The Equilibrium Impact of Agricultural Support Prices and Input Subsidies

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Abstract

We study the implications of agricultural price support programs, which offer a minimum price to farmers of certain crops, and farm input price subsidies for consumer welfare and the misallocation of talent across sectors. We develop a dynamic general equilibrium model with heterogeneous agents and endogenous occupational sorting between two sectors: agriculture and non-agriculture, and two crops: staples and cash crops. The government procures staple crops at predetermined prices and distributes them as free rations. The model is calibrated to the Indian economy. Our results suggest that in the absence of the minimum support price policy, labor reallocates from the staple crop sector to the non-agricultural sector; however, both aggregate output and consumer welfare in the economy are lower due to general equilibrium effects. A reduction of the input price subsidy raises crop prices in equilibrium, keeping employment shares fairly unchanged while lowering aggregate output and consumer welfare.

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

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

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1 Introduction

Agricultural productivity in developing countries is low, yet the agricultural sector continues to employ a majority of the labor force[1]. The low returns to agriculture in developing countries also lead to a concentration of poor households in rural areas[2], who rely on agriculture as their primary source of livelihood (Alkire et al. (2022)). 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[3]. While the aim of the former group of policies is to boost input usage and farmer returns, the latter group of policies enable farmers to hedge against *ex-post* shocks to sale prices. This is welfare-enhancing for farmers as it provides an indirect form of insurance, with direct crop insurance being either unavailable or not availed of (Giné & Yang, 2009; Mobarak & Rosenzweig, 2013; Karlan, Osei, Osei-akoto, & Udry, 2014). However, policies that directly affect input and output prices can distort the allocation of inputs both within the agricultural sector and across sectors, which in turn affects aggregate productivity[4]. In this paper, we study the implications of input price subsidies and crop price floors both empirically and through the lens of a general equilibrium macroeconomic model, which is calibrated to the Indian economy. We use the model and run various counterfactual exercises to quantify the effect of these policies on sectoral misallocation and their impact on consumer welfare.

We begin with the empirical findings that motivate our project. Our first exercise studies the impact of a fertilizer policy change in 2009 in India on area cultivated and production. This policy deregulated the prices of fertilizers that deliver potassium and phosphorus nutrients to the soil. Using a difference-in-difference approach, we find that districts with more fertilizer

[1] See Figures A1 and A2 in the Appendix

[2] Alkire, Kanagaratnam, and Suppa (2022) find that almost 84 percent of poor people live in rural areas, and in South Asia, nearly 340 million (87.5 percent) poor people live in rural areas.

[3] 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.

[4] 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.

usage 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. Rajasthan, a northern Indian state, discontinued the procurement of rice from 2009 onwards. 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 price floor increased. We also analyse the effect of MSP for the whole of India by using variation in the procurement of rice and wheat by respective 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 productivities in each occupation and can save in a risk-free asset, which induces a distribution of asset holdings in equilibrium in an environment with incomplete markets. At the beginning of each period, agents decide which sector to work in and which crop to grow if they choose to operate in the agricultural sector. Farmers also face idiosyncratic risk in terms of the market price that they receive for their produce. Staple crops are protected by a minimum support price (MSP) policy wherein they can be procured by the government at a fixed price and then distributed freely as rations to all households. The intermediate input utilised by farmers is subsidised. 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 equilibrium of the benchmark economy with price support policies and input subsidies to the Indian economy. The model is calibrated to capture an agricultural employment share exceeding 50 percent, consistent with the empirical evidence, according to the 2018 Economic Survey of India[5]. To quantify the impact of each policy, we then conduct two counterfactual experiments. In the first exercise, we withdraw the minimum support price and associated staple crop procurement and ration disbursal program. In the second exercise,

[5]Even though more than half the workforce is employed here, 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.

the input price subsidy is reduced, which leads to higher input costs for all farmers. Our general equilibrium (GE) framework allows us to quantify both the direct effect of these policies on the occupational and production choices and consequent consumption-savings decisions of households, as well as indirect effects operating through changes in equilibrium prices.

We find that in the absence of the minimum support price, lower expected profits incentivise staple crop producers to relocate to the non-agricultural sector. Interestingly, the impact of the policy keeping prices unchanged from the benchmark, which we shall refer to as the 'partial equilibrium' impact, is negligible. This reflects limited inter-sectoral mobility and perhaps the limited salience of the policy change for most agents in the economy. In the general equilibrium analysis wherein prices adjust, staple crops formerly procured by the government are now released on the market, driving down the market price of staple crops, which in turn lowers the demand for, and hence the equilibrium price of, cash crops. The lower crop prices also lower farmer income, which reinforces the fall in prices through an income effect. In equilibrium, the employment share of staple crop producers falls slightly. Agricultural output declines, while lower demand for the non-agricultural good due to a reduction in farmer income and an increase in demand for staple crops to compensate for the loss of rations also reduces non-agricultural production. Consequently, aggregate output falls. Misallocation, captured by the productivity gap between non-agriculture and agriculture, is exacerbated. This is mainly affected by limited inter-sectoral mobility and the reduction in crop production following the removal of the MSP.

When input subsidies are reduced, the returns to farming fall, incentivizing farmers at the margin to move to the non-agricultural sector. This is the 'partial equilibrium' response. However, the reduction in supply leads to higher crop prices in general equilibrium, which offsets the initial decline in expected profits. Employment shares remain unchanged, but agricultural output falls as intermediate input usage declines. Aggregate output also declines, driven again by lower demand for all goods. Misallocation is again exacerbated, being driven now by lower intermediate input usage in agriculture that lowers agricultural labour productivity.

Regarding the welfare implications of these policies, measured using consumption equivalent variations, we find that the removal of the minimum support price policy results in lower consumer welfare due mainly to the loss of free rations. Alternative budget-equivalent policies, wherein government expenditure on procurement is instead utilized to make either in-kind (mimicking a disbursal of rations) or income transfers to all households in the absence of an MSP, leads to lower welfare losses for all agents. A reduction in input price subsidies also results in welfare losses as the market prices for both crops rise. A policy that compensates households with lump-sum transfers that are equivalent to the amount saved by the lowering of these subsidies leads to slight welfare gains.

1.1 Related Literature

Several papers have highlighted the productivity gap between the agricultural and non-agricultural sectors, with the gap being wider in the relatively poorer countries (Caselli, 2005; Gollin, Lagakos, & Waugh, 2014). Since a large part of the workforce in developing economies is employed in the agricultural sector, it is imperative to investigate factors that contribute to the low productivity in this sector[6].

Our paper contributes to the literature that explores the impact of agricultural policies in contributing to or alleviating misallocation in the economy. Several papers have studied the role of land-based policies in several countries such as China (Adamopoulos, Brandt, Leight, & Restuccia, 2022), the Philippines (Adamopoulos & Restuccia, 2020), Mexico (De Janvry, Emerick, Gonzalez-Navarro, & Sadoulet, 2015), and Ethiopia (Chen, Restuccia, & Santaeulàlia-Llopis, 2022)[7]. In contrast, we quantify the effect of the minimum support price and fertilizer subsidies, policies that directly affect both the output prices of crops and input prices. Moreover, our use of a heterogeneous agent general equilibrium model allows us to study the welfare impact of these policies across occupations and the distribution in general.

McArthur and McCord (2017) estimate that low fertilizer usage can contribute to lower productivity and higher employment share in the agricultural sector, especially in developing countries. This could be due to low total factor productivities in the intermediate inputs and investment goods sector (Boppart, Kiernan, Krusell, & Malmberg, 2023) or due to other frictions that inefficiently raise their prices, which when coupled with labor market frictions, may deter migration, lower the cost of labor relative to the intermediate inputs, and result in their low adoption (Restuccia, Yang, & Zhu, 2008). Donovan (2021) and Rodríguez-Sala (2023) discuss the role of incomplete markets in the presence of agricultural income risk, which leads

[6] Lagakos and Waugh (2013); Herrendorf and Schoellman (2018) are examples of papers that have analyzed factors that explain these differences

[7] Other factors discussed in the literature that explains the sub-optimal use of land in agricultural production include the role of institutions that distort farm sizes (Adamopoulos & Restuccia, 2014), underdeveloped land markets (Chen, Restuccia, & Santaeulàlia-Llopis, 2023; Bolhuis, Rachapalli, & Restuccia, 2021) or absence of titles and deeds (Manysheva, 2022; Chen, 2017). Dasgupta and Rao (2022) compares potential and actual crop yield data in India and finds that if land was reallocated in an efficient way from the agricultural sector to the manufacturing sector, aggregate output would increase substantially.

to low input utilization. Pietrobon (2024) finds that insurance in the form of informal risk-sharing arrangements may dampen the effect of agricultural income risk but lead to low effort in agricultural production, including the optimal use of fertilizers, especially in an environment where monitoring effort is costly.

An input subsidy policy may mitigate many of these factors by incentivizing farmers to increase their fertilizer usage, as discussed by Diop (2023). However, it can also lead to inefficient sorting across sectors, as Mazur and Tetenyi (2022) find while studying the Farm Input Subsidy Program in Malawi. Using a dynamic general equilibrium framework with incomplete markets and endogenous occupational choice, we find that in India, input subsidies have no effect on occupational choices since equilibrium crop prices adjust to completely offset any change; however, they reduce the productivity gap between sectors and increase aggregate output and welfare in the economy. While analysing the input subsidy policies, we keep the MSP policy in place. Relative to these papers, we show how the impact of input subsidies can change when they interact with other agricultural policies.

Our work relates to the nascent literature that studies the impact of the minimum support price policy in India. While Chatterjee, Lamba, and Zaveri (2022) examines its effect on groundwater depletion, Garg and Saxena (2022) analyzes the heterogeneous welfare implications of these price subsidies for households. We quantify the effect of these interventions on agricultural productivity and discuss the welfare implications of alternative policies that can replace these. Krishnaswamy (2018) investigates this question empirically using a reduced-form approach; however, our dynamic general equilibrium framework allows us to quantify the effect of equilibrium prices on choices pertaining to occupation, production, and consumption made by different households in the presence of the MSP and the subsequent distribution of procured crops as rations, which in turn affects aggregate output in the economy and welfare.

