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Six Puzzles in Indian Agriculture‡

ABSTRACT A quarter century after India's historic shift to a more market-oriented economy, the agriculture sector continues to be racked by severe policy distortions, despite its importance for the livelihoods of the majority of India's population and in addressing major long-term challenges facing the country, from food security to natural resource sustainability. The paper highlights some key empirical realities and data anomalies to raise some fundamental questions about Indian agriculture and anchors the analysis in six major puzzles: prices, procurement, political economy, trade, productivity, and exit. While the list is neither exhaustive nor original in and of itself, these puzzles raise important policy issues. We conclude by arguing that more unified frameworks of analysis are needed for effective policy in a much neglected but crucial sector for securing India's future.

Keywords: *Agriculture, Market Imperfection, International Trade, Agriculture and Environment, India, Land Ownership, Political Processes*
JEL Classification: *D43, D45, O1, Q11, Q12, Q13, Q18*

1. Introduction

A quarter century after India's historic shift to a more market-oriented economy, with industrial delicensing, trade liberalization, and (more limited) reforms in factor markets, one sector continues to be plagued by severely intrusive government regulations in both factor and product markets, an arbitrary policy and regulatory environment, and low public investment. Unfortunately, that sector—agriculture—not only accounts for the livelihoods of the majority of India's population but also is critical to multiple long-term challenges facing the country, from food security to natural resource sustainability, especially soil and water.

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The challenges facing Indian agriculture and its tens of millions of farmers have been well recognized, whether by the media attention and hand wringing on farmer suicides, the reports of the National Commission on Farmers (led by M. S. Swaminathan) or official government documents, such as the *Economic Survey*, *2016*. Yet academic research has largely not kept pace with the most pressing challenges facing Indian agriculture, barring certain exceptions.[1] Given the increasing availability of computing power, novel geospatial datasets and new quantitative tools in trade, industrial organization, economic geography, and political science, this might be an opportune moment to focus on some old and new puzzles in Indian agriculture—all of which have major welfare implications for the tens of millions of Indian farmers.

The primary purpose of this paper is to raise some fundamental questions about Indian agriculture by highlighting a number of empirical realities and anomalies in the data. We discuss six major puzzles in Indian agriculture related to prices, procurement, political economy, trade, productivity, and the near-absence of exit. Our list is by no means exhaustive. Nor do we claim to be the first ones to identify these issues, but these puzzles raise, we argue, important policy issues, and they are all the more salient when viewed through the lens of a unified framework. We argue that it is often simplistic and naïve to provide isolated answers to these questions. For instance, as we note below, there appears to be little change in the time trends of spatial price variation in agriculture at both the retail as well as the wholesale level, and this is despite substantial investments in rural infrastructure in recent years, especially in rural roads and cell phone connectivity.

More broadly, our goal is to assemble some of the building blocks for an internally consistent framework and, in doing so, also highlight the need for more quantitative macro-research in agriculture. Much recent research on agriculture in developing countries has a micro-focus with limited generalizability. However, for policy, it is essential to be able to build a macro-framework that not only enables the incorporation of key actors and modeling their interaction with each other but also helps analyze meaningful policy counterfactuals with general equilibrium effects. We discuss this in greater detail in the concluding section.

We examine six key puzzles in detail below. First, we highlight high and stable spatial price dispersion (of wholesale prices) in the decade 2005–2014. Others have found the same in retail prices (Li 2016). This observation is

1. Examples include the following: Allen and Atkin 2016; Banerji, Gupta, and Meenakshi (2012); Banerji and Meenakshi (2004, 2008); Fafchamps and Minten (2012); Goyal (2010); Kapur and Krishnamurthy (2014a, 2014b); Krishnamurthy 2011; and Mitra et al. (2015).

at odds with the law of one price, which would predict a decline in price dispersion following massive investments in rural roads and communications (via cell phone penetration) in this period. Second, we show that while in principle the Minimum Support Price (MSP) policy is a national policy meant to protect the incomes of all farmers, there is substantial variation (both across regions and crops) in its implementation. Third, while farmers' incomes have languished, they have been unable to leverage their sheer numbers into pressuring governments to undertake policies and programs that benefit them, as one might expect in a democracy. Why has this been the case?

