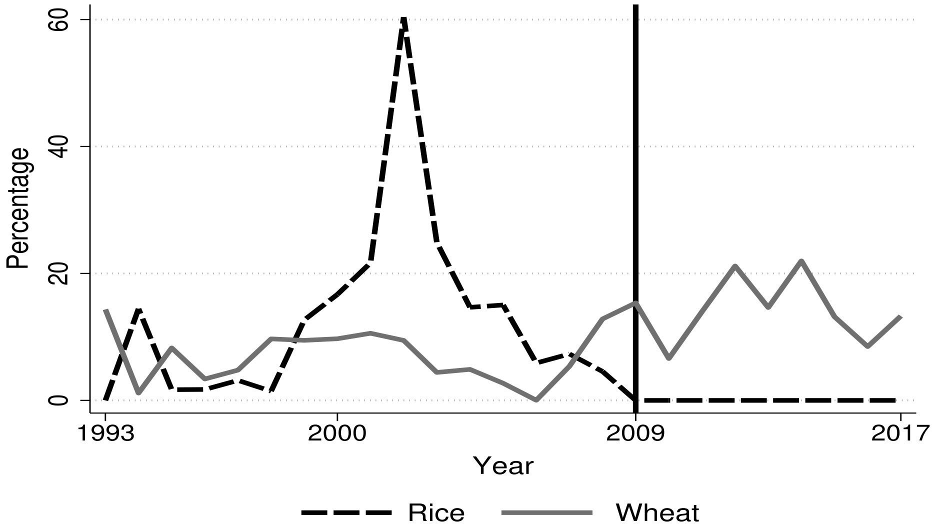
We will use two key factors in our empirical approach to test the effect of price support on agricultural production: first, MSP is announced before planting and second, variation in output procured across states and time. We first consider the case of Rajasthan which procured a positive amount of rice from 1993 onwards until 2008 after which it stopped rice procurement entirely. Though, it continued to procure wheat after 2009 as shown in figure 2. To provide some evidence of the impact of MSP on agricultural decisions, we will compare whether districts respond more to MSP pre 20009 compared to post 2009. The regression specification is:

$$Y_{dt} = \beta_0 + \beta_1 \text{MSP} + \mathbf{1}_{t<2009} + \boldsymbol{\beta}_2 \text{MSP} * \mathbf{1}_{t<2009} + \phi_d + +\varepsilon_{dt} \tag{3}$$

where Y_{dt} is log area, share of total area or log production in district d at time t, ϕ_d is district fixed effect and $\mathbf{1}_{t<2009}$ is a dummy variable that takes value 1 for years before 2009.[12] ε_{dt} is the mean zero random error term and standard errors are clustered at the district level. β_2 is the coefficient of interest capturing the difference in the impact of MSP as government's procurement policy changed.

[12] Results are unchanged if we used year fixed effects instead of post 2009 dummy variable.

Figure 2: Share of rice and wheat procurement in Rajasthan



We use ICRISAT district level data from 1994-2016 on area sown and production of rice and share of area sown for rice out of total cropped area. Table 3 shows the differential effect of MSP before 2009 relative to post 2009 on rice cropped area and output. The first column highlights that farmers increased rice plantation area more as MSP price increased when the government pursued an active procurement policy. Consequently, the share of area devoted to rice production and rice output also increased more before 2009 relative to after 2009. Thus, changes in the price floor affect farmer choices consistent with Krishnaswamy (2018) and Garg and Saxena (2022).

Table 3: Difference-in-Difference estimate of MSP prices in Rajasthan

	Log Area (000 hectare) (1)	Share Area (%) (2)	Log Output (000 tonnes) (3)
Pre 2009 * MSP	0.339***	0.619**	0.482***
	(0.089)	(0.259)	(0.099)
District FE	Yes	Yes	Yes
Observations	349	506	352
R-Squared	0.957	0.866	0.933

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We also provide evidence that the effect of price support on farmer choices holds throughout India. To do so, we will build on the case study by comparing regions with differential intensity of procurement in the previous period and not current period as it will be correlated with current production. The regression specification is:

$$
\begin{aligned}
Y_{dt} &= \beta_0 + \beta_1 \text{MSP} + \beta_2 \text{Share of output procured}_{t-1} \\
&+ \beta_3 \text{Share of output procured}_{t-1} * \text{MSP} + \phi_d + +\varepsilon_{dt} \qquad (4)
\end{aligned}
$$

Table 4: Difference-in-Difference estimate of MSP prices

	Log Area (000 hectare) (1)	Share Area (%) (2)	Log Output (000 tonnes) (3)
Share of Output Procured t-1 * MSP	0.176***	1.551***	0.158***
	(0.030)	(0.313)	(0.035)
District x crop FE	Yes	Yes	Yes
Observations	15689	16574	15675
R-Squared	0.951	0.983	0.946

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The first column of table 4 shows that comparing districts in which the government procured more intensely in the previous period, area planted of rice/wheat rises as MSP rises. Furthermore, the share of area devoted to the crop out of total area also rises and production increases as the price support rises. We show in Appendix table 7 that the effect of price support is similar if we considered a dummy variable of whether procurement occurred or not in the last year instead of the share of output procured. Below we discuss the mechanisms through the lens of a model to explain how input and output subsidies influence farmer decisions. We also undertake counterfactual exercises of removing MSP and input subsidy.

3 Model

There are two sectors in the economy: agriculture and non-agriculture. The agricultural sector in turn, comprises *staple* crops and *cash* crops. The non-agricultural good serves as the numeraire, and its price is normalized to 1 $\forall t$. The prices of the staple and cash crops are denoted by $\{p_{st}, p_{rt}\}$ respectively.

A measure 1 of individuals can choose to be either farmers of cash or staple crops, or workers in the non-agricultural sector. Each farmer faces crop-specific idiosyncratic productivity shocks z_{jt}, drawn from a truncated log-normal distribution Q_j with zero mean and s.d. σ_j. The realization of z_{jt} is i.i.d with respect to individuals, crops and time.

Individuals make their occupational choices *after* the idiosyncratic shocks are realized. However, farmers choose inputs before observing an idiosyncratic shock to the *market price*, δ, that is log-normally distributed with s.d. σ_δ and an upper bound of 1, i.e. the farmer cannot receive a price above the market price. The price that a farmer of crop j obtains is then δp_j.

3.1 Technologies

The non-agricultural good is produced by a representative firm, which uses labour n_{nt}, hired at competitive wage w_t, as its sole input:

$$y_{nt} = A n_{nt}, \tag{5}$$

where A is economy-wide total factor productivity (TFP).

The agricultural good of each type ($j = \{r, s\}$) is produced by home-operated farms according to the following production function, which takes intermediate inputs k_{jt} and land l_{jt} as inputs:

$$y_{jt} = (A\kappa_j z_{jt})\left[k_{jt}^{\zeta_j} l_{jt}^{\gamma_j}\right] \tag{6}$$

where ζ_j and γ_j are production function parameters satisfying $\zeta_j + \gamma_j < 1$; and κ_j is the crop-specific productivity shock.

There is a total amount L of land in the economy. Land can be rented at the market rate q_t from absentee landlords, who are unmodeled.

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. Expenditure on the intermediate input by a farmer of crop j is then $p_k k_j$.