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

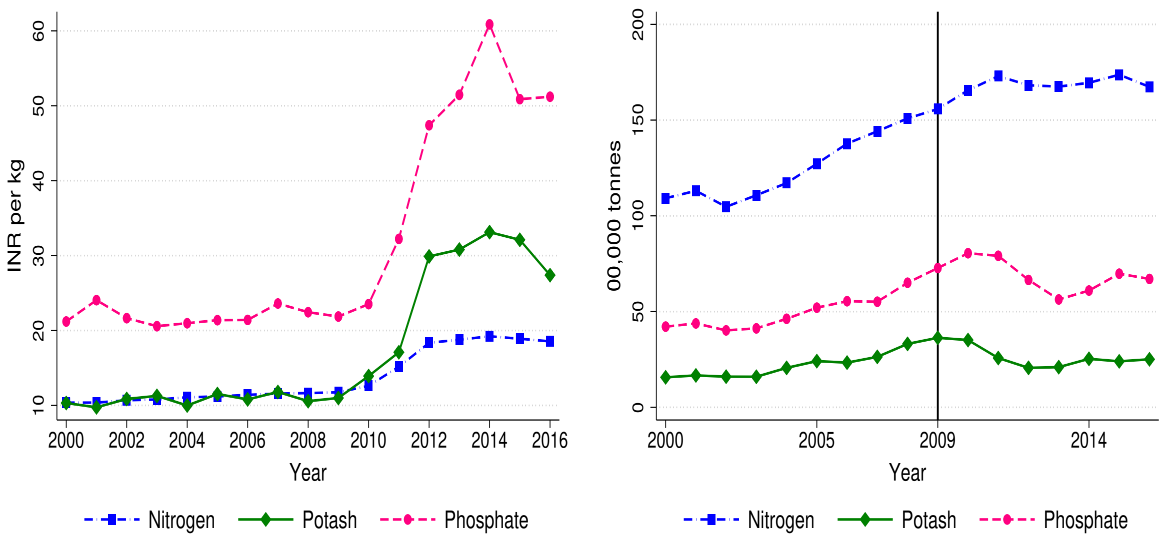
2 Empirical Evidence

In this section, we discuss the institutional context and the impact of two types of subsidies given by the Government of India (GOI) on farmers' choices: (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.[8] The government decontrolled retail prices in 1991 as part of the economic liberalization and structural adjustment program and further in 2010.

Figure 1: Fertilizer price and consumption over time



(a) Price of N, P and K

(b) Consumption of N, P and K

In 2010, the government delinked the international price of P and K fertilizers from its cost of production and allowed the fertilizer manufacturers control over the retail prices as part of the Nutrient Based Subsidy Scheme. The price of urea continues to be regulated by the

[8]Source: https://govtschemes.in/fertilizer-subsidy-scheme-2022

Government. We compute the mean fertilizer price per hectare that farmers paid each year from 2004-2014 using the Cost of Cultivation Survey.[9] Figure 1a shows that fertilizer prices of 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 led to a fall in national consumption of P and K fertilizers but not urea after 2009, as seen in figure 1b.[10] 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 agricultural production. 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 value of output. The regression specification we employ is the following:

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

where Y_{dt} is log area or log value of output 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. 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 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 weights.[11]

We use data on cropped area (thousand hectare), value of output (rupees per thousand tonne) and yield (output per unit of area) 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, staples (cereals and pulses) and cash crops (oil crops and other commercial crops).

[9] Appendix C contains details on the different datasets used in the analysis.

[10] Source: Fertilizer Association of India

[11] 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.

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

	Total	Staple	Cash
	(1)	(2)	(3)
	A: Log Area		
Post * log (Fertilizer Usage Intensity)	-0.044**	-0.044 **	-0.075***
	(0.020)	(0.021)	(0.022)
District FE	Yes	Yes	Yes
Observations	4030	4030	3967
R-Squared	0.988	0.978	0.975
Mean Dependent	5.766	5.515	3.457
Mean Average Usage	6.645	6.645	6.624
	B: Log Value of Output		
Post * log (Fertilizer Usage Intensity)	-0.098***	-0.104***	-0.093***
	(0.021)	(0.023)	(0.026)
District FE	Yes	Yes	Yes
Observations	4030	4030	3952
R-Squared	0.962	0.947	0.968
Mean Dependent	22.472	22.117	20.449
Mean Average Usage	6.645	6.645	6.614
	C: Log Yield		
Post * log (Fertilizer Usage Intensity)	-0.0542***	-0.0601***	-0.0160
	(0.010)	(0.012)	(0.018)
District FE	Yes	Yes	Yes
Observations	4030	4030	3946
R-Squared	0.846	0.829	0.881
Mean Dependent	16.706	16.603	16.968
Mean Average Usage	6.645	6.645	6.610

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

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 and B highlights that a district with one standard deviation (sd) higher fertilizer usage before the policy experienced a 4.9% ($4.9 = 4.4 \times 1.1$) and 10.8% fall in area and value of output respectively. The reduction in usage of fertilizer reduces yield by 6% in districts with one sd higher fertilizer usage is consistent with evidence provided by Zahra Diop (2022) for Zambia. Furthermore, staple and cash crop area planted falls by 4% and 7.4% respectively in districts that more intensely used fertilizers and consequently, production of both crops falls by around 10%. Yield of both crops fall but the cash crop coefficient is imprecisely estimated. 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, A5 and A6 that we do not find strong evidence of more exposed areas being different in agricultural area employed, production or yield than less exposed areas before the decontrolling of fertilizer prices.[12] Thus, the reduction in 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 as 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.[13]

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.[14] In practise, most of the government procurement occurs for two crops: rice and wheat. The nominal price at which the government procures (Appendix figure A7a) and the amount of procurement to overall production (Appendix figure A7b) 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.

[12] The only case where some difference in high versus low exposed region occurs while analysing staple crop yield.

[13] Source: National Food Security Portal

[14] 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. There is no uncertainty about MSP price as they are announced at the start of the cultivation season. Moreover, decision on area under cultivation for rice/wheat need to made at the start of the season due to the cultivation cycle for these crops. Even though MSP prices are decided nationally, procurement decision occurs at the state level. There is substantial variation across states and years in procurement due to differences in policy and political cycles.

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.[15] 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:

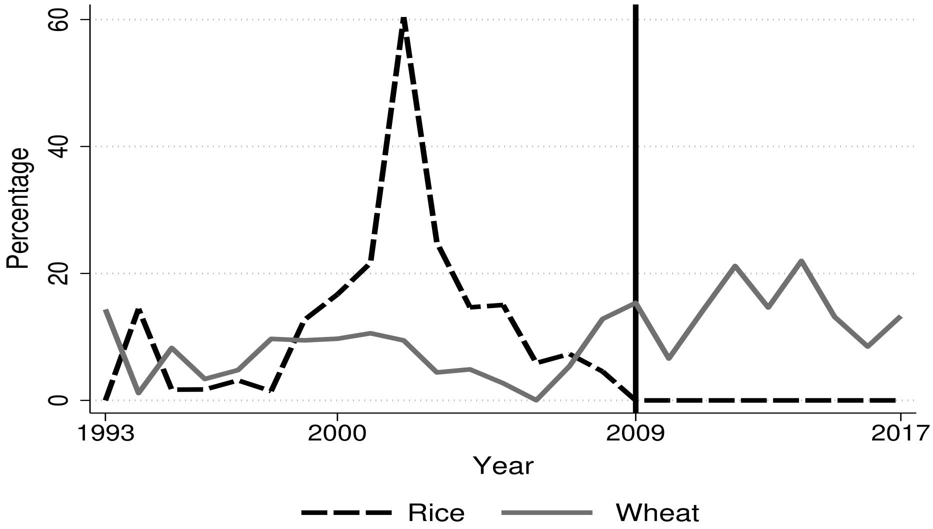
$$Y_{dt} = \beta_0 + \beta_1 \text{MSP}_t + \mathbf{1}_{t<2009} + \boldsymbol{\beta}_2 \text{MSP}_t * \mathbf{1}_{t<2009} + \phi_d + +\varepsilon_{dt} \tag{3}$$

where Y_{dt} is dependent variable 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. 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.

We use ICRISAT district level data from 1994-2016 on area sown (thousand hectare), share

[15]The likely reason to stop procurement was to disincentive farmers to reduce cultivation of rice as Rajasthan receives low rainfall and rice is a water-intensive crop.

Figure 2: Share of rice and wheat procurement in Rajasthan



of area sown for rice out of total cropped area, production of rice (thousand tonnes) and yield (output per area). Table 3 shows the differential effect of MSP before 2009 relative to post 2009 . The first column highlights that farmers increased rice cultivation area more as MSP price rose when the government pursued an active procurement policy relative to when it stopped. Consequently, the share of area devoted to rice production as farmers move away from planting cash crops and rice output also increased more before 2009 relative to after 2009. Furthermore, an increase in MSP led to higher yield when the policy was active relative to when it was discontinued. One possible explanation is that MSP provides insurance to farmers which can lead to higher intermediate input use in the presence of risk and incomplete insurance against it. Thus, consistent with Krishnaswamy (2018) and Garg and Saxena (2022) we show that changes in the price floor affect farmers' choices.

Table 3: Difference-in-Difference estimate of MSP prices in Rajasthan on agricultural output

	Log Area (1)	Share Area (2)	Log Output (3)	Yield (4)
Pre 2009 * MSP	0.339***	0.619**	0.482***	309.644***
	(0.089)	(0.259)	(0.099)	(89.705)
District FE	Yes	Yes	Yes	Yes
Observations	349	506	352	350
R-Squared	0.957	0.866	0.933	0.656

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

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:

$$\begin{aligned} Y_{cdt} &= \beta_0 + \beta_1 \mathrm{MSP}_t + \beta_2 \text{Share of output procured}_{t-1} \\ &+ \beta_3 \text{Share of output procured}_{t-1} * \mathrm{MSP}_t + \phi_{cd} + +\varepsilon_{cdt} \end{aligned} \tag{4}$$

where Y_{cdt} is dependent variable of crop c in district d at time t and ϕ_{cd} is crop-district dummies. ε_{cdt} is the mean zero random error term and standard errors are clustered at the district level. β_3 is the coefficient of interest capturing the difference in the impact of MSP between states with high versus low procurement.

Table 4: Difference-in-Difference estimate of MSP prices on agricultural output

	Log Area (1)	Share Area (2)	Log Output (3)	Yield (4)
Share of Output Procured $t-1\times$ MSP	0.182^{***} (0.030)	1.565^{***} (0.310)	0.162^{***} (0.034)	77.718^{**} (32.270)
District x crop FE	Yes	Yes	Yes	Yes
Observations	16192	17206	16158	16150
R-Squared	0.951	0.983	0.946	0.812

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

The first column of table 4 shows that comparing areas where the government procured a crop more intensely in the previous period, area planted of that crop rises as MSP rises. Moreover, similar to our results for the case of Rajasthan, the share of area, production and yield also increase as the price support rises. We show in Appendix table B1 that the effect of price support is similar if we consider a dummy variable of whether procurement occurs or not in the last year instead of procurement share. We also show that the difference in sensitivity to MSP is driven by farmers responding to only when the government procures a positive amount of crop. Appendix table B2 shows that share area and production rise in response to a MSP rise only when some positive procurement occured in the last period. The relationship between MSP and farmers' production choices are insignificant from zero when no procurement occured in the last period in their state.