Fourth, India produces an excess of commodities and then exports them even though they have a high factor content of its scarce natural resources—water and land. This violates one of the central tenets of international trade theory—the Heckscher–Ohlin theorem. What factors might explain this puzzle? Fifth, there are large productivity gaps across geography, that is, the productivity level that can be reached conditional on natural endowments. Why? And why do these productivity gaps persist, that is, what prevents the diffusion of efficiency/efficacy norms across space? Finally, why do farmers not exit agriculture even when agricultural incomes remain abysmally low and highly uncertain, when they could potentially earn a riskless stream of income by selling their land, for instance?

We hope that the cataloguing of these puzzles in a unified manner will help to structure and motivate future research on Indian agricultural markets, policies, and their consequences.

2. The Price Variation Puzzle

Economic theory predicts that spatial price dispersion is a function of trade costs (such as transport costs and information asymmetries) and mark-ups charged by market intermediaries (the law of one price). Since the early 2000s, there have been large public investments in India in constructing highways and rural roads. The Pradhan Mantri Gram Sadak Yojana (PMGSY), launched in end-2000, aimed at providing all-weather road connectivity to every rural habitation with a minimum population of 500 in the plains (250-plus in hill states, tribal districts, and desert areas). Of a total of 178,184 habitations identified, two-thirds were connected by mid-2016 with nearly half a million km of roads. In the case of telecommunications infrastructure, the investments were made by the private sector. According to the Socio-Economic and Caste Census 2011, two out of every three rural Indian households have access to cell phones (from negligible numbers in 2000), and there have been active efforts by the central and state governments to inform farmers of *mandi* prices near them (Tewari 2015). The twin investments in core connectivity infrastructure—roads and cell phones—have resulted in substantial reductions of both transport and information costs in India. Yet we do not see evidence of spatial price convergence in agriculture commodities during this time period. As we show below using high frequency data, the variation in prices of commodities between agricultural markets or *mandis* has been stable over the past decade and is consistent across different crops.

Fafchamps and Minten (2012) found no evidence of the impact of SMS-based information on the prices received by farmers in a field experiment in Maharashtra. Although Goyal (2010) finds mild effects of improvement in farm gate prices for soybean farmers because of the introduction of electronic kiosks in villages of Madhya Pradesh (MP) in early 2000 by Indian Tobacco Company (ITC), the aggregate effects are negligible since the overall price variation has not gone down.

Before we look for possible answers, we examine the data in detail. We focus on average monthly price data for eight, major, non-perishable commodities—paddy, wheat, barley, maize, finger millet, pearl millet, sorghum and soybean—sold in any *mandi* in India between 2005 and 2014. It should be noted that the prices we analyze are wholesale prices observed at Agricultural Produce Market Committee (APMC) *mandis*. It is very likely that these are not prices received by farmers in general, since it is large farmers who sell in *mandis*, whereas small farmers are more likely to sell to local village intermediaries (Table 1). However, our price data has

TABLE 1. Percentage of Cereal Output by Farm Size Sold to Various Buyers

		Paddy			
Farm Size	*Local Private*	*Mandi*	*Government*	*Input Dealers*	*Processors*
0–2 ha	55.44	20.19	11.17	8.72	1.62
2–5 ha	41.89	28.92	5.54	19.44	2.44
5–10 ha	29.58	34.77	6.52	27.46	0.51
> 10 ha	14.15	50.43	3.76	15.38	0.65

		Wheat			
Farm Size	*Local Private*	*Mandi*	*Government*	*Input Dealers*	*Processors*
0–2 ha	41.40	38.71	11.01	8.1	0.14
2–5 ha	25.23	49.97	5.02	19.42	0.24
5–10 ha	16.68	45.68	7.36	29.8	0.3
> 10 ha	6.07	40.45	1.67	51.77	0.08

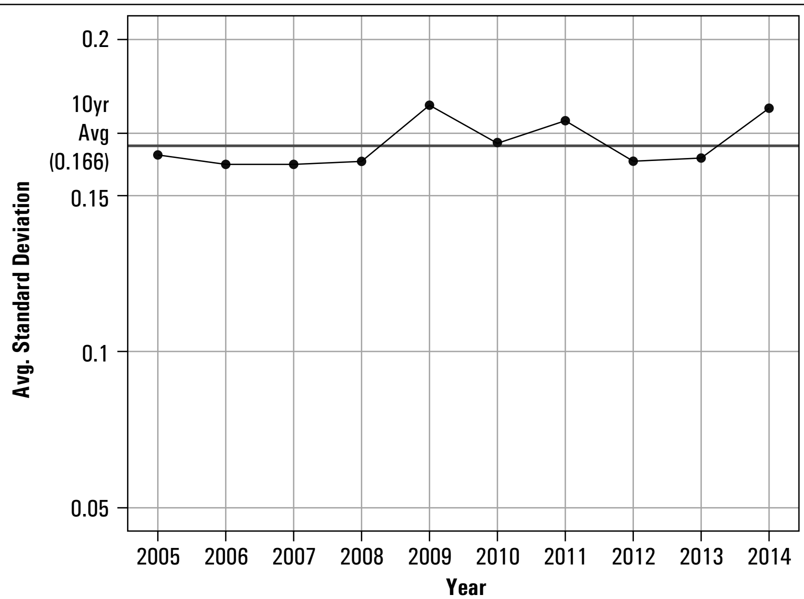
Source: NSS Situation Assessment Survey of Agricultural Households (2012).