Expenditure on the intermediate inputs must be incurred prior to the harvest, by borrowing from lenders at rate $\tilde{r}_l = \tilde{r} + d$, where $\tilde{r}$ is the return on saving and d captures wedges between the deposit and lending rates, e.g. intermediation costs. Let the interest factor be $\tilde{R} = 1 + \tilde{r}_l$.

Borrowing is subject to a collateral constraint that is a linear function of the asset holdings (a) of the borrower:

$$p_k k_j = b \leq \phi a$$

The parameter $\phi \geq 1$ represents the degree of financial frictions, with $\phi \to \infty$ capturing perfect financial markets.

3.2 Preferences

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

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

The period utility function is non-homothetic and includes a subsistence requirement for staple crops:

$$u(\mathbf{c}) = \frac{\left[\phi_s(c_s - \bar{c_s})^{1-\theta} + \phi_r(c_r)^{1-\theta} + (1 - \phi_s - \phi_r)(c_n)^{1-\theta}\right]}{1-\theta} \tag{7}$$

Here, $\mathbf{c} = (c_s, c_r, c_n)$ is the bundle of consumption goods. $\bar{c_s}$ measures the subsistence level of consumption of the staple crop, and ϕ_j is the weight that individuals assign to agricultural good j.

Households do not have access to insurance markets, so that consumption can only be insured through saving in a risk-free asset that earns interest $\tilde{r}_t$, as in Bewley-Aiyagari-Huggett models. Savings (a_t) is denominated in the non-agricultural good. Define the compact set of asset holdings $A = [\underline{a}, \bar{a}]$. Individuals cannot borrow to finance consumption, i.e. $\underline{a} = 0$.

3.3 Role of Government: Procurement and Distribution of Staple Crops

We consider a support mechanism wherein staples are procured from farmers at a fixed price (the support price $\bar{p_t}$), and the procured staples are in turn freely distributed to farming households. Finally, we assume that all agents obtain a ration of staple crops determined in equilibrium and denoted by c^{ration}.

3.4 Profit maximization problems

The profit maximization problem of the representative firm (in units of the non-agricultural sector) is simple and yields the equilibrium wage $w = A$:

$$\max_{n_{nt}} An_{nt} - w_t n_{nt} \tag{8}$$

A period's decision problem can be divided into two stages: (i) *ex ante*, i.e. prior to the realization of the δ shock but after observing the $\mathbf{z}$ shocks, when occupational and farm input choices are made; and (ii) *ex post*, i.e. after *all* shocks $\{\mathbf{z}, \delta\}$ are observed and individuals make saving and consumption choices.

A farmer of crop r solves the following:

$$\max_{k_{rt}, l_{rt}} \mathbb{E}_\delta \; \delta p_{rt}(A\kappa_r z_{rt})\left[k_{rt}^{\zeta_r} l_{rt}^{\gamma_r}\right] - \tilde{R}_t p_k k_{rt} - q_t l_{rt} \tag{9}$$

and subject to the collateral constraint $k_{rt} \leq \frac{\phi a}{p_k}$.

The unconstrained optimal choices of capital and labour by a farmer of crop j are denoted by k_j^u and l_j^u respectively. Further, the expectation of the market price received by a farmer of crop j is denoted by $p_j^e = \mathbb{E}_\delta \delta p_j$ Combining the first order conditions of the problem above, one obtains:

$$k_r^u(z_r) = \left(\frac{\gamma_r}{q}\right)^{\frac{\gamma_r}{1-\gamma_r-\zeta_r}} \left(\frac{\zeta_r}{p_k \tilde{R}}\right)^{\frac{1-\gamma_r}{1-\gamma_r-\zeta_r}} \left(A\kappa_r z_r p_r^e\right)^{\frac{1}{1-\gamma_r-\zeta_r}} \tag{10}$$

$$l_r^u(z_r) = \left[\frac{A\gamma_r p_r^e z_r \left(k_r^u(z_r)\right)^{\zeta_r}}{q}\right]^{\frac{1}{1-\gamma_r}} \tag{11}$$

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

$$k_r(z_r, a) = \min\{k_r^u(z_r), \frac{\phi a}{p_k}\} \tag{12}$$

As the choice of land is unconstrained, it is obtained from the first-order condition setting the marginal product of land to equal the land rent, yielding:

$$l_r(z_r, a) = \left[\frac{A\gamma_r p_r^e z_r (k_r)^{\zeta_r}}{q}\right]^{\frac{1}{1-\gamma_r}} \tag{13}$$

Plugging these back into the production function and the profit expression:

$$y_r(z_r, a) = (A\kappa_r z_{rt})\big[k_{rt}^{\zeta_r} l_{rt}^{\gamma_r}\big] \tag{14}$$

$$\Pi_r(z_r, a, \delta) = \delta p_{rt}(A\kappa_r z_{rt})\big[k_{rt}^{\zeta_r} l_{rt}^{\gamma_r}\big] - \tilde{R}_t p_k k_{rt} - q_t l_{rt} \tag{15}$$

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

A farmer of the staple crop is assumed to hold the option to sell her produce at the announced support price $\bar{p}_t$ after observing the realisation of the idiosyncratic market price shock δ. The staple farmer decides the share of her harvest μ_t she wishes to sell at the support price $\bar{p}_t$ as opposed to selling it at the market price δp_{st}, based on whichever price yields her the highest revenue per unit sold, which reduces to a comparison of the two prices. Thus, $\mu(\delta) = 1$ if $\bar{p} > \delta p_s$, and is zero otherwise.

The input choices of a farmer of crop s solve a similar optimization problem, with the difference that the staple crop farmer could sell her crop at the support price.

Let $p_s^{\max}(\delta) = \max\{\delta p_s, \bar{p}\}$, and denote the expectation of this price by $p_s^e = \mathbb{E}_\delta\, p_s^{\max}(\delta)$.

Then, the staple crop farmer's input choices solve:

$$\max_{k_{st}, l_{st}} p_{st}^e(A\kappa_s z_{st})\big[k_{st}^{\zeta_s} l_{st}^{\gamma_s}\big] - \tilde{R}_t p_k k_{st} - q_t l_{st} \tag{16}$$

subject to the collateral constraint $k_{st} \leq \frac{\phi a}{p_k}$.

The expressions for k_s^u and l_s^u are analogous to those for derived above for cash crop farmers' unconstrained input choices.

The capital input choice for the staple crop farmer is:

$$k_s(z_s, a) = \min\{k_s^u(z_s), \frac{\phi a}{p_k}\} \tag{17}$$

This yields:

$$l_s(z_s, a) = \left[\frac{A\gamma_s p_s^e z_s \big(k_s(z_s, a)\big)^{\zeta_s}}{q}\right]^{\frac{1}{1-\gamma_s}} \tag{18}$$

and an expression for staple crop production that is similar to the corresponding expression derived for cash crop farmers.

The profit of a staple crop farmer with shocks (z_s, δ) and saving a is:

$$\Pi_s(z_s, a, \delta) = p_s^{\max}(\delta)(A\kappa_s z_{st})\left[k_{st}^{\zeta_s} l_{st}^{\gamma_s}\right] - \tilde{R}_t p_k k_{st} - q_t l_{st} \tag{19}$$

3.5 Utility maximization and Occupational Choice

An individual can choose to be either a farmer of cash or staple crops in the agricultural sector, or a worker in the non-agricultural sector. Workers in the non-agricultural sector face idiosyncratic shocks denoted by τ, drawn from a distribution Q_τ with mean $\bar{\tau}$ and standard deviation σ_τ, that reduce their wage. This shock can be interpreted as an earnings shock arising, for instance, due to the possibility of unemployment in the non-agricultural sector.