We use individual data to show the effect of MSP on labour supply decisions using the National Sample Survey (NSS) in Table 5. We follow a similar identification strategy as before and control for quadratic of rainfall deviations from long-term average and individual and household characteristics (age, log of land holdings, dummies for district-season, gender, household size, marital status, education, household type, religion and social group.) The first column shows that days worked in agriculture increase more as MSP rises in states with higher procurement compared to lower procurement. This increase due to either individuals moving into agriculture or farmers working more intensely. The second column show that even conditional on already being employed, the probability of working in agriculture rises as MSP rises. This suggests that individuals move out of the non-agriculture sector into the agriculture sector.

Table 5: Difference-in-Difference estimate of MSP prices on employment in agriculture

		Conditional on working
	Days	Dummy Worked in Agriculture
	(1)	(2)
Share of Output Procured $t-1\times$ MSP	0.008**	0.001*
	(0.004)	(0.001)
District x season FE	Yes	Yes
Observations	3,99,834	2,43,929
R-Squared	0.361	0.528

Standard errors clustered at district-level in parentheses. ***, ** and * represent the statistical significance at 1%, 5% and 10% levels respectively. All regressions use survey weights. Covariates include quadratic of rainfall shock, age, log of land holdings, dummies for district-season, gender, household size, marital status, education, household type, religion and social group.

2.3 Summary of empirical facts

The empirical findings highlight that firstly, a fall in input subsidy leads to lower agricultural output and yield. Secondly, a rise in MSP leads to farmers increasing output and yield of staple crop, substituting away from cash by devoting more area to staple crop and a shift towards employment in agriculture. Below we discuss the mechanisms through the lens of a model to explain how input and output subsidies influence individual occupation 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 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 capital k_{nt} and labour n_{nt}, hired at interest rate r_t and wage w_t respectively, as inputs:

$$y_{nt} = A n_{nt}^{\alpha} k_{nt}^{1-\alpha},\ 0 < \alpha < 1 \tag{5}$$

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

The agricultural good of each type ($j = \{r, s\}$) is produced by home-operated farms according to the following production function, which uses intermediate inputs (e.g. fertilisers) k_{jt} as the sole input:

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

where $\zeta_j < 1$ is the elasticity of production w.r.t intermediate inputs, and κ_j is the crop-specific productivity shock. We abstract from considering land as a choice variable, and modeling the frictions associated with adjusting landholdings, which are considered in, e.g., Adamopoulos and Restuccia (2014) and Bolhuis et al. (2021).

One unit of the intermediate input is produced by transforming p_k units of the non-agricultural good, hence p_k is the price of the intermediate input. Expenditure on the intermediate input by a farmer of crop j is then $p_k k_j$.

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[16]:

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

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. θ is inversely related to the elasticity of substitution across goods.

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 standard incomplete markets models. Savings (a_t) is denominated in units of the non-agricultural good. Define the compact set of asset holdings $A = [\underline{a}, \bar{a}]$. Individuals cannot borrow to finance consumption, i.e. $\underline{a} \geq 0$.

3.3 Role of Government: Procurement and Distribution of Staple Crops

We consider a support mechanism wherein staple crops are procured from farmers at a fixed price (the support price $\bar{p_t}$), and the procured crops are in turn freely distributed to all 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 standard and yields first-order conditions that equate the marginal products of inputs

[16] Lagakos and Waugh (2013) find that in poor countries, which are typically associated with low economy-wide efficiency, the subsistence requirement incentivizes the relatively unproductive farmers to inefficiently choose agriculture as their occupation

to their factor prices:

$$\max_{n_{nt},k_{nt}} An_{nt}^{\alpha}k_{nt}^{1-\alpha} - w_t n_{nt} - r_t k_{nt} \tag{8}$$

$$w_t = \alpha A k_{nt}^{1-\alpha} n_{nt}^{\alpha-1} \tag{9}$$

$$r_t = (1-\alpha) A k_{nt}^{-\alpha} n_{nt}^{\alpha} \tag{10}$$

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 idiosyncratic ($\mathbf{z}$) 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:

$$\max_{k_{rt}} \mathbb{E}_{\delta}\ \delta p_{rt}(A\kappa_r z_{rt})\big[k_{rt}^{\zeta_r}\big] - \tilde{R}_t p_k k_{rt} \tag{11}$$

The 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:

$$k_r^u(z_r) = \big(\frac{\zeta_r}{p_k\tilde{R}}\big)^{\frac{1-\gamma_r}{1-\gamma_r-\zeta_r}} \Big(A\kappa_r z_r p_r^e\Big)^{\frac{1}{1-\zeta_r}} \tag{12}$$

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

$$y_r(z_r, a) = (A\kappa_r z_{rt})\big[k_{rt}^{\zeta_r}\big] \tag{13}$$

$$\Pi_r(z_r, a, \delta) = \delta p_{rt}(A\kappa_r z_{rt})\big[k_{rt}^{\zeta_r}\big] - \tilde{R}_t p_k k_{rt} \tag{14}$$

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:

$$\max_{k_{st}} p_{st}^e (A\kappa_s z_{st}) \left[k_{st}^{\zeta_s}\right] - \tilde{R}_t p_k k_{st} \tag{15}$$

The expression for k_s^u is analogous to the corresponding one derived above for cash crop farmers' intermediate input choices.

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

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

$$\Pi_s(z_s, a, \delta) = p_s^{\max}(\delta)(A\kappa_s z_{st}) \left[k_{st}^{\zeta_s}\right] - \tilde{R}_t p_k k_{st} \tag{16}$$

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 productivity shocks denoted by τ, drawn from a distribution Q_τ with mean $\bar{\tau}$ and standard deviation σ_τ. Thus, a worker with productivity τ inelastically supplying one unit of labour effectively supplies τ units of labour, leading to labour earnings of $\tau_t w_t$.

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 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.

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

$$V^w(z_s, z_r, \tau, a) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{17}$$

subject to:

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

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.

$$V^r(z_s, z_r, \tau, a, \delta) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{18}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi^r(z_r, a, \delta) + a(1 + \tilde{r})$$

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

$$V^s(z_s, z_r, \tau, a, \delta) = \max_{c_r, c_n, c_s, a' \in A} u(c^{\text{ration}} + c_s, c_r, c_n) + \beta \mathbb{E}_{\mathbf{z}', \tau'} V(z_s', z_r', \tau', a') \tag{19}$$

subject to:

$$p_r c_r + p_s c_s + c_n + a' = \Pi^s(z_s, a, \delta) + a(1 + \tilde{r})$$

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:

$$\mathbb{E}\ V^r(z_s, z_r, \tau, a) = \mathbb{E}_\delta V^r(z_s, z_r, \tau, a, \delta) \tag{20}$$

$$\mathbb{E}\ V^s(z_s, z_r, \tau, a) = \mathbb{E}_\delta V^s(z_s, z_r, \tau, a, \delta) \tag{21}$$

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:

$$V(z_s, z_r, \tau, a) = \max\{\mathbb{E}V^s(z_s, z_r, \tau, a), \mathbb{E}V^r(z_s, z_r, \tau, a), V^w(z_s, z_r, \tau, a)\} \tag{22}$$

This yields the occupational choice functions:

$$\omega(z_s, z_r, \tau, a) = 1,\ \sigma(z_s, z_r, \tau, a) = 0 \ \text{ if } V(z_s, z_r, \tau, a) = V^w(z_s, z_r, \tau, a) \tag{23}$$

$$\omega(z_s, z_r, \tau, a) = 0,\ \sigma(z_s, z_r, \tau, a) = 1 \ \text{ if } V(z_s, z_r, \tau, a) = \mathbb{E}V^s(z_s, z_r, \tau, a) \tag{24}$$

$$\omega(z_s, z_r, \tau, a) = \sigma(z_s, z_r, \tau, a) = 0 \ \text{ if } V(z_s, z_r, \tau, a) = \mathbb{E}V^r(z_s, z_r, \tau, a) \tag{25}$$

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:

$$
\begin{aligned}
&\int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\; c_n(z_s, z_r, \tau, a)\; dF(z_s, z_r, \tau, a) + \\
&\qquad \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big) \sum_{\delta} P(\delta)\; c_n(z_s, z_r, \tau, a, \delta)\; dF(z_s, z_r, \tau, a) + \\
&\qquad \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big)\; \sigma(z_s, z_r, \tau, a) p_k k_s(z_s, a) dF(z_s, z_r, \tau, a) + \\
&\int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big)\big(1-\sigma(z_s, z_r, \tau, a)\big)\; p_k k_r(z_s, a)\; dF(z_s, z_r, \tau, a) = y_n
\end{aligned} \tag{26}
$$

   (b) Cash crop:

$$
\begin{aligned}
&\int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\; c_r(z_s, z_r, \tau, a)\; dF(z_s, z_r, \tau, a) + \\
&\qquad \int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big) \sum_{\delta} P(\delta)\; c_r(z_s, z_r, \tau, a, \delta)\; dF(z_s, z_r, \tau, a) \\
&\qquad = \int_{\mathbf{Z}\times A} \big(1-\sigma(z_s, z_r, \tau, a)\big)\big(1-\omega(z_s, z_r, \tau, a)\big)\; y_r(z_r, a)\; dF(z_s, z_r, \tau, a)
\end{aligned} \tag{27}
$$

   (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.

$$
\begin{aligned}
&\int_{\mathbf{Z}\times A} \Big(1-\omega(z_s, z_r, \tau, a)\Big) \sum_{\delta} P(\delta)\; c_s(z_s, z_r, \tau, a, \delta)\; dF(z_s, z_r, \tau, a) \\
&\qquad + \int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\; c_s(z_s, z_r, \tau, a)\; dF(z_s, z_r, \tau, a) \\
&\qquad = \int_{\mathbf{Z}\times A} \sigma(z_s, z_r, \tau, a) \sum_{\delta} P(\delta)\big(1-\mu(\delta)\big)\; y_s(z, a)\; dF(z_s, z_r, \tau, a)
\end{aligned} \tag{28}
$$

(d) Asset market:

$$\int_{\mathbf{Z}\times A} a^{'}(z_s, z_r, \tau, a)\ dF(z_s, z_r, \tau, a) = k_n \tag{29}$$

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

$$c^{\text{ration}} = \int_{\mathbf{Z}\times A} \sigma(z_s, z_r, \tau, a) \sum_{\delta} P(\delta)\mu(\delta)\ y_s(z_s, a)\ dF(z_s, z_r, \tau, a) \tag{30}$$

2. The distribution F evolves as per:

$$TF(z_s', z_r', \tau', a') = \int_{\mathbf{Z}\times A} \omega(z_s, z_r, \tau, a)\ \mathbb{I}_{\{a'(z_s,z_r,\tau,a)=a'\}}\ dF(z_s, z_r, \tau, a) +$$
$$\int_{\mathbf{Z}\times A} \big(1-\omega(z_s, z_r, \tau, a)\big) \sum_{\delta} P(\delta)\ \mathbb{I}_{\{a'(z_s,z_r,\tau,a,\delta)=a'\}}\ dF(z_s, z_r, \tau, a),\ \ \forall (z_s', z_r', \tau', a') \in \mathbf{Z}\times A \tag{31}$$

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 $(z_s, z_r, \tau, a, \delta)$ has savings a'. T is an operator that maps distributions into distributions.