several advantages. They are actual prices recorded at a high frequency and at a crucial stage in the supply chain: *mandis* are key points of aggregation. Other sources of price data are usually recalled estimates of unit values, geographically aggregated and at a very low frequency.

We use log (real) prices (with the consumer price index for agricultural laborers [CPIAL; food] as the deflator) so that the variance of log prices is unit-independent and compatible for pan-country comparisons. The average standard deviation of log (real) prices across *mandis* in a given month is 0.17. For comparative purposes, this is higher than the Philippines: for rice and corn (the country's principal home-grown food commodities), Allen (2014) found the standard deviation to be 0.15, and this in a country comprising a group of over a thousand islands, with high transport and information costs.

As stated earlier, we do not observe any trend in time-series of the standard deviation, which implies that the trade cost during this period does not appear to have had a causal effect on price variation in grains across India (Figure 1). There is some heterogeneity in the price dispersion across

FIGURE 1. Average Spatial Variation in *Mandi* Prices



Source: AgMarknet data.

Notes: Standard deviation computed for each month and each crop. The figure plots the yearly averages. Commodities in data: Barley, pearl millet, finger millet, maize, paddy, soybean, sorghum, wheat.

TABLE 2. Price Variation between *Mandis* in Commodities

		Avg Std Dev
Full Sample	All commodities	0.17
	Paddy	0.22
	No Basmati/Superfine	0.21
	Wheat	0.13
	All other	0.17
Trimmed Sample	All commodities	0.16
	Paddy	0.21
	Wheat	0.13
	Soybean	0.07
	Sorghum	0.28
	All other	0.16

Source: Authors' Calculations from AgMarknet data.
Note: The trimmed sample drops the top 5th percentile of the sample in terms of prices. Commodities in data: Barley, pearl millet, finger millet, maize, paddy, soybean, sorghum, and wheat.

commodities. It is lowest for soybean, which is chiefly grown in MP as well as parts of Maharashtra, and higher for other cereals (Table 2).

Some of the variation in price might be due to high-value varieties—for example, basmati rice is more expensive than common rice. To control for that, we drop the top 5 percentile of our data by crop in terms of prices. That brings down the average annual variation only mildly. Most importantly, however, even in the trimmed sample, we do not see any evidence of reduction in spatial price variation over time (Table 3).

The average standard deviation of log (real) prices across *mandis* within states is also high. To the extent that high average standard deviation of log (real) prices across *mandis* in the country might be due to different varieties of wheat and rice grown in agro-ecological zones that vary across different states, this finding attenuates the concern. High within-state variation provides additional evidence that the variation is not entirely due to quality.

TABLE 3. Spatial Price Variation in Commodities over Time

	2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Barley	0.11	0.14	0.11	0.12	0.16	0.16	0.16	0.11	0.11	0.11
Millets	0.19	0.16	0.17	0.18	0.20	0.17	0.17	0.16	0.18	0.20
Maize	0.17	0.17	0.15	0.14	0.16	0.13	0.14	0.15	0.16	0.16
Paddy	0.18	0.19	0.22	0.23	0.23	0.22	0.19	0.20	0.24	0.21
Soybean	0.06	0.06	0.06	0.06	0.09	0.05	0.06	0.09	0.06	0.09
Sorghum	0.25	0.25	0.27	0.25	0.27	0.31	0.38	0.29	0.24	0.32
Wheat	0.14	0.15	0.14	0.11	0.12	0.13	0.14	0.12	0.13	0.12

Source: Authors' calculations from AgMarknet data.