The relevant state vector is (z_s, z_r, τ, a). However, potential farmers do not observe their idiosyncratic price shock δ until they visit the market.

If an individual chooses to be a worker and supplies one unit of labour inelastically, she receives the wage payment w_t but faces the idiosyncratic earnings shock τ_t. As a result, workers receive after-tax labor income of $(1 - \tau_t)w_t$.

If she chooses to be a farmer in sector $j = \{s, r\}$, she obtains the *expected profit* from operating her farm, denoted by $\mathbb{E}_\delta\, \Pi_j(z_{jt}, a, \delta_t)$ specified in the equations above.

The land rents generated are assumed to be distributed equally across all agents in the economy. Denoting the land revenue rebate by T^l, this shall enter the budget constraints of all agents and shall be defined in the next section.

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

$$V^w(z_s, z_r, \tau, a) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{20}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = w(1 - \tau) + a(1 + \tilde{r}) + T^l$$

Note that total staple crop consumption is the free ration c^{ration} plus the amount chosen, c_s.

Next, consider the value associated with becoming a farmer of the cash crop, *after* the idiosyncratic shock δ is observed. There is a fixed cost ξ associated with choosing cash crop farming.

$$V^r(z_s, z_r, \tau, a, \delta) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{21}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi^r(z_r, a, \delta) - \xi + a(1 + \tilde{r}) + T^l$$

Similarly, the value associated with becoming a farmer of the staple crop is:

$$V^s(z_s, z_r, \tau, a, \delta) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{22}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi^s(z_s, a, \delta) + a(1 + \tilde{r}) + T^l$$

Each *ex post* crop-specific value function $\{V^r(z_s, z_r, \tau, a, \delta),\ V^s(z_s, z_r, \tau, a, \delta)\}$ is associated with a corresponding *ex ante* crop-specific value function, prior to the realisation of the idiosyncratic price shock:

$$\mathbb{E}\ V^r(z_s, z_r, \tau, a) = \mathbb{E}_\delta V^r(z_s, z_r, \tau, a, \delta) \tag{23}$$

$$\mathbb{E}\ V^s(z_s, z_r, \tau, a) = \mathbb{E}_\delta V^s(z_s, z_r, \tau, a, \delta) \tag{24}$$

The value function $V(z_s, z_r, \tau, a)$ for an agent with saving a and shocks $\{z_s, z_r, \tau\}$ is the maximum of the *ex ante* choice-specific value functions:

$$V(z_s, z_r, \tau, a) = \max\{\mathbb{E}V^s(z_s, z_r, \tau, a), \mathbb{E}V^r(z_s, z_r, \tau, a), V^w(z_s, z_r, \tau, a)\} \tag{25}$$

This yields the occupational choice functions:

$$\omega(z_s, z_r, \tau, a) = 1\ \sigma(z_s, z_r, \tau, a) = 0 \text{ if } V(z_s, z_r, \tau, a) = V^w(z_s, z_r, \tau, a) \tag{26}$$

$$\omega(z_s, z_r, \tau, a) = 0,\ \sigma(z_s, z_r, \tau, a) = 1 \text{ if } V(z_s, z_r, \tau, a) = \mathbb{E}V^s(z_s, z_r, \tau, a) \tag{27}$$

$$\omega(z_s, z_r, \tau, a) = \sigma(z_s, z_r, \tau, a) = 0 \text{ if } V(z_s, z_r, \tau, a) = \mathbb{E}V^r(z_s, z_r, \tau, a) \tag{28}$$

3.6 Equilibrium

A competitive equilibrium is defined in the usual manner. In the following, I list some of the market clearing conditions and the equation which updates the distribution of agents in the economy. To simplify notation, let the probability of facing idiosyncratic shock δ be represented by $P(\delta)$. Further, let the state space for the idiosyncratic shock vector (z_s, z_r, τ) be denoted by $\mathbf{Z}$.

1. Markets clear:

   (a) Non-agricultural good:

$$\begin{aligned}\int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\ c_n(z_s, z_r, \tau, a)\ dF(z_s, z_r, \tau, a) +\\ \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big) \sum_{\delta} P(\delta)\ c_n(z_s, z_r, \tau, a, \delta)\ dF(z_s, z_r, \tau, a) +\\ \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big)\ \sigma(z_s, z_r, \tau, a) p_k k_s(z_s, a) dF(z_s, z_r, \tau, a) +\\ \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big)\big(1-\sigma(z_s, z_r, \tau, a)\big)\ p_k k_r(z_s, a)\ dF(z_s, z_r, \tau, a) = y_n \end{aligned} \tag{29}$$

   (b) Cash crop:

$$\begin{aligned}\int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\ c_r(z_s, z_r, \tau, a)\ dF(z_s, z_r, \tau, a) +\\ \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big) \sum_{\delta} P(\delta)\ c_r(z_s, z_r, \tau, a, \delta)\ dF(z_s, z_r, \tau, a)\\ = \int_{\mathbf{Z}\times A} \big(1-\sigma(z_s, z_r, \tau, a)\big)\big(1-\omega(z_s, z_r, \tau, a)\big)\ y_r(z_r, a)\ dF(z_s, z_r, \tau, a) \end{aligned} \tag{30}$$

   (c) Marketed staple crops: total staple crops purchased for an agent with state (z_s, z_r, τ, a) is given by $c(z_s, z_r, \tau, a)$. On the supply side, a fraction $1-\mu(\delta)$ of the amount produced is sold on the market.

$$\begin{aligned}\int_{\mathbf{Z}\times A} \Big(1-\omega(z_s, z_r, \tau, a)\Big) \sum_{\delta} P(\delta)\ c_s(z_s, z_r, \tau, a, \delta)\ dF(z_s, z_r, \tau, a)\\ + \int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\ c_s(z_s, z_r, \tau, a)\ dF(z_s, z_r, \tau, a)\\ = \int_{\mathbf{Z}\times A} \sigma(z_s, z_r, \tau, a) \sum_{\delta} P(\delta)\big(1-\mu(\delta)\big)\ y_s(z, a)\ dF(z_s, z_r, \tau, a) \end{aligned} \tag{31}$$

(d) Land market:

$$\int_{\mathbf{Z}\times A} \big(1-\omega(z_s,z_r,\tau,a)\big)\ \sigma(z_s,z_r,\tau,a)\ l_s(z_s,a)\ dF(z_s,z_r,\tau,a)+$$
$$\int_{\mathbf{Z}\times A} \big(1-\sigma(z_s,z_r,\tau,a)\big)\big(1-\omega(z_s,z_r,\tau,a)\big)\ l_r(z_r,a)\ dF(z_s,z_r,\tau,a) = L \quad (32)$$

(e) Rationed staple crops: these are disbursed equally to all agents

$$c^{\text{ration}} = \int_{\mathbf{Z}\times A} \sigma(z_s,z_r,\tau,a) \sum_{\delta} P(\delta)\mu(\delta)\ y_s(z_s,a)\ dF(z_s,z_r,\tau,a) \quad (33)$$