4 Calibration

We calibrate some parameters of the model internally to match certain moments of the Indian agricultural sector, and the rest of the parameters are chosen based on the literature.

4.1 Externally calibrated parameters

For simplicity, we assume that the sector-neutral TFP A and crop-specific productivities κ_r, κ_s are all set equal to 1. Following Mazur and Tetenyi (2023), we calibrate the preference parameters to the US as a benchmark, setting $\phi_s = 0.13$ and $\phi_r = 0.06$. Staple includes food whereas, expenditure on beverages, clothes, personal care and tobacco captures spending on cash crop. Using the consumption shares for the US economy implies that preferences are not changing along the development path, which is the standard practice in the literature. In the benchmark equilibrium that is calibrated to the Indian economy, this results in an equilibrium staple crop price that exceeds the equilibrium cash crop price. θ, the inverse of the elasticity of substitution across crops, is set at 2. This leads to an elasticity of substitution across crops that is below

Table 6: Internally calibrated parameters

Parameter	Value	Target/Source	Data	Model
Standard dev. of agricultural shocks $\{\eta, \eta_r\}$	0.408	Variance of all crops, IHDS-I	0.58	0.58
Support price $\bar{p}$	$0.887 * p_s$	Share of staple crops procured in 2010; RBI, IndiaStat	30.6%	30.6%
Mean of non-agricultural shocks μ_t	-1	Agricultural employment share, 2008	52%	52%
Subsistence requirement $\bar{c}$	0.01	Value of staple relative to cash crop production	1.17	1.7

the value of 0.95 chosen by Buera, Kaboski, and Shin (2011).

The discount factor, $\beta = 0.9$, is chosen to lie between the $\beta = 0.85$ value chosen by Buera, Kaboski, and Shin (2021) and the $\beta = 0.96$ chosen by Donovan (2021). The labour share of income, $\alpha = 0.67$, as is standard. The intermediate input 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, which is equal to 0.24 from Bolhuis et al. (2021). The intermediate input price is exogenously set following Donovan (2021), $p_k = 2.77$.

4.2 Internally calibrated parameters

The standard deviations of crop-specific shocks, η_r, η_s, are assumed to be equal and are chosen to match household-level variation in average crop harvest across all crops, which is 0.58 from wave one (2004) of the Indian Human Development Survey (IHDS). Only the first wave of IHDS contains information about the type and value of crops grown and inputs used in agriculture production. We estimate the household-level variance in crop harvest by removing the variation that we do not model here, following Donovan (2021) and others. We regress household level harvest on dummies of family size, married males, married females, religion and caste, gender of household head and education, total types of crops grown, harvest season, intermediate inputs usage, labour usage district, and age.[17] These factors explain 62% or roughly two-thirds of the total variation in log agricultural harvest. We match the variance of the residual term in the above regression implying that $\eta_r = \eta_s = 0.408$. The model implied standard deviation in harvest is similar to the estimate of 0.32 by Donovan (2021).

For the non-agricultural sector, the standard deviation of the idiosyncratic productivity shock, η_n, is chosen to match the variance of non-agricultural income, which is 0.99 from wave

[17] Dummies for intermediate inputs and labour usage includes irrigation employed or not, fertilizers used or not, pesticides used or not, machinery used or not, and four categories of labour employed (0, 1-10, 11-100 and greater than 100).

Table 7: Non-targeted moments

Moment/Source	Data	Model
Aggregate saving rate	26%	22.2%
Agricultural saving rate	15.9%	15%
Non-agricultural saving rate	29.4%	30.1%
Share of staple crop farmers in agriculture	65.2%	61.53%
Relative labour productivities of non-agri to agri	4.33	1.83
Relative income of agri to non-agri	0.78	0.6
Income share of top 10%	36.48%	27.3%
Income share of bottom 50%	16.6%	14%

two of the IHDS in 2011. We follow a similar to estimate the individual-level variance in non-agriculture income as variance in crop harvest. We purge out some of the heterogeneity in non-agricultural income due to education, caste, religion, age, family size, number of married males and females and urban versus rural area, and district fixed effects. These regressors explain 44% of the total variation in log non-agricultural income. The mean $\bar{\tau}$ of the idiosyncratic productivity shock is chosen to match the agricultural employment share in 2008 of 52%.

The standard deviation of the market price shock, η_d, is computed using the equilibrium market price of staple crops and the standard deviation of the crop-specific shocks, η_s. The support price $\bar{p}$ is then chosen to match the share of staple crops procured, which is 30.6% in 2010 from the RBI and IndiaStat. The total value of production of staple crops relative to cash crops, which was 1.17 from IHDS-I, is used to determine the subsistence requirement, $\bar{c}$.

4.3 Non-targeted moments

In Table 7, we report some over-identifying moments that have not been targeted in the calibration. First, the implied aggregate saving rate of the economy equals 22.2%, which is slightly lower than the 26% saving rate in 2010 obtained from the World Development Indicators. Disaggregating saving rates by sector, the model implied agricultural saving rate is 15%, slightly below the 15.9% saving rate in IHDS-I; while the model implied non-agricultural saving rate is 30%, which is almost exactly equal to the 29.4% rate in the data. Second, the share of staple crop farmers in the agricultural sector is 61.53%, which is quite similar to the corresponding share of 65.2% reported in IHDS-I. Third, the model generates a ratio of labour productivities of the non-agricultural to the agricultural sector that far exceeds one but is lower than the ratio of 4.33 for 2010 estimated using the India KLEMS database. Fourth, we also compute the relative income of agriculture to non-agriculture to be equal to 0.6, which is below the corresponding ratio of 0.78 from IHDS-II.

We also compute some measures of income inequality in the model, which we compare to inequality measures obtained at the household level using data from the IHDS-II. In particular, the income share for the top 10% is around 27.3%, which compares fairly well to the corresponding share of 36.48%, keeping in mind the difficulty typically faced by Bewley models in matching top income and wealth shares. The model also does fairly well at the lower end of the income distribution: the share of income of the bottom 50% is 14%, which is slightly below the 16.6% share in the data.

5 Results

In this section, we discuss the results of various counterfactual exercises conducted using the calibrated general equilibrium model presented above. Our benchmark model is one in which the minimum support price policy is present. First, in order to investigate the role of the subsidies, we conduct two broad types of counterfactual exercises: (i) to assess the role of the minimum support price policy, we set $\bar{p}$ below the worst realisation of the realised market price of the staple crop ($\delta_0 p_s$) effectively eliminating this insurance option; (ii) to assess the role of the input subsidy, we nearly double the price of the intermediate input, p_k from 2.77 to 5. Next, we discuss the welfare implications of these policies. Finally, we discuss the role of assets in this environment.

5.1 Role of the minimum support price

Figure 3 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; which we shall refer to as the *partial equilibrium* outcome[18]. 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 and boosted intermediate input demand, individuals with relatively low productivity in the staple crop sector are incentivised to move out of staple crop farming toward the non-agricultural sector. Further, some cash crop

[18]The partial equilibrium outcomes of the counterfactual exercises conducted here are listed in table B5 in the appendix.

growers in the baseline also respond to the reduction in demand for cash crops by switching to the non-agricultural sector. In figure 3, the small band labeled 'ΔNON-AGRI' represents those agents who switch to the non-agricultural sector upon the removal of the MSP. This is consistent with the empirical evidence presented before in Table 5.

However, the impact on aggregate output in partial equilibrium is negligible, as documented in column 2 in Appendix table B5. This suggests that the marginal agents who are likely to switch away from growing staple crops following the removal of MSP are quantitatively insignificant. Noting that $p_s > p_r$ in the benchmark equilibrium, these agents would tend to have a productivity vector (z_s, z_r, τ) such that $\Pi_s(z_s, a, \delta; \bar{p}) > \tau w$ but $\Pi_s(z_s, a, \delta; p_s) < \tau w$. In other words, with access to the support price, these agents would choose staple crops but once the support price is removed, these agents receive a higher return in the non-agricultural sector. Quantitatively, around 30% of staple crop growers (who in turn comprise (32% of agents) choose the procurement option in the benchmark, which amounts to around 10% of agents. However, only those agents in this group with a combination of (z_s, τ) that are not too dissimilar would tend to switch across sectors following the removal of the support price, which could explain our quantitative finding.

Figure 3: Occupational choices: removing MSP

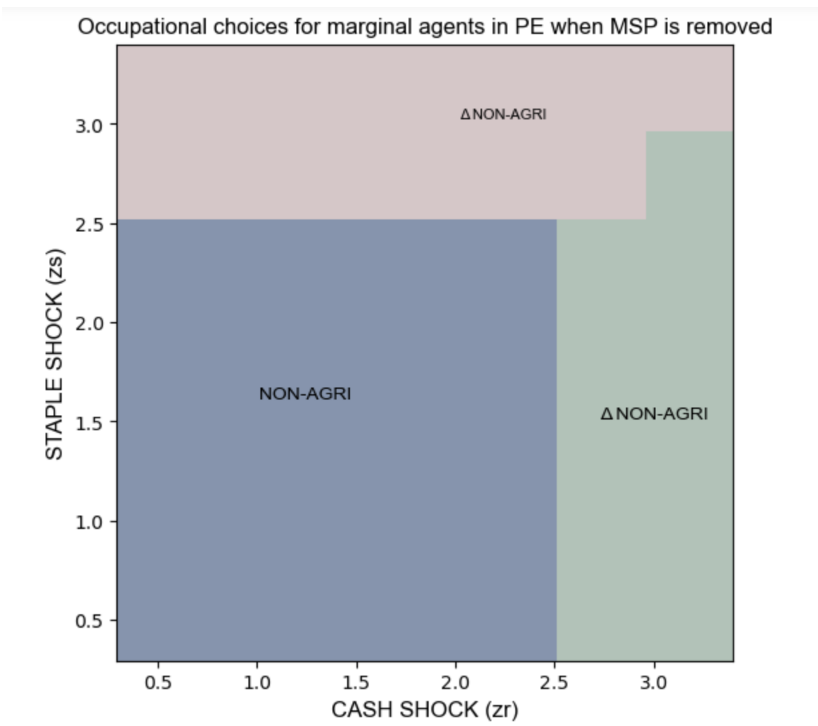


Table 8 displays the quantitative results obtained in general equilibrium from this counterfactual exercise (Column 2) to the benchmark (Column 1). In general equilibrium, an inflow of staple crop farmers into the non-agricultural sectors raises the share of non-agricultural workers at the expense of staple crop farmers. While this would tend to drive wages down, the falling interest rate boosts capital demand, which in turn raises wages. Hence, the overall effect is a rise in wages. There is also a decline in the staple crop price, p_s. This is because the staple crops hitherto procured by the government are now supplied to the market, which brings down the market price of staple crops. The lower price of staple crops substitutes demand away from cash crops, thereby driving the cash crop price, p_r, down as well. This decline in crop prices also feeds back into the income earned by farmers, further lowering demand and prices. This offsets the movement of farmers away from growing staple crops toward growing cash crops, resulting in an unchanged share of cash crop farmers.