TABLE 4. Variation in Real Prices Across *Mandis* Within States in 2014

State	*Standard Deviation*
Andhra Pradesh	0.15
Chhattisgarh	0.13
Gujarat	0.14
Haryana	0.13
Jharkhand	0.14
Karnataka	0.18
Kerala	0.17
Madhya Pradesh	0.21
Maharashtra	0.16
Odisha	0.70
Punjab	0.26
Rajasthan	0.14
Tamil Nadu	0.21
Uttar Pradesh	0.11

Source: Authors' calculations from AgMarknet data.

We present the results for 2014 in Table 4. The results for previous years are similar.

What is the relative weight of different factors in the variation in prices? To get at this, we performed a Shapley–Shorrocks decomposition. This procedure considers the various factors that together determine an indicator (such as the overall variation in prices) and assigns to each factor an average marginal contribution. This technique ensures that the decomposition is always exact and that the factors are treated symmetrically. The results from the Shapley–Shorrocks decomposition found that 37 percent of the variation in log (real) prices is due to time-invariant district fixed effects (which in this case could be soil quality effecting yields and hence prices), 20 percent is due to location-invariant aggregate time shocks (like global demand), 4 percent is due to differences in monthly rainfall across districts, and 39 percent remains unexplained. The residual time- and location-varying effects could be due to changes in connectivity, crop choice, or the expansion of welfare schemes—such as the Public Distribution System (PDS) and National Rural Employment Guarantee Act (NREGA)—impacting agriculture.

This analysis is revealing because, if the law of one price is valid, then trade costs alone cannot create the binding constraint. The law of one price states that the difference in prices at two locations is a function of trade costs and market power. There is compelling evidence that the PMGSY has reduced trade costs in rural India (Agarwal 2014), and highways have done so between regions (Allen and Atkin 2016). Therefore, it must be either that the market power of intermediaries has stayed constant over the years and/or that it interacts with trade costs in ways that need better understanding.

In ongoing work, Chatterjee (2017) explores the role of spatial competition in price variation between *mandis*. Using a large dataset on prices in *mandis* and their geo-locations, the paper finds evidence that additional markets create more competition and hence increase the prices received by farmers. A causal border-discontinuity model, which exploits restrictions to inter-state movement of goods to tease out the competition effect, estimates price increases of 4 percent for an additional *mandi* in the neighborhood. The limitation of this approach is that it is unable to capture any within-*mandi* friction that might give rise to market power.[2] While we have a good understanding of how trade costs impact prices, we know much less about the sources of market power within a *mandi*. To that end, understanding the *mandi* as an institution, and its internal political economy that gives market power to traders vis-à-vis farmers, is the logical analytical next step. Then, ideally, economists can model these forces and should be able to quantify their effects on price dispersion.

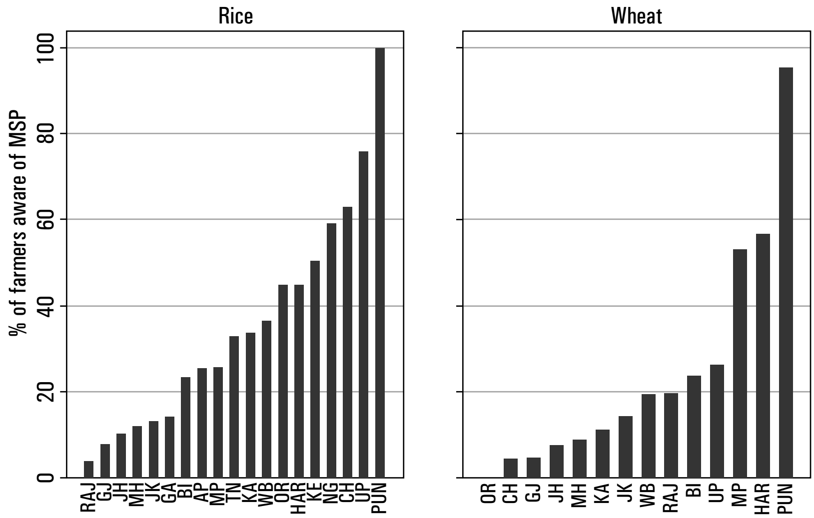
3. The Procurement Puzzle

Two key government interventions that affect agriculture markets and commodity prices in India are the MSP and procurement by government agencies (mainly, but not solely, at *mandi* sites). The MSP sets a floor price and thereby shapes the investment decisions of farmers. Its rationale is to ensure that farmers are not compelled to sell their produce below the support price due to either exploitation by large market players or a bumper harvest. The MSP is effective mainly for four crops: wheat, paddy, cotton (albeit only to a modest degree), and sugarcane (for which mills are legally obligated to buy cane from farmers at government-fixed prices).