2. Land rental income is rebated to all agents in the economy uniformly:

(a) Land rental income:

$$T^l = q\int_{\mathbf{Z}\times A} \big(1-\omega(z_s,z_r,\tau,a)\big)\ \sigma(z_s,z_r,\tau,a)\ l_s(z_s,a)\ dF(z_s,z_r,\tau,a)+$$
$$q\int_{\mathbf{Z}\times A} \big(1-\sigma(z_s,z_r,\tau,a)\big)\big(1-\omega(z_s,z_r,\tau,a)\big)\ l_r(z_r,a)\ dF(z_s,z_r,\tau,a) \quad (34)$$

3. The distribution F evolves as per:

$$TF(z_s',z_r',\tau',a') = \int_{\mathbf{Z}\times A} \omega(z_s,z_r,\tau,a)\ \mathbb{I}_{\{a'(z_s,z_r,\tau,a)=a'\}}\ dF(z_s,z_r,\tau,a)+$$
$$\int_{\mathbf{Z}\times A} \big(1-\omega(z_s,z_r,\tau,a)\big) \sum_{\delta} P(\delta)\ \mathbb{I}_{\{a'(z_s,z_r,\tau,a,\delta)=a'\}}\ dF(z_s,z_r,\tau,a),\quad \forall (z_s',z_r',\tau',a') \in \mathbf{Z}\times A \quad (35)$$

Here, $\mathbb{I}_{\{a'(z_s,z_r,\tau,a)=a'\}}$ is an indicator function that takes the value 1 when a worker-saver with state (z_s,z_r,τ,a) has saving a'. Similarly, $\mathbb{I}_{\{a'(z_s,z_r,\tau,a,\delta)=a'\}}$ is an indicator function that takes the value 1 when a farmer-saver with state (z_s,z_r,τ,a,δ) has savings a'. T is an operator that maps distributions into distributions.

4 Parameterization

In this section, we discuss the parameter choices in this model. For simplicity, we assume that the sector-neutral TFP A and crop-specific productivities κ_r, κ_s are all set equal to 1. The interest rate is chosen exogenously and set equal to 3%. Following Rivera-Padilla (2020), the utility parameters, $\phi_s = 0.1$, and $\phi_r = 0.1$ are chosen to match the budget shares of staples and cash crops respectively. The endowment L is set following Adamopoulos and Restuccia (2014) to match an average farm size of 1.15 hectares in 2010-11 as per the Agriculture Census. Average farm size in the model would be $\frac{L}{\int \left(1-\omega(a)\right) dF(a)}$. The agricultural share of employment in 2010-11 is approximately 0.5, hence $L = 0.575$ hectares.

The rest of the parameters will be calibrated as described here. Following Donovan (2021)'s approach, the discount factor, β, is chosen to match the total value of savings relative to harvest value, standard deviations of crop-specific shocks, η_r, η_s, are chosen to match household-level variation in crop yields, and for the non-agricultural sector, the standard deviation, η_n, and the mean τ of the shock are based on earnings regressions for workers in that sector. The standard deviation of the market price shock, η_d, is chosen to match the standard deviations of observed crop prices (similar to Garg and Saxena (2022)). Following Rivera-Padilla (2020), the total production of staple crops relative to cash crops is used to determine the subsistence requirement, $\bar{c}$. The capital elasticity of cash crops, ζ_r, and staple crops, ζ, are assumed to be equal and are chosen to match the capital share of total revenue. The minimum support price, $\bar{p}$, is chosen to match the share of total staple production sold to the procurement agency. The intermediate input price, p_k, is assumed to be fixed and is chosen to match the ratio of the price of the intermediate input to that of the non-agricultural output (similar to Restuccia et al. (2008); Donovan (2021)). Finally, we assume that the credit constraint parameter, ϕ, equals 2. However, we conduct robustness exercises and find that changes in ϕ do not affect the equilibrium results.

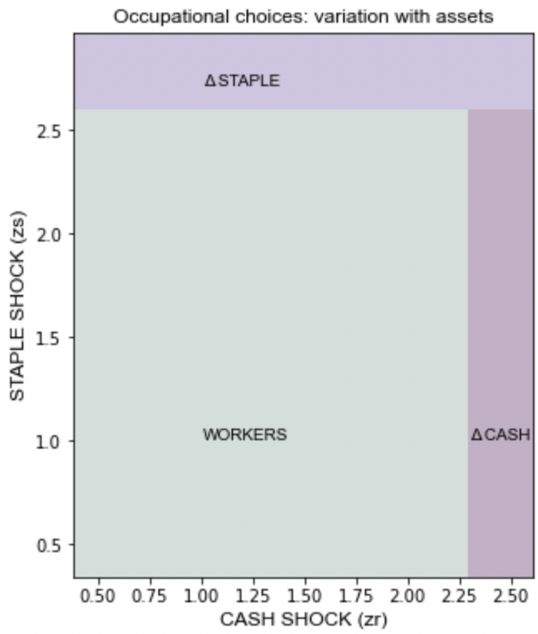
5 Results

In this section, we discuss the preliminary results when we solve our general equilibrium model using the parameter values described above. Our benchmark model is one in which the minimum support price policy is present. We first analyze the role of assets in determining occupational choices. Next, in order to investigate the role of the subsidies, we conduct two counterfactuals: (i) to assess the role of the minimum support price policy, we set $\bar{p} = 0.0001$, effectively eliminating this insurance option; (ii) to assess the role of the input subsidy, we increase the price of the intermediate input, p_k to 3.5. Finally, we discuss the welfare implications of these policies.

5.1 Role of assets in influencing occupational choices

An interesting feature of the model presented above is the role of assets in occupational choices. Dynamic models of misallocation such as Donovan (2021) allow assets to influence occupational choices through the variation of risk aversion with asset holdings, which affects saving and hence value associated with various occupations. The assumption that idiosyncratic productivity shocks (z_s, z_r, τ) are observed prior to occupational choices being made implies that the sole source of uncertainty that would make the channel in Donovan (2021) operational is uncertainty about the idiosyncratic shock δ. The relatively limited variation in δ makes this channel less relevant in our model.

Figure 3: Occupational choices: comparing agents with no assets and sizable assets



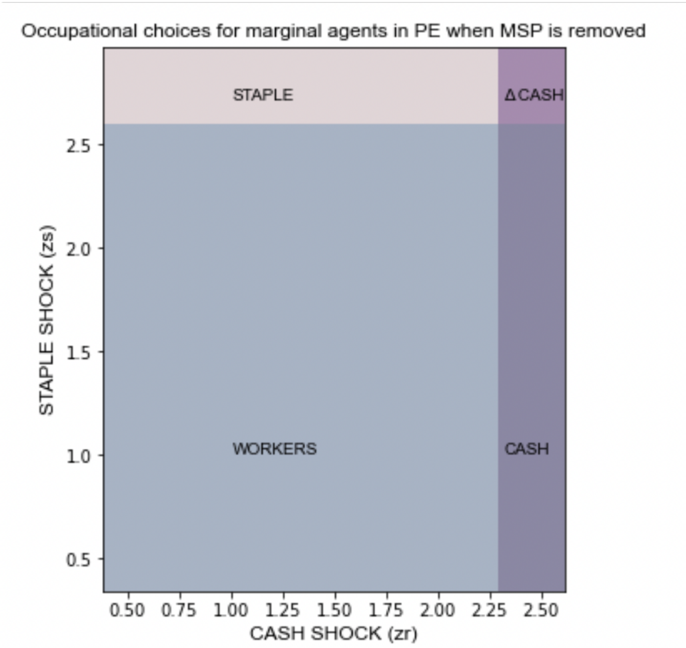
The model above also features another channel for assets to influence occupational choice through the borrowing constraint in equation (17). Greater asset holdings enable farmers to choose the unconstrained optimal input choices of capital and land. This raises the profits associated with cultivating crops. Consequently, holding idiosyncratic shocks constant, agents with more assets are at least as likely to choose farming compared to agents with lower assets.