Lower prices of cash and staple crops reduce intermediate input demand and hence production for farmers of both crops, thereby lowering production of both types of crops. The overall value of production, $\sum_j p_j y_j$, therefore declines. Real output, which is calculated using benchmark equilibrium prices, also falls as production of both crops fall as does the demand for the non-agricultural good. The labour productivity of the non-agricultural sector relative to the agricultural sector, and the labour productivity of cash relative to staple crops, both rise. These ratios are computed using prices in the benchmark equilibrium, and the increases are driven by the relatively greater fall in agricultural production in the case of the former ratio, and the relatively greater fall in staple crop production as opposed to cash crop production in the case of the latter ratio.

5.1.1 Decomposing the effects of removing MSP

The results above highlights three effects associated with the removal of MSP, viz. (a) the loss of support prices received by staple crop farmers; (b) the loss of staple crop rations by all agents in the economy; and (c) the release of formerly procured staple crops on the market.

We disentangle these effects by considering first an environment where the MSP policy is retained but all procured crops are destroyed or thrown away. Hence, we isolate the impact of the support price for staple crop farmers by assuming away rations. We find that agents now deprived of rations increase their demand for staple crops, leading to a higher staple crop price and a higher employment share of staple crop production at the expense of non-agricultural employment.

Next, we consider an environment with no procurement by the government (and therefore no support prices for staple crop farmers); but with a budget-equivalent rationing scheme wherein the government purchases staple crops at market prices and redistributes them to all agents in the economy, keeping total expenditure unchanged relative to the baseline model with a MSP policy. We find that this policy results in almost equivalent outcomes compared to the baseline.

In both exercises, note that the supply of staple crops to the market is reduced, either because the procured crops are thrown away or because they are purchased by the government. Hence, the slight increase in non-agricultural employment share that accompanied a removal of the MSP in table 8 is driven by the additional supply of staple crops to the market that were formerly procured. The additional supply drives down staple crop prices, pushing agents away from staple crop production toward the non-agricultural sector. Altogether, the effects of MSP removal arise from the increased supply of staple crops to the market.

Table 8: Equilibrium Outcome Comparison

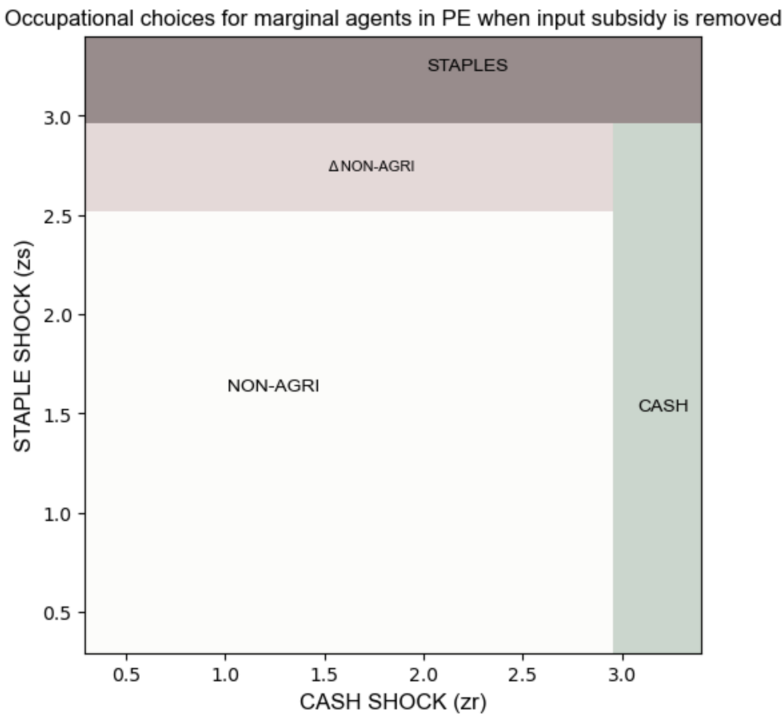
	Benchmark	Removing MSP	Reducing input subsidy*
Aggregate Quantities			
Aggregate Output, $\sum_j p_j Y_j$	1.25	1.13	1.214
Real Output† , $\sum_j p_j^* Y_j$	1.25	1.18	1.14
Non-agricultural Good, y_n	0.793	0.762	0.75
Cash Crop, y_r	0.169	0.163	0.148
Staple Crop, y_s	0.258	0.229	0.224
Rations, c^{ration}	0.079	0	0.0686
Intermediate input demand, $k_s + k_r$	0.028	0.022	0.016
Capital demand, k_n	1.95	2.02	1.84
Labour productivity‡ of non-agri to agri	1.7	2.02	2.1
Labour productivity of cash to staple crops	0.943	0.972	0.946
Prices			
Non-agricultural Good	1 (normalized)	1 (normalized)	1 (normalized)
Cash Crop, p_r	0.995	0.879	1.179
Staple Crop, p_s	1.11	0.995	1.288
Support Price, $\bar{p}$	0.986	-	1.144
Interest rate, r	0.088	0.078	0.088
Wage, w	1.05	1.09	1.05
Employment Shares			
Non-agricultural Sector	0.475	0.49	0.475
Cash Crop Farmers	0.202	0.202	0.202
Staple Crop Farmers	0.322	0.308	0.322

*For this exercise we increase the price of input, p_k from 2.77 to 5
†p^* represents prices in the benchmark
‡Labour productivity computed using benchmark equilibrium prices

5.2 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 4 depicts how occupational choices respond to a reduction in the input subsidy when all other prices are fixed at the benchmark level (the *partial equilibrium* outcome). This lowers the expected profits for farmers by reducing their demand for intermediate inputs. Marginal agents respond to this reduction in profits by switching to the non-agricultural sector. If we interpret the intermediate input as representing fertilizers, then one finds that the decline in staple and cash crop output in partial equilibrium is consistent with the production estimates in table 1.

Figure 4: Occupational choices: reducing input subsidy



The quantitative results in GE are listed in Column 3 of Table 8. A rise in input prices lowers intermediate input usage and thereby farm profits, moving farmers away from crop production toward non-agriculture. However, preferences for agricultural good consumption mandate an upward adjustment in crop prices to incentivise crop production. The net effect is that sectoral employment shares are unchanged. While the rise in crop prices offsets to a large degree the effect of higher intermediate input prices on crop production, the overall effect is a fall in crop production relative to the benchmark. This also results in a fall in real output, calculated using baseline prices. However, the value of crop production rises as the prices of both crops rise. Non-agricultural production falls slightly, as relatively less productive agents choose non-agriculture, driving down effective labour supplied to that sector and capital demanded by the non-agricultural sector. The labour productivity of the non-agricultural sector relative to the agricultural sector, and the labour productivity of cash relative to staple crops, both rise, albeit marginally for the latter ratio. As before, the increases are driven by the relatively greater fall in agricultural production in the case of the former ratio, and the relatively greater fall in staple crop production as opposed to cash crop production in the case of the latter ratio.

Our results on misallocation following the reduction of the input subsidy differ from corresponding results in Mazur and Tetenyi (2023). Unlike their environment, our model features no frictions faced by agents other than the price-distorting policies themselves. In particular, we do not consider transaction costs associated with staple crop purchases, nor do we have within-period borrowing constraints for intermediate input usage; which leads to sizable misallocation in their environment. They also consider correlated shocks across rural and urban areas, and they do not have crop-specific productivity shocks. These assumptions allow for greater occupational movement within agriculture across crops, and increase the potential base of 'marginal' agents who might switch across the non-agricultural and agricultural sector following a removal of the input subsidy. In the absence of these features, occupational choices made by agents are close to optimal in our benchmark equilibrium with the distortionary policies, and in GE, prices adjust to not affect occupational choices significantly following the input subsidy reduction. As the sectoral employment shares of agents do not move much, the productivity gap between non-agriculture and agriculture is mainly influenced by the reduction in input demand following the lowering of the subsidy, which exacerbates the productivity gap and worsens misallocation.

5.3 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:

$$W^{j*} = \int V^*(z_s, z_r, \tau, a)\, \mathbb{I}_j^*\, dF^*(z_s, z_r, \tau, a) \tag{32}$$

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 and the input price subsidy). This welfare

Table 9: Welfare changes under counterfactual policies

Group	No MSP	No MSP (balanced)	No MSP (doubled)	No MSP (in-kind)	Higher p_k	Higher p_k (balanced)
Workers	15.26%	3.56%	−4.23%	3.56%	8.82%	0.2%
Staple crop farmers	16.47%	3.14%	−4.78%	3.14%	8.29%	−0.5%
Cash crop farmers	16.65%	3.14%	−5%	3.14%	8.29%	−0.8%

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:

$$\hat{W^j} = \int \hat{V}(z_s, z_r, \tau, a)\, \mathbb{I}_j^*\, dF^*(z_s, z_r, \tau, a) \tag{33}$$

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:

$$\chi^j = \left[\frac{W^{j*}}{\hat{W^j}}\right]^{\frac{1}{1-\theta}} - 1 \tag{34}$$

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 case is an economy with the MSP and input subsidy.

Consider first the counterfactual exercise entailing removing the MSP. Noting from the discussion in section 5.1.1 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 an income transfer) is unlikely to improve welfare. This insight is confirmed in column 2 of table 9.