The puzzle is that although in principle the MSP procurement policy is a national policy and should benefit all farmers regardless of their location or crop choice, in practice, it varies (a) across states, (b) across districts within states, and (c) across crops. Although we understand some of this variation, a large part of it is still left unexplained. To highlight this puzzle, we first consider an indirect measure: farmers' awareness about MSP. The reason

2. See Krishnamurthy (2011) for an ethnographic study of the multiple ways in which market power works within a *mandi*.

FIGURE 2. Farmer Awareness about Minimum Support Prices 2012–13



Source: NSS Situation Assessment Survey of Agricultural Households Round 70.

for choosing this measure over actual procurement is that the quantum of procurement is a choice of the farmer. If market prices are above MSP, then even in the presence of efforts by public agencies, farmers may choose not to sell since the MSP acts like an option. However, the farmers' awareness about MSP is more likely to reflect the presence of government agencies in his neighborhood.

Figure 2 shows that most farmers are not even aware of the existence of MSPs, and there is considerable variation across states. Whereas most farmers in Punjab and Haryana are aware of MSP, very few are aware in other states such as Gujarat, Maharashtra, Jharkhand, or West Bengal. This is indicative of the absence of active government procurement efforts by public agencies in many parts of the country.

It follows, therefore, that there are large disparities across states in actual procurement. In Tables 5 and 6, not surprisingly, one observes that the states where awareness of MSP is high are also the states where there is heavy procurement of grains—both in absolute terms and relative to total production. Therefore, awareness is highly correlated to the intensity of procurement in a state (Figure 3). Notice also that as paddy is more intensely procured than wheat (as a percentage of total production), the overall level of awareness is higher for paddy than for wheat.

TABLE 5. Production and Procurement of Rice

	Production (million tons)		*Procurement by FCI and State Agencies (million tons)*		*% of All India Procurement*	*Procurement as a % of Total Production*
State	*2013–14*	*2014–15*	*2013–14*	*2014–15*	*2013–15*	*2013–15*
Andhra Pradesh	6.97	7.23	3.737	3.596	11.65	51.63
Bihar	5.51	6.36	0.942	1.614	4.06	21.55
Chhattisgarh	6.72	6.32	4.29	3.423	12.26	59.16
Gujarat	1.64	1.83	0	0	0.00	0.00
Haryana	4.00	4.01	2.406	2.015	7.03	55.23
Jharkhand	2.81	3.36	0	0.006	0.01	0.10
Karnataka	3.57	3.54	0	0.088	0.14	1.24
Kerala	0.51	0.56	0.359	0.374	1.16	68.42
Madhya Pradesh	2.84	3.63	1.045	0.807	2.94	28.62
Maharashtra	3.12	2.95	0.161	0.1988	0.57	5.93
Odisha	7.61	8.30	2.801	3.357	9.79	38.70
Punjab	11.27	11.11	8.106	7.786	25.26	71.03
Rajasthan	0.31	0.37	0	0	0.00	0.00
Tamil Nadu	5.35	5.73	0.684	1.051	2.76	15.66
Telangana	5.75	4.44	4.353	3.504	12.49	77.06
Uttar Pradesh	14.64	12.17	1.127	1.698	4.49	10.54
West Bengal	15.37	14.68	1.359	2.032	5.39	11.29