Figure 3 illustrates this point by comparing the occupational choices of agents with no assets and agents with sizable assets. The band labeled 'Δ CASH' corresponds to agents who, for the same combination of (z_s, z_r, τ), chose to be workers when they had no assets and switch to growing cash crops when they have sizable assets. Similarly, the band labeled 'Δ STAPLE' corresponds to agents who, for the same combination of (z_s, z_r, τ), chose to be workers when they had no assets and switch to growing staple crops when they have sizable assets. These changes occur primarily because of a relaxation of the borrowing constraint for agents with high assets.

5.2 Role of the minimum support price

Figure 4 depicts the impact on occupational choices for marginal agents, i.e., those likely to switch occupations following a change in the minimum support price policy, keeping all prices fixed. While agents with low realizations of z_s and z_r remain as workers in the non-agricultural sector, agents with high $z_s(z_r)$ and low $z_r(z_s)$ choose staple (cash) crop farming. As compared to the benchmark case, in the absence of the minimum support price policy, which acted as insurance against downward market price risk, individuals with low productivity in the staple crop sector are incentivized to move out of staple crop farming towards other sectors, noting the fixed cost associated with cultivating cash crops. In figure 4, the small band labeled 'Δ CASH' represents those agents who switch from staple to cash crop farming upon the removal of the MSP.

Figure 4: Occupational choices: removing MSP



In equilibrium, an inflow of staple crop farmers into the cash crop and non-agricultural sector results in a fall in the cash crop price, p_r, whereas there is a slight increase in that of staple crop price, p_s. This is also because, as the expected profits of cash crop producers fall, there is an income effect, due to which their demand for all goods decreases; however, the unavailability of free rations for farmers, along with the subsistence requirement, offsets the fall in demand for staple crops. Lower output prices for cash crop producers, along with the absence of free rations, result in individuals with low productivity in the cash crop sector moving out. Similarly, the expected profit of staple crop producers may rise or fall depending on the overall effect on p_s in the absence of the MSP. In our equilibrium, employment share in the non-agricultural sector rises, which is driven by a reduction in the mass of both staple crop and cash crop farmers. Since the supply of land is fixed, a resulting lower demand for land leads to a fall in the land price, q. Cash crop production, y_r, and staple crop production, y_s, fall, whereas production of the non-agricultural good, y_n, rises, thereby resulting in an overall increase in the aggregate output of the economy. Table 5 compares the quantitative results obtained from this counterfactual exercise (Column 2) to the benchmark (Column 1).

Table 5: Equilibrium Outcome Comparison

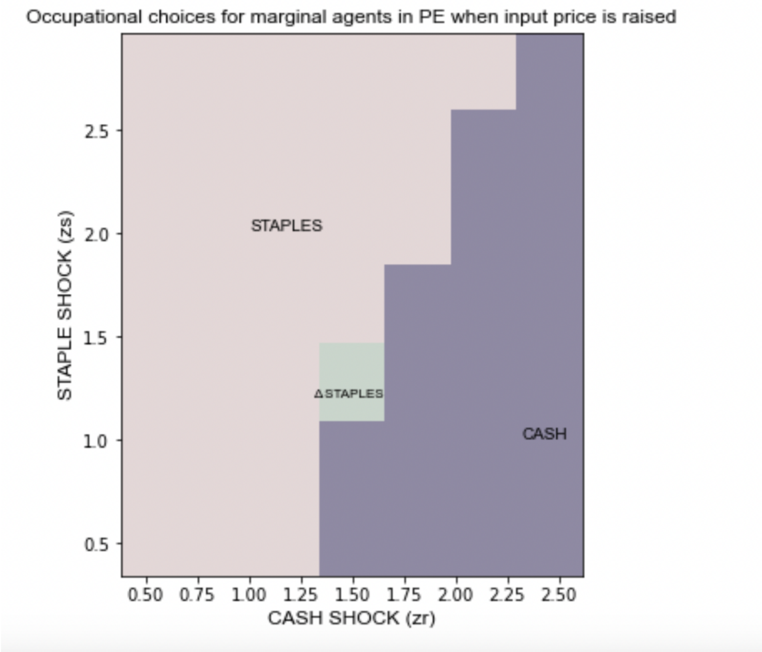
	Benchmark	Removing MSP	Reducing input subsidy*
Aggregate Quantities			
Aggregate Output	0.475	0.562	0.476
Non-agricultural Good, y_n	0.441	0.529	0.441
Cash Crop, y_r	0.125	0.122	0.117
Staple Crop, y_s	0.164	0.160	0.160
Rations, c^{ration}	0.039	0	0.038
Prices			
Non-agricultural Good	1 (normalized)	1 (normalized)	1 (normalized)
Cash Crop, p_r	0.116	0.108	0.120
Staple Crop, p_s	0.122	0.123	0.127
Support Price, $\bar{p}$	0.118	-	0.123
Land Rental Price, q	0.035	0.033	0.035
Employment Shares			
Non-agricultural Sector	0.441	0.529	0.441
Cash Crop Farmers	0.123	0.115	0.123
Staple Crop Farmers	0.436	0.356	0.436

*For this exercise we increase the price of input, p_k from 2.77 to 3.5

5.3 Role of input subsidies

A reduction in input subsidies is captured by an exogenous increase in the price of the intermediate input, p_k. Figure 5 depicts how occupational choices respond to a reduction in the input subsidy when all other prices are fixed at the benchmark level. This lowers the expected profits for farmers and effectively tightens their collateral constraint, thereby reducing their ability to use their optimal quantity of inputs. However, the presence of the MSP still induces farmers leaving the cash crop sector to move to the staple crop sector (the band labeled 'Δ STAPLES'). If we interpret the capital good as corresponding to fertilizer, then one finds that the decline in staple crop and total output is consistent with the production estimates in table 1.

Figure 5: Occupational choices: reducing input subsidy



Further, due to the income effect, the demand for all goods by farmers also reduces. In our specification, the resulting equilibrium price of cash and staple crops increases, which helps to offset the increase in input price, but the quantity of crops produced in both these sectors falls. Thus, the equilibrium employment shares across the three sectors remain fairly similar to the benchmark case, and the aggregate output shows a small increase. The quantitative results are listed in Column 3 of Table 5.

5.4 Welfare

The welfare measure that we shall focus on is based on Buera and Shin (2011), which is an aggregate consumption equivalent measure.