A more reasonable comparison is with welfare in environments where the MSP is replaced by alternative policies that support 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 9 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 9 shows that doubling the income transfer considered in column 3 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[19]. 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 9 shows that this results in lower welfare losses compared 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 8 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 9. In this case, a policy that reduces the input subsidy but transfers the amount saved to agents in the form of income transfers results in slight welfare gains in the counterfactual economy. These slight gains arise because the income transfer boosts consumption slightly without raising prices meaningfully.

5.4 Role of assets

An interesting feature of the model presented above is the role of assets. In dynamic models of occupational choice such as Buera et al. (2011), agents are allowed to switch between occupations each period. In the absence of occupational switching costs, the continuation value is identical for all agents regardless of occupation, implying that the current period occupation is determined

[19] Equilibrium outcomes under these alternative policies are discussed in tables B3 and B4 in the appendix.

purely by current period payoffs. To the extent that current asset-holdings do not affect current period occupational returns (wages or profits), e.g. by affecting input choices for farmers through a collateral constraint, the only potential mechanism for assets to influence occupational choice is through the degree of risk aversion. For instance, Donovan (2021) allows assets to influence occupational choices through the variation of risk aversion with asset holdings, primarily by assuming that idiosyncratic productivity shocks (z_s, z_r, τ) are observed prior to occupational choices being made. Our model instead assumes that occupational choices are made after observing the idisoyncratic productivity shocks. Hence, the sole source of uncertainty that would make the risk-aversion channel operational is uncertainty about the idiosyncratic shock δ. The relatively limited variation in δ makes this channel less relevant in our model.

However, assets do influence the welfare results that we obtain. Agents face uncertainty about the idiosyncratic productivity shocks drawn in the future, and the ability to engage in precautionary saving enables them to insure against this risk. Certainly, the ability to move across sectors provides a degree of insurance against a negative productivity draw in one's chosen sector entering into a period. However, as agents choose the occupation that yields them their highest current period return, they also build up a buffer stock of precautionary saving that insures against the possible realisation of poor productivity draws across sectors. This self-insurance option, which is a standard feature of standard incomplete markets models, thereby materially affects consumer welfare.

6 Conclusion

This article studies the productivity and welfare consequences 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. Our results indicate that aggregate output falls in a counterfactual exercise that removes the support price policy, while a counterfactual exercise that reduces the input subsidy raises aggregate output slightly. These outcomes arise through the interaction of occupational flows and, particularly, crop price changes in general equilibrium following the change in policy. Welfare gains arise under the counterfactual policies when they are replaced by suitably large income transfers.

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Appendix

A Additional Figures

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

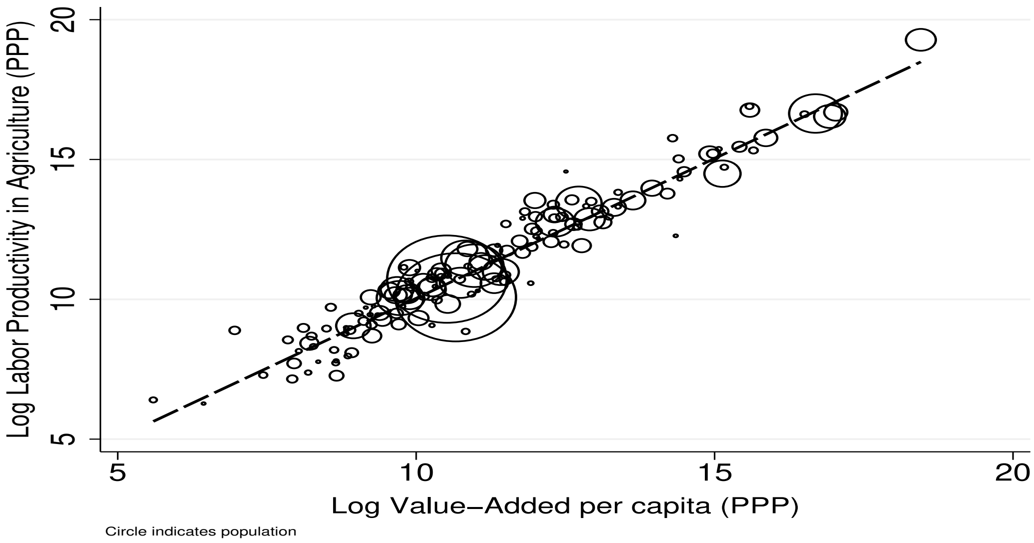


Figure A2: Employment shares across sectors in rich and poor countries

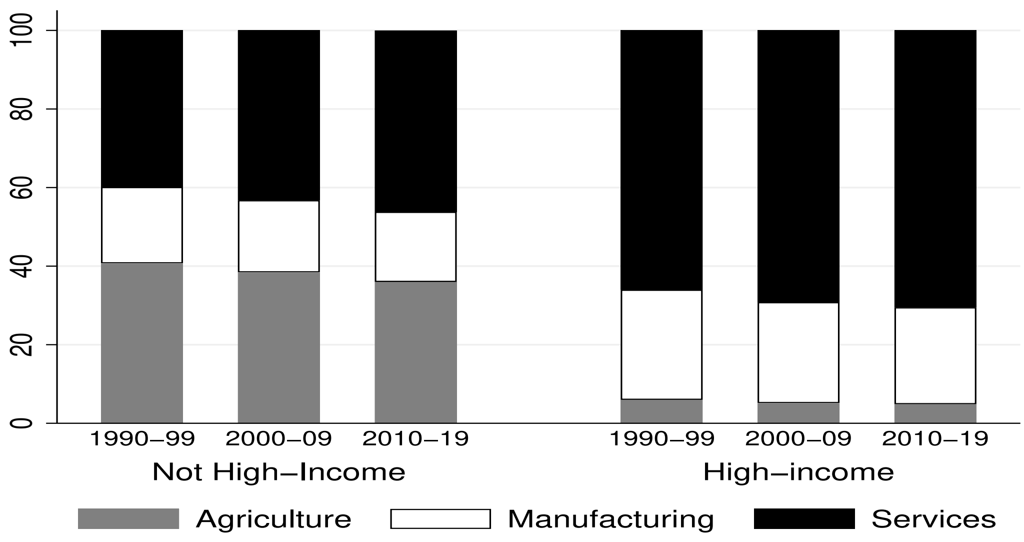


Figure A3: Fall in Consumption of Potash and Phosphate

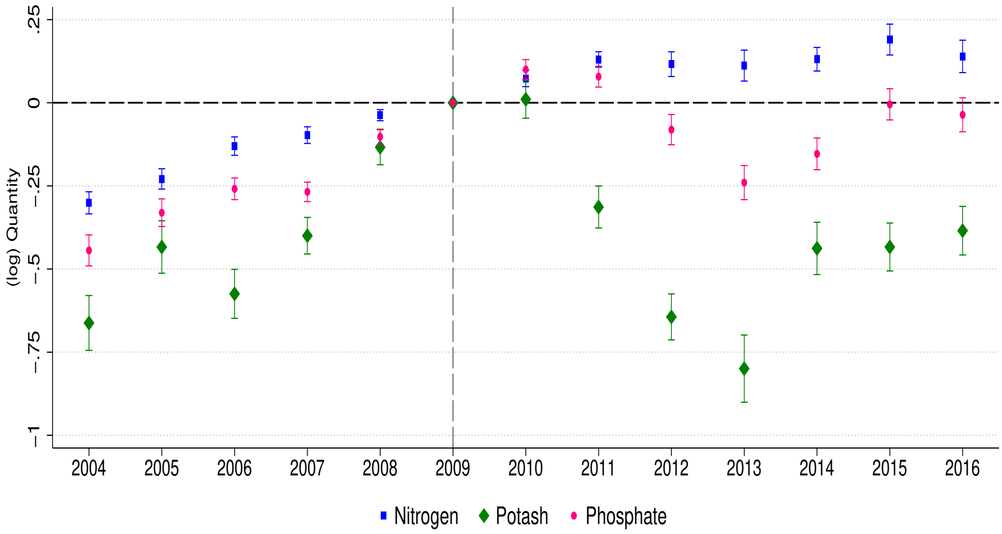
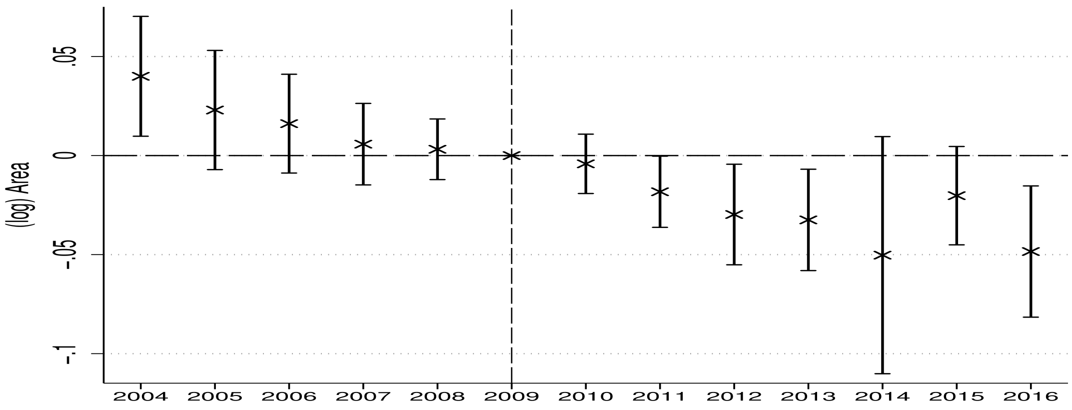
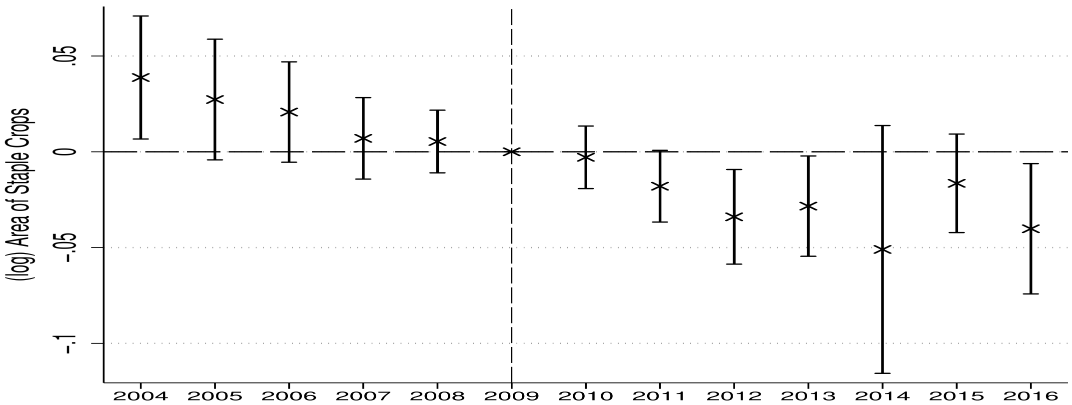