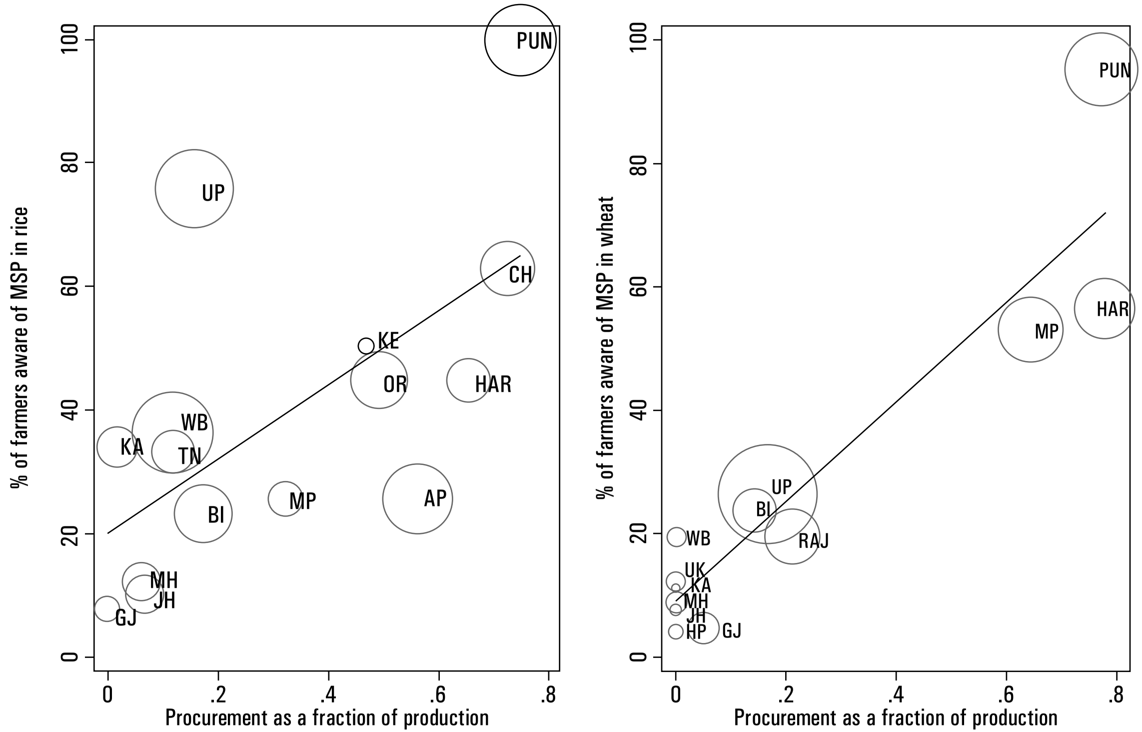
Source: Ministry of Agriculture and Farmers Welfare, Government of India.

TABLE 6. Production and Procurement of Wheat

	Production (lakh tons)		*Procurement by FCI and State Agencies (lakh tons)*		*% of All India Procurement*	*Procurement as a Percentage of Total Production*
State	*2013–14*	*2014–15*	*2013–14*	*2014–15*	*2013–15*	*2013–15*
Andhra Pradesh	0.04	0	0	0	0.00	0.00
Bihar	47.38	39.87	0	0	0.00	0.00
Chhattisgarh	1.34	1.35	0	0	0.00	0.00
Gujarat	46.94	30.59	0	0	0.00	0.00
Haryana	118.00	103.54	58.73	6.50	23.29	55.8
Jharkhand	3.70	3.30	0	0	0.00	0.00
Karnataka	2.10	2.61	0	0	0.00	0.00
Madhya Pradesh	129.37	171.04	63.55	70.94	25.33	44.8
Maharashtra	16.02	13.08	0	0	0.00	0.00
Odisha	0.01	0.006	0	0	0.00	0.00
Punjab	176.20	150.50	108.97	116.41	42.45	69.0
Rajasthan	86.63	98.24	12.70	21.59	6.46	18.5
Telangana	0	0.07	0	0	0.00	0.00
Uttar Pradesh	298.91	224.17	6.82	6.28	2.47	2.5

Source: Ministry of Agriculture and Farmers Welfare, Government of India.

FIGURE 3. Farmer Awareness versus Procurement



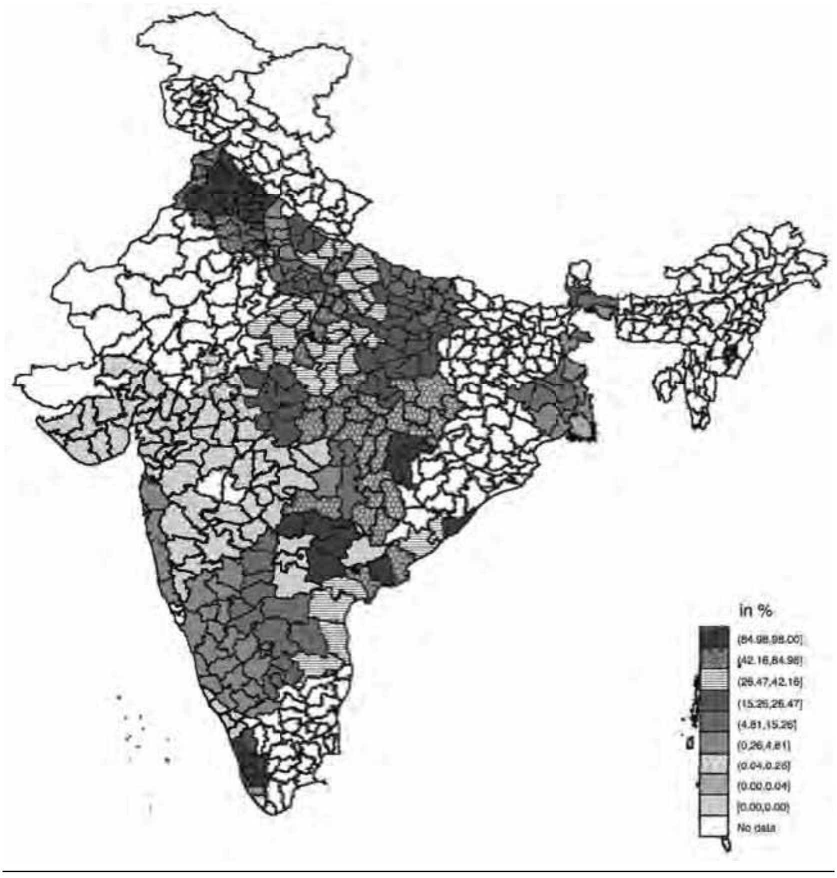
Source: NSS–SAS (2012).