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

$$W^{j*} = \int V^*(z_s, z_r, \tau, a)\, \mathbb{I}_j^*\, dF^*(z_s, z_r, \tau, a) \tag{36}$$

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

Similarly, define the welfare of a model economy, using the stationary distribution of agents $F^*(z_s, z_r, \tau, a)$ in the benchmark model, under the counterfactual equilibrium:

$$\hat{W^j} = \int \hat{V}(z_s, z_r, \tau, a)\, \mathbb{I}_j^*\, dF^*(z_s, z_r, \tau, a) \tag{37}$$

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

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

$$\chi^j = \left[\frac{W^{j*}}{\hat{W^j}}\right]^{\frac{1}{1-\theta}} - 1 \tag{38}$$

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

We construct this welfare measure to consider welfare gains from the two exercises discussed above, viz. removing the MSP and reducing the input subsidy, where the benchmark in each

Table 6: Welfare changes under counterfactual policies

Group	No MSP	No MSP (balanced)	No MSP (doubled)	No MSP (in-kind)	Higher p_k
Workers	3.95%	2.59%	−0.6%	1%	2.31%
Staple crop farmers	4.5%	2.88%	−0.73%	0.94%	2.46%
Cash crop farmers	4.5%	2.9%	−0.71%	1.01%	2.47%

case is an economy with the MSP.

Consider first the counterfactual exercise entailing removing the MSP. Noting that removing the MSP also removes rations disbursed to all agents, a policy that removes the MSP without compensating agents by means of an alternative policy (such as income transfer) is unlikely to improve welfare. This insight is confirmed in column 2 of table 6.

A more reasonable exercise is to compare welfare in an environment where the MSP is replaced by alternative policies that supports farmers. We begin by considering income transfers to all agents in the economy, where the total amount available for disbursal is the expenditure of the government on procurement, $\bar{p} * c^{\text{ration}}$. We refer to this as a balanced budget transfer policy. Column 3 of table 6 shows that welfare losses from removing the MSP under the counterfactual with an income transfer are lower. However, the income transfer is not sufficient to make the counterfactual regime without a MSP more attractive to agents. Column 4 of table 6 shows that doubling the income transfer to all agents leads to welfare gains for all agents. The increased resources overcome the loss of rations and the insurance benefit of an MSP policy[13]. A replacement policy that is a natural contrast to income transfers is a balanced budget program that uses the amount spent on subsidies to purchase staples that are disbursed to all agents as rations. This is, therefore, an in-kind policy. Column 5 of table 6 shows that this results in lower welfare losses compares to the no MSP counterfactual (column 2), suggesting that the provision of rations or in-kind transfers is valued by agents. However, the amount of staples provided under the in-kind transfer policy is lower than the rations provided under MSP in the benchmark, while both equilibrium crop prices are also higher in this counterfactual.

The second counterfactual we consider is a reduction of the input subsidy, keeping the MSP policy in place. Noting from table 5 that prices of staple and cash crops rise in the counterfactual that reduces the input subsidy, the welfare of all agents should not rise in the counterfactual economy, which is confirmed in column 5 of table 6. Again, we find that a policy that reduces

[13]Equilibrium outcomes under the replacement policies are discussed in table 8 in the appendix.

the input subsidy but transfers the amount saved to agents in the form of income transfers reduces the welfare losses from the counterfactual economy but does not eliminate them. As with the exercise where the MSP is reduced, we find that more generous transfers eventually make all agents prefer the economy with reduced input subsidies.

6 Conclusion

This article studies the impact of policies that offer guaranteed minimum prices to farmers of certain crops, as well as subsidies to input prices, in the context of India. The empirical analysis uses a natural experiment that deregulated certain fertilizer prices in 2009 to show that the impact of the deregulation was to lower the area cultivated and the production of staple and cash crops. With regard to price supports, districts with farmers who sold their produce at MSP to the government previously tend to increase both area cultivated and crop production in years when the MSP is high.

These insights guide the dynamic quantitative model, which features heterogeneous agents, occupational choice, support prices, and input subsidies. Preliminary results indicate that aggregate output rises in a counterfactual exercise that removes the support price policy, while a counterfactual exercise that reduces the input subsidy does not impact aggregate output significantly. These outcomes arise through the interaction of occupational flows and crop price changes following the change in policy. Welfare gains arise under the counterfactual policies when they are replaced by sizable income transfers.