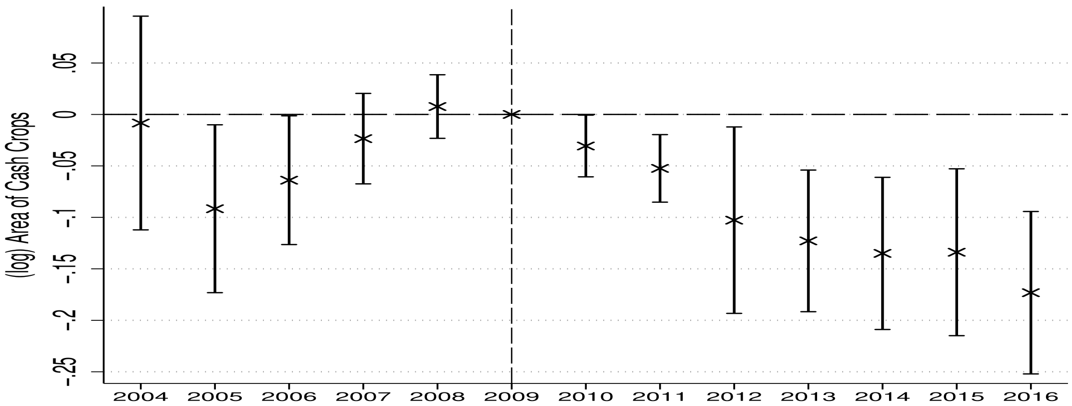
Figure A4: Effect of change in fertilizer subsidy on agricultural area



(a) Total Area



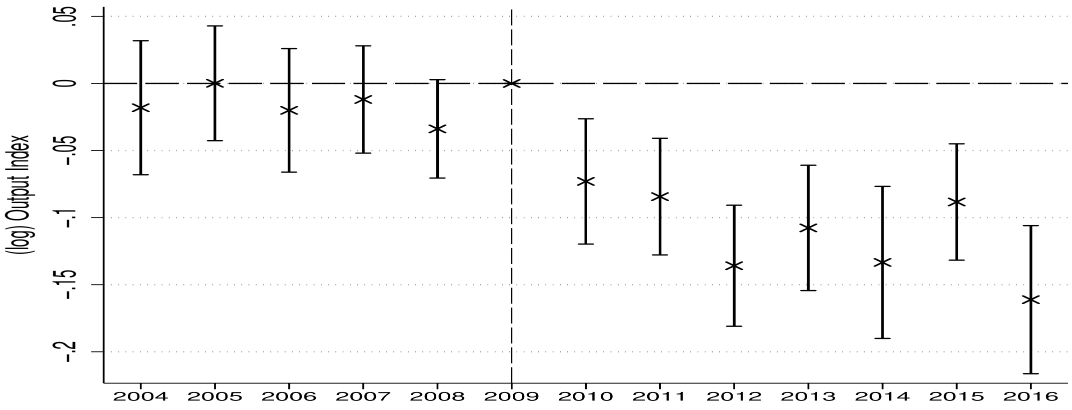
(b) Staple Crops Area



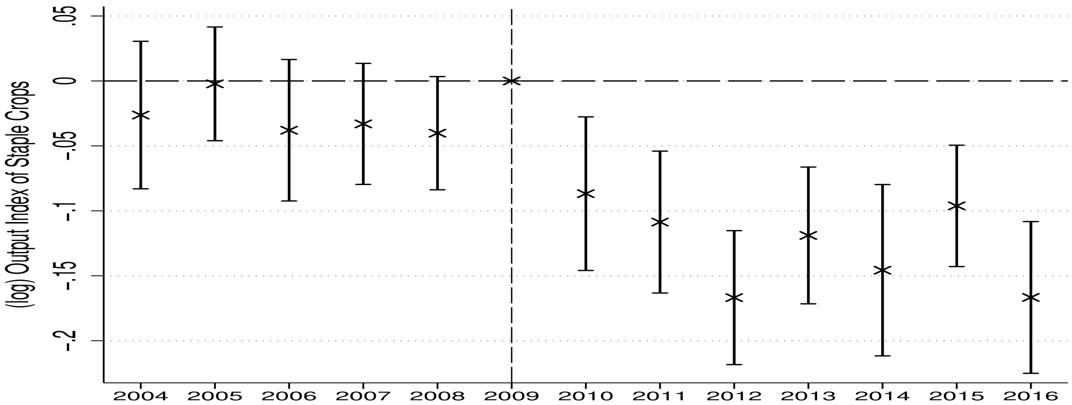
(c) Cash Crops Area

Note: Figure shows 95% confidence interval.

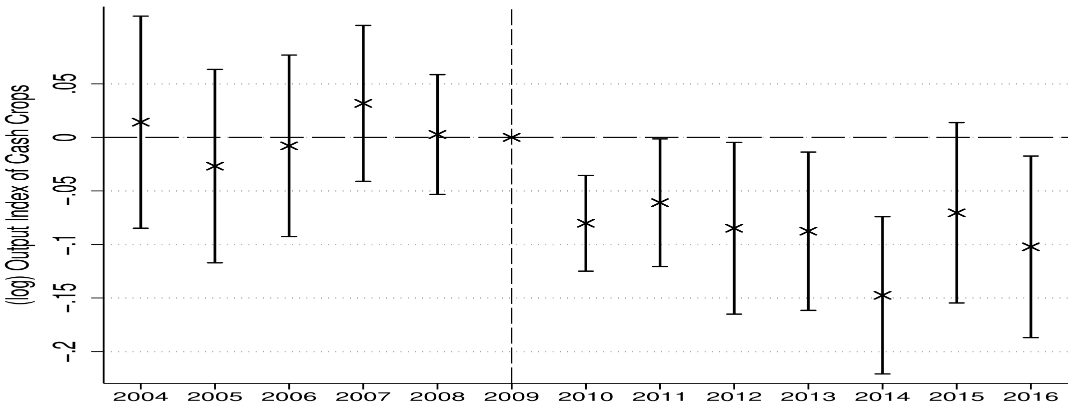
Figure A5: Effect of change in fertilizer subsidy on agricultural output



(a) Total Output



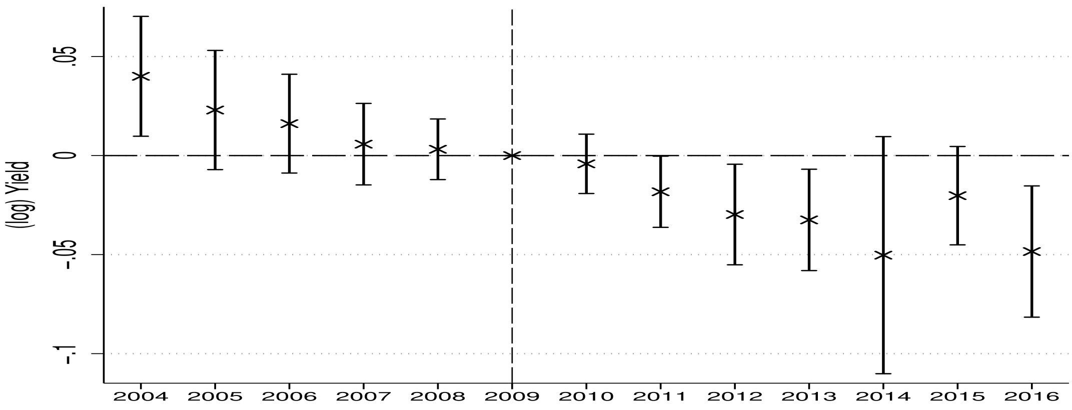
(b) Staple Crops Output



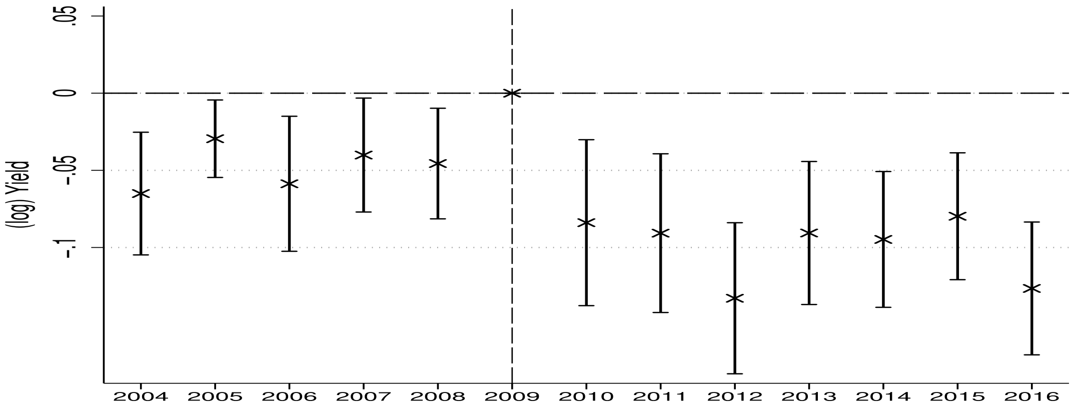
(c) Cash Crops Output

Note: Figure shows 95% confidence interval.