Note: Size of the bubble represents state shares in national output. Acronyms refer to state names.

While there has been considerable discussion on procurement of food grains by public agencies for the PDS, the key point that is often missed is that government procurement is a luxury for most farmers in the country. There are large differences not only across states but within them as well. And this variation in procurement has substantial consequences on the price that farmers receive and the crops they choose to produce.

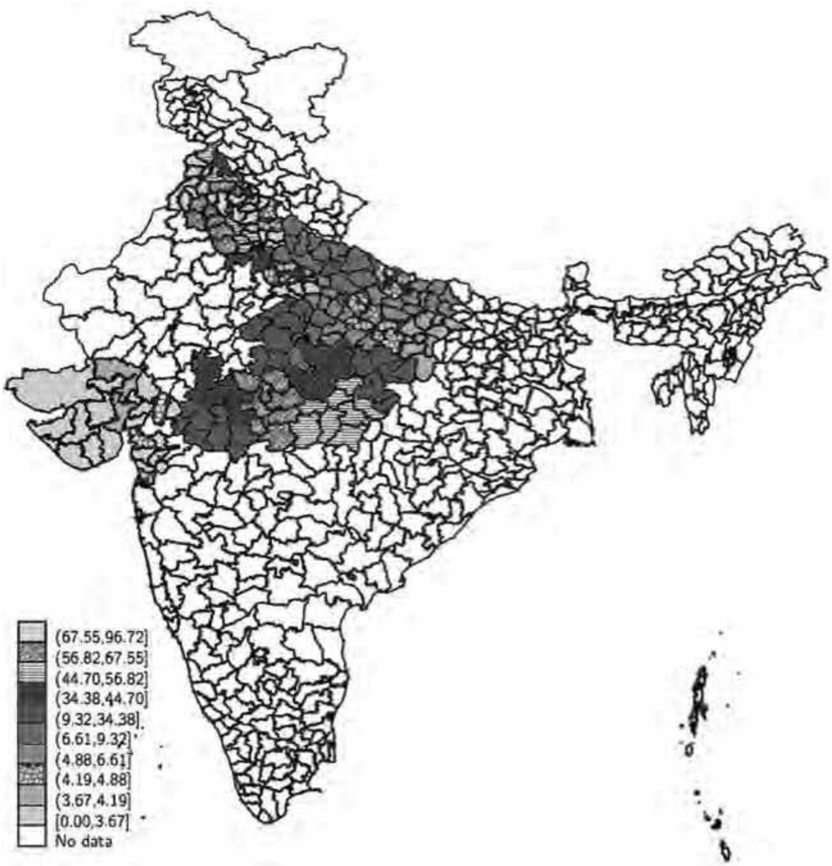
The disparity in procurement within states can be seen in the maps in Figures 4 and 5. The figures plot, for each district, paddy and wheat procured as a percentage of total production for that district. Although there is

FIGURE 4. Average Fraction of Paddy Production Procured 2005–14



Sources: Food Corporation of India and Ministry of Agriculture and Farmers Welfare, Government of India.
Note: This map is not to scale and may not depict authentic boundaries.

FIGURE 5. Average Fraction of Wheat Production Procured 2005–14



Sources: Food Corporation of India and Ministry of Agriculture and Farmers Welfare, Government of India.
Note: This map is not to scale and may not depict authentic boundaries.

uniformly high procurement across districts in Punjab and Haryana, there is large variation across districts in UP, MP, Maharashtra, and Odisha.