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Appendix

Additional Figures

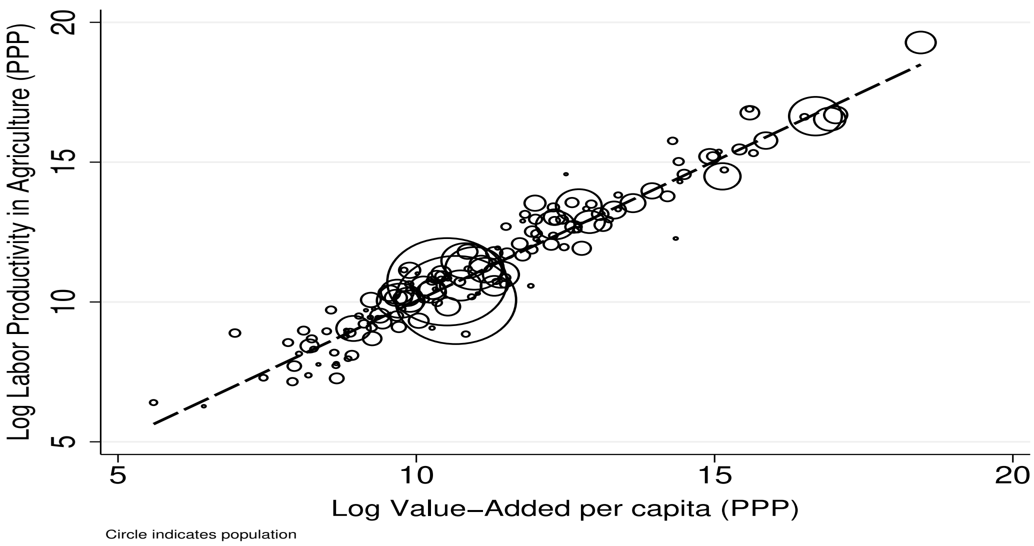


Figure A1: Employment shares across sectors in rich and poor countries

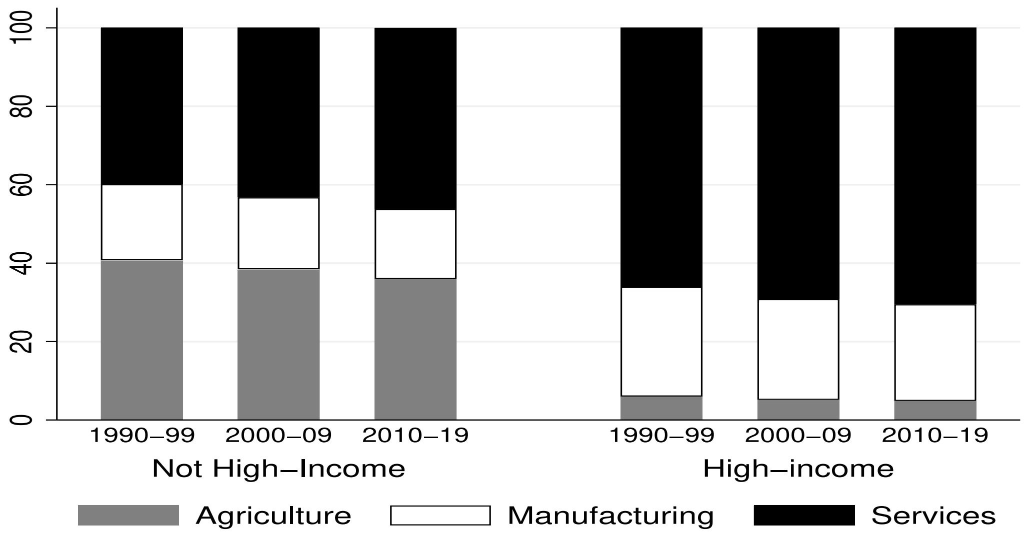


Figure A2: Employment shares across sectors in rich and poor countries

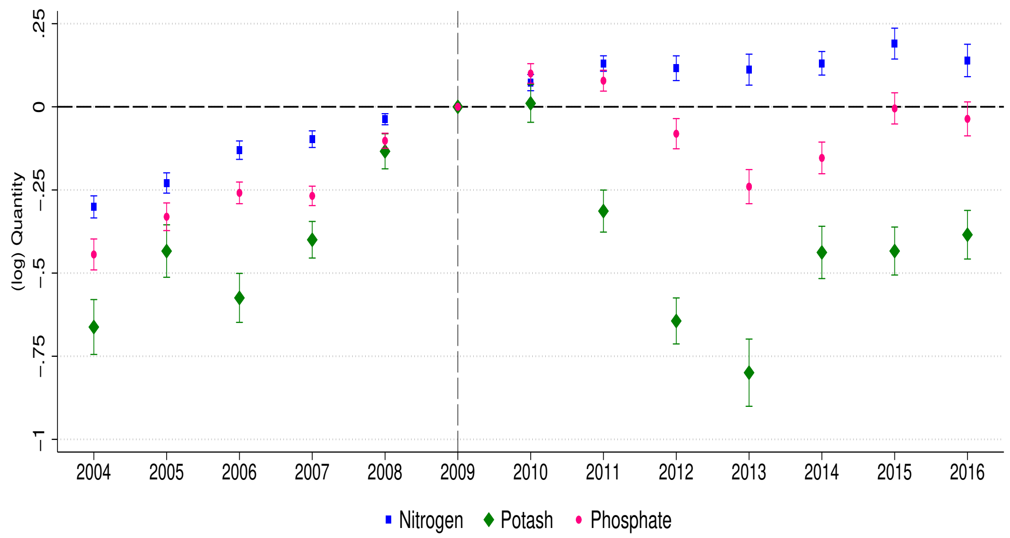
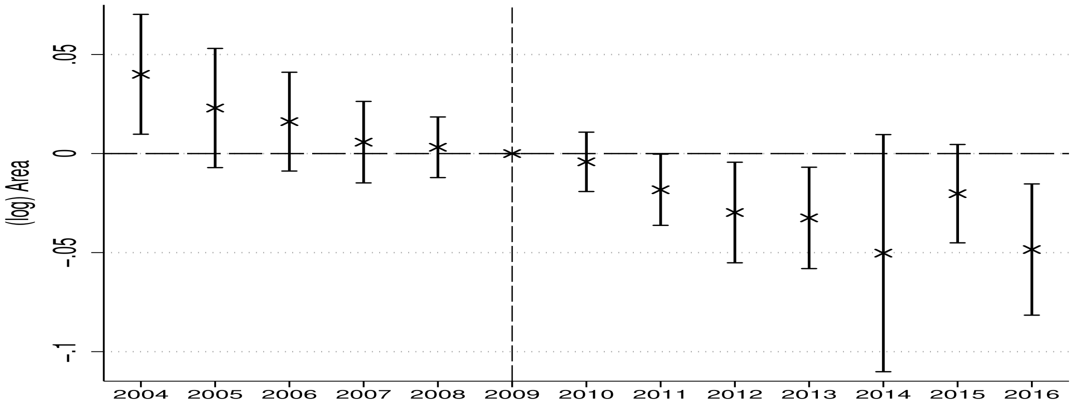
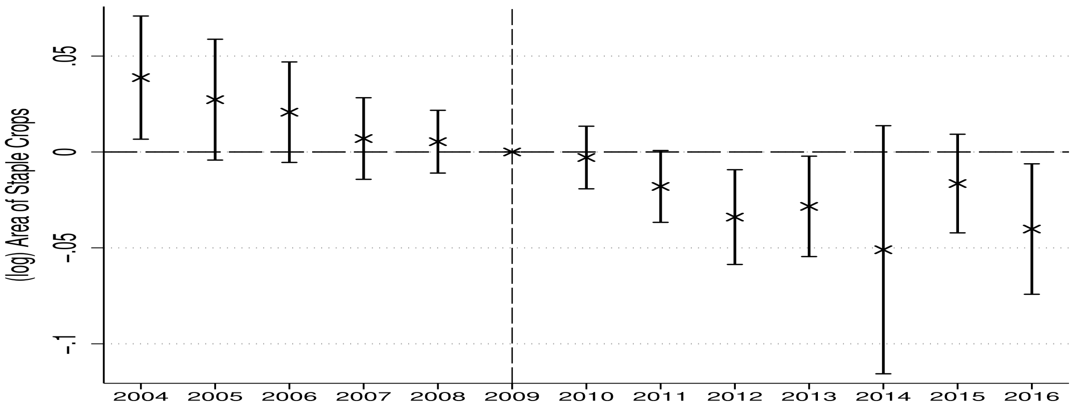


Figure A3: Fall in Consumption of Potash and Phosphate

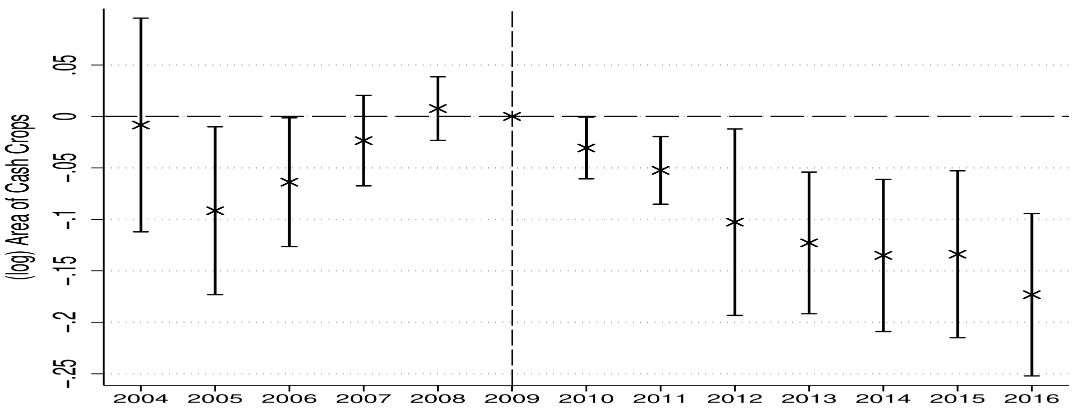
Figure A4: Effect of change in fertilizer subsidy on agricultural area