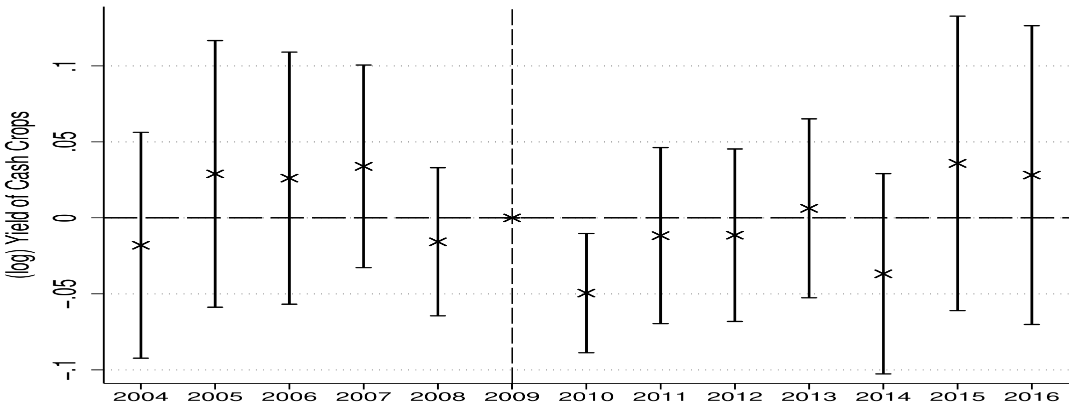
Figure A6: Effect of change in fertilizer subsidy on agricultural yield



(a) Total Yield



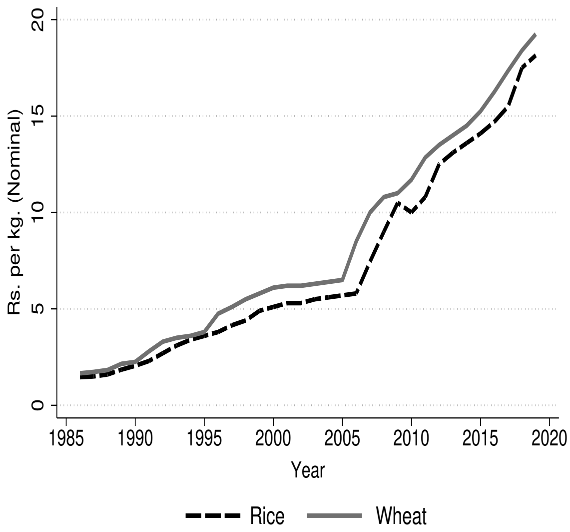
(b) Staple Crops Yield



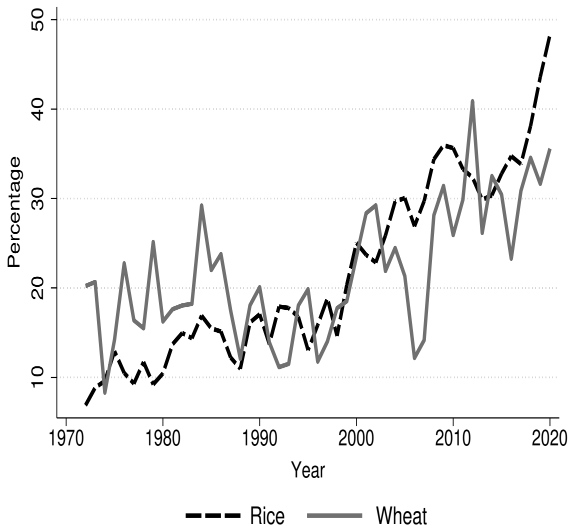
(c) Cash Crops Yield

Note: Figure shows 95% confidence interval.

Figure A7: Minimum Support Price and procurement over time

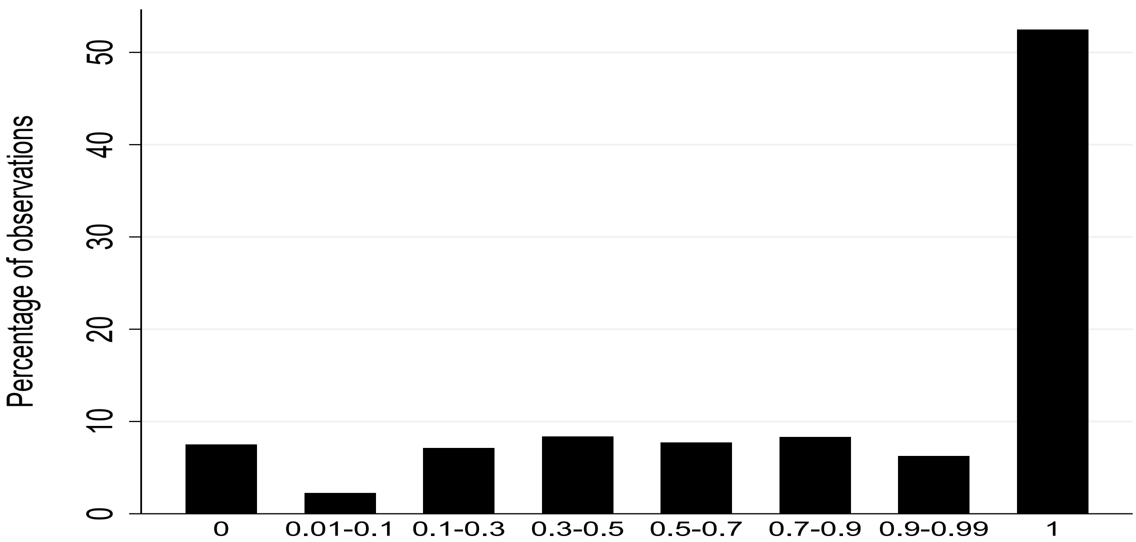


(a) Nominal MSP of rice and wheat



(b) Ratio of Procurement to Production

Figure A8: Distribution of staple crop share



B Additional Tables

Table B1: Difference-in-Difference estimate of MSP prices with procurement dummy

	Log Area (1)	Share Area (2)	Log Output (3)	Yield (4)
Dummy Output Procured $t-1\times$ MSP	0.069***	0.496***	0.099***	90.045***
	(0.016)	(0.119)	(0.017)	(9.655)
District x crop FE	Yes	Yes	Yes	Yes
Observations	16192	17206	16158	16150
R-Squared	0.951	0.983	0.945	0.795

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

Table B2: Difference-in-Difference estimate of MSP prices with no and positive procurement

	Log Area (1)	Share Area (2)	Log Output (3)	Yield (4)
No Procurement $t-1\times$ MSP	-0.042***	-0.009	0.006	62.088***
	(0.014)	(0.069)	(0.014)	(7.427)
Procurement $t-1\times$ MSP	0.026***	0.486***	0.105***	152.134***
	(0.010)	(0.087)	(0.011)	(7.137)
District x crop FE	Yes	Yes	Yes	Yes
Observations	16192	17206	16158	16150
R-Squared	0.951	0.983	0.945	0.795

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

Table B3: Equilibrium outcomes under replacement policies when MSP is removed

Group	No MSP	No MSP (balanced)	No MSP (doubled)	No MSP (in-kind)
Aggregate Quantities				
Aggregate Output	1.13	1.196	1.2	1.197
Real Output	1.18	1.196	1.2	1.196
Non-agricultural Good, y_n	0.762	0.743	0.746	0.743
Cash Crop, y_r	0.163	0.169	0.171	0.169
Staple Crop, y_s	0.229	0.256	0.256	0.256
Rations, c^{ration}	0	0	0	0.07
Intermediate input demand, $k_s + k_r$	0.022	0.027	0.027	0.0277
Capital demand, k_n	2.02	1.83	1.82	1.83
Labour productivity of non-agri to agri	2.02	1.84	1.825	1.84
Labour productivity of cash to staple crops	0.972	0.946	0.957	0.946
Prices				
Non-agricultural Good	1 (normalized)	1 (normalized)	1 (normalized)	1 (normalized)
Cash Crop, p_r	0.879	0.995	1.02	0.995
Staple Crop, p_s	0.995	1.11	1.106	1.11
Support Price, $\bar{p}$	0.75	0.84	0.837	0.084
Interest rate, r	0.078	0.088	0.089	0.088
Wage, w	1.09	1.05	1.04	1.05
Employment Shares				
Non-agricultural Sector	0.49	0.475	0.475	0.475
Cash Crop Farmers	0.202	0.202	0.202	0.202
Staple Crop Farmers	0.308	0.323	0.323	0.323

Table B4: Equilibrium outcomes under replacement policies when input subsidy is reduced

	Higher p_k	Higher p_k (balanced)
Aggregate Quantities		
Aggregate Output	1.214	1.2
Real Output	1.14	1.12
Non-agricultural Good, y_n	0.75	0.66
Cash Crop, y_r	0.148	0.165
Staple Crop, y_s	0.224	0.265
Rations, c^{ration}	0.0686	0.0812
Intermediate input demand, $k_s + k_r$	0.016	0.018
Capital demand, k_n	1.84	1.64
Labour productivity of non-agri to agri	2.1	2.22
Labour productivity of cash to staple crops	0.946	1.1
Prices		
Non-agricultural Good	1 (normalized)	1 (normalized)
Cash Crop, p_r	1.179	1.205
Staple Crop, p_s	1.288	1.285
Support Price, $\bar{p}$	1.144	1.15
Interest rate, r	0.088	0.0875
Wage, w	1.05	1.05
Employment Shares		
Non-agricultural Sector	0.475	0.36
Cash Crop Farmers	0.202	0.215
Staple Crop Farmers	0.322	0.424

Table B5: Partial Equilibrium Outcome Comparison*

	Benchmark	Removing MSP	Reducing input subsidy
Aggregate Quantities			
Aggregate Output	1.25	1.2467	1.175
Real Output	1.25	1.2467	1.175
Non-agricultural Good, y_n	0.793	0.793	0.816
Cash Crop, y_r	0.169	0.169	0.141
Staple Crop, y_s	0.258	0.256	0.197
Rations, c^{ration}	0.079	0	0.06
Intermediate input demand, $k_s + k_r$	0.028	0.0276	0.012
Capital demand, k_n	1.95	1.95	2
Labour productivity of non-agri to agri	1.7	1.84	2.25
Labour productivity of cash to staple crops	0.943	0.95	0.975
Employment Shares			
Non-agricultural Sector	0.475	0.475	0.4897
Cash Crop Farmers	0.202	0.202	0.202
Staple Crop Farmers	0.322	0.322	0.308

*In these exercises, all prices are kept at the baseline level.

C Data

This section describes the various datasets used for empirical analysis and calibrating the model.

ICRISAT

District level area, production, yield and price data for 20 major states come from ICRISAT. 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). We use median prices over 2004-2009 for a crop across districts while defining its value of production. We use all the crops listed above as we can assign prices only for these crops.

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 price of fertilizers N, P and K per kg.

National Sample Survey (NSS)

The NSS is a cross-sectional survey on employment and consumption representative at the district level. We use the employment rounds 61^{st}, 64^{th}, 66^{th} and 68^{th} rounds which correspond to the years 2004-05, 2007-08, 2009-10 and 2011-12. The survey provides daily information on labour supply over a week at the individual and activity level. We focus on rural households during the Rabi and Kharif seasons. We assign MSP of rice to the Kharif season and MSP of wheat to the Rabi season. We drop districts with zero rice and wheat production in Kharif and Rabi season respectively for all the years in the data. We drop individuals with missing information on religion, caste, household size, marital status, education and date of survey. We focus on individuals between age 16-64 living in the 19 major Indian states. We assign the split districts back to their parent district and end up with 449 unique districts.

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. Also, the second wave provides individual level data on income from non-agricultural activities.

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

When estimating the individual-level variance in non-agricultural income, we drop individuals with missing information on religion, caste, education and age between 16-70 years. Moreover, we remove the top and bottom 1% of non-agriculture income earners.