(a) Total Area

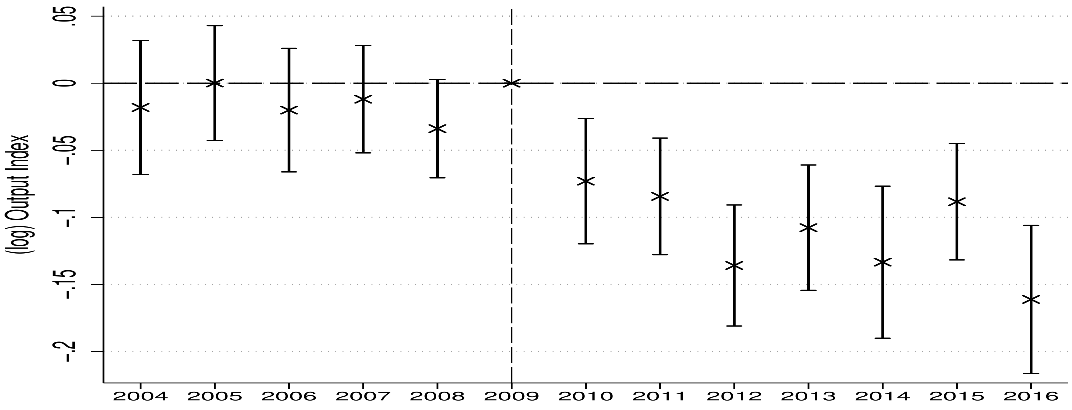


(b) Staple Crops Area

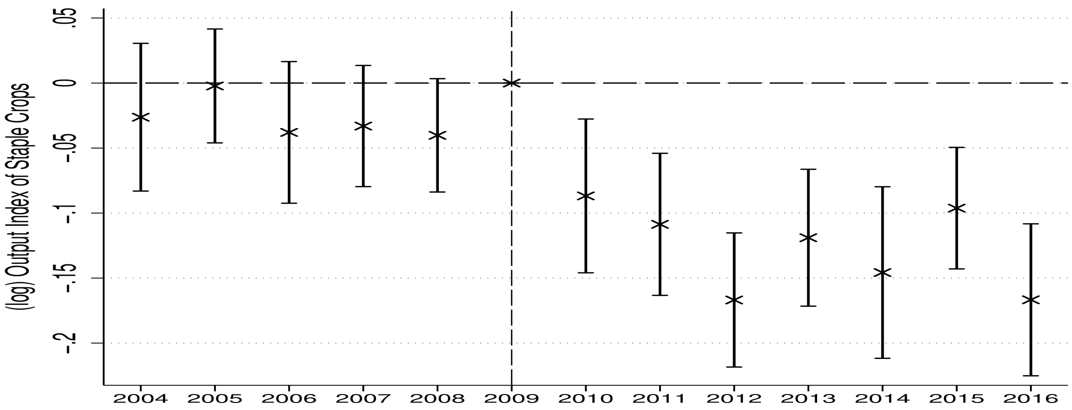


(c) Cash Crops Area

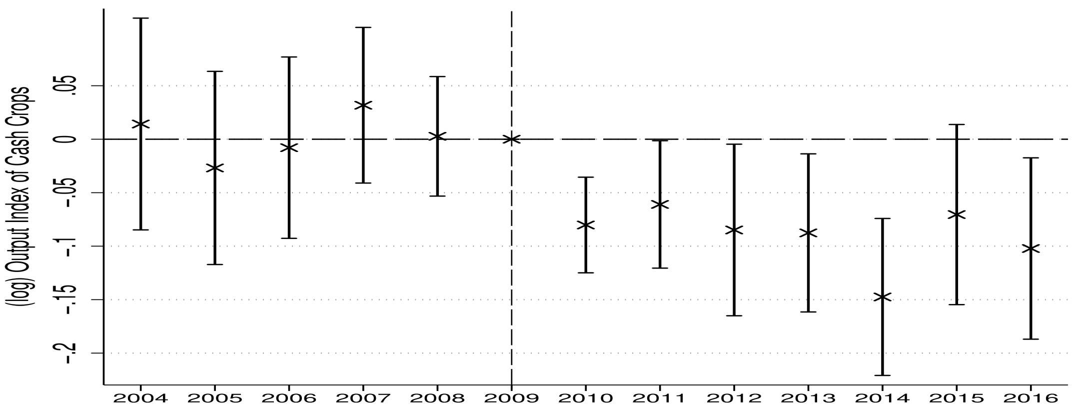
Figure A5: Effect of change in fertilizer subsidy on agricultural output



(a) Total Output

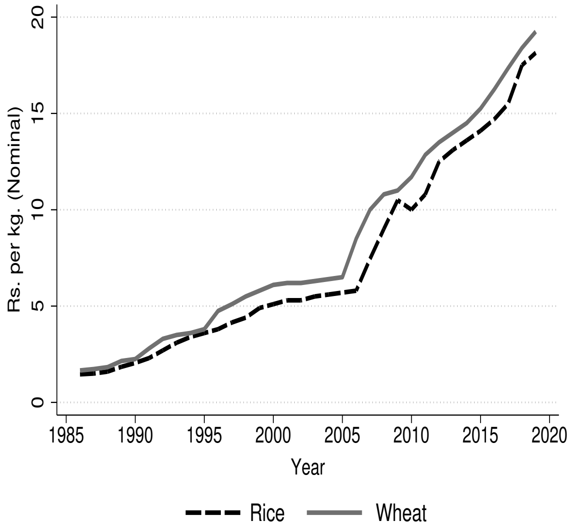


(b) Staple Crops Output

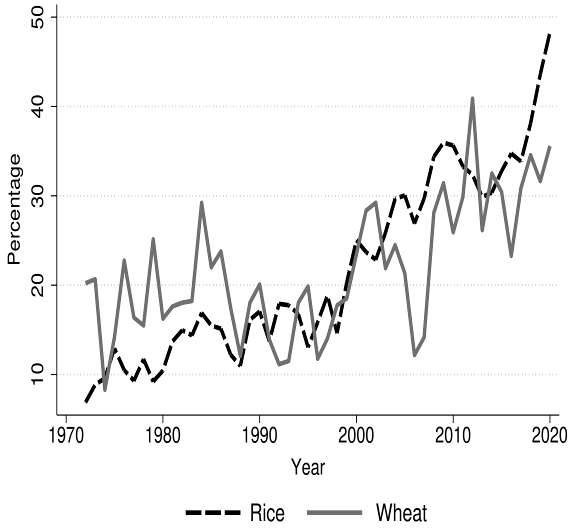


(c) Cash Crops Output

Figure A6: Minimum Support Price and procurement over time



(a) Nominal MSP of rice and wheat



(b) Ratio of Procurement to Production

Additional Tables

Table 7: Difference-in-Difference estimate of MSP prices

	Log Area (000 hectare) (1)	Share Area (%) (2)	Log Output (000 tonnes) (3)
Dummy of Output Procured t-1 * MSP	0.066***	0.491***	0.098***
	(0.017)	(0.123)	(0.017)
District x crop FE	Yes	Yes	Yes
Observations	15689	16574	15675
R-Squared	0.951	0.982	0.945

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Equilibrium Outcomes under replacement policies

	Benchmark	No MSP (balanced)	No MSP (doubled)	No MSP (in-kind)
Aggregate Quantities				
Aggregate Output	0.475	0.565	0.562	0.562
Non-agricultural Good, y_n	0.441	0.531	0.527	0.521
Cash Crop, y_r	0.125	0.122	0.128	0.116
Staple Crop, y_s	0.164	0.161	0.156	0.176
Rations, c^{ration}	0.039	0	0	0.031
Prices				
Non-agricultural Good	1 (normalized)	1 (normalized)	1 (normalized)	1 (normalized)
Cash Crop, p_r	0.116	0.111	0.117	0.124
Staple Crop, p_s	0.122	0.128	0.132	0.148
Support Price, $\bar{p}$	0.118	-	-	-
Land Rental Price, q	0.035	0.034	0.036	0.041
Employment Shares				
Non-agricultural Sector	0.441	0.531	0.527	0.521
Cash Crop Farmers	0.123	0.114	0.116	0.117
Staple Crop Farmers	0.436	0.354	0.357	0.362