What explains the variation in procurement across districts? Potential explanations (all of which require careful research) include the following:

1. In districts where procurement is low, market prices are above MSP such that it is not in the farmers' interest to sell to the government.
2. Output per person is relatively low in districts where procurement is low, indicating that low procurement reflects low marketable

surplus. In other words, a larger fraction of production is used for self-consumption.

3. Variations in procurement could also reflect variations in the nodal procurement agencies. While the Food Corporation of India (FCI) is the principal storage and distribution agency for food grains, a substantial portion of the actual physical procurement is done by state agencies on behalf of the FCI. All procurement agencies—whether the FCI or state agencies—face resource constraints. However, since they must procure a target amount of grains for the PDS, they are likely to deploy limited resources efficiently by mobilizing them in spatially concentrated, high-productivity districts.
4. Procurement of grains can also be used by politicians to selectively channel resources toward their constituencies (or away from their rivals' constituencies) and thereby reward or penalize sections of the electorate. For instance, if the local politician is from the ruling party at the Center, then he can potentially influence the FCI on the location and number of purchase centers or, if he is from the ruling party in the state, the state procurement agencies.

The first and second explanations are in line with government-mandated policies. The last two, however, can have important welfare and policy implications. If we regress fraction of output procured in each district on log yields and log population, we indeed find support for (2) and (3) (Table 7). Districts with larger populations have relatively lower procurement, and districts with higher productivity have relatively greater procurement. Nonetheless, these regressions can only explain about 30 percent of the cross-sectional variation in procurement, which leaves much scope for future research.

TABLE 7. Regression Table

	Dep var: Fraction of Output Procured	
Log yield	28.40	32.22
	(2.68)***	(5.58)***
Log population	−16.69	−20.78
	(1.40)***	(2.76)***
N	445	188
R^2	0.32	0.35
Crop	Rice	Wheat

Source: District population is from 2011 Census of India.

Notes: All observations are district averages between 2011 and 2014. Crops include paddy and wheat. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4. Political Economy Puzzles

Historically, India has been seen as a rural society, with farming the dominant occupation and economic mainstay for the vast majority of the population. In the 1950s, agriculture accounted for more than half of India's gross domestic product (GDP), and cultivators accounted for half of the workforce. From that position, agriculture's share of GDP had declined by two-thirds (to about 16 percent) by 2011, while the percentage of cultivators in the workforce had declined from nearly 50 percent in 1951 to 24 percent in 2011. Nonetheless, the absolute numbers are very large (118.6 million as per the 2011 Census), and if we add agricultural laborers who account for 30 percent of the labor force (144 million in 2011 up from 27.3 million and 19.5 percent of the workforce in 1951), the two still constitute more than half of India's labor force.

Furthermore, as per National Sample Survey (NSS) data from the 70th Round, during the agricultural year July 2012–June 2013, rural India had an estimated total of 90.2 million agricultural households, which constituted about 57.8 percent of all rural households and 37 percent of all households. In a democracy, these massive numbers suggest that farmers should be a potent political force. But their economic travails suggest otherwise. Why have Indian farmers not leveraged their sheer numbers into pressuring governments to undertake policies and programs that benefit them more?

An obvious counter to this question is that farmers do enjoy substantial political influence. Many of India's agriculture policies are in place precisely because of farmers' political clout. Subsidies on inputs—whether electricity, water, fertilizer, or credit—or on outputs (especially price supports) are in place precisely because farmers matter politically. While there are many questions on the incidence and distributional impact of these subsidies, the reality that the vast majority of Indian farmers have low and volatile incomes is not in doubt. And yet, the reality is that famers' movements were much more politically salient in the 1970s and 1980s than in the last two decades.

In the early decades following India's independence, the Indian state enjoyed substantial autonomy from powerful rural interests, which, while they could thwart rural programs (such as land reforms or community development programs), had weak impact on agriculture policies and programs. This changed dramatically after the Green Revolution. Initially there were fears that the Green Revolution would "turn red," based on apprehensions that the gains would accrue disproportionally to large farmers, widening the gap with marginal farmers and landless laborers (Frankel 1978). Instead, as the Green Revolution started empowering the landed peasantry (owner-cultivators—the so-called "bullock capitalists"), the focus shifted to rural farmer-led "demand groups" that became an important political constituency shaping public spending on agriculture subsidies and pitting rural India against urban India (Rudolph and Rudolph 1987). The "Bharat versus India" tension was especially manifest in pressures for higher MSPs, since these benefited producers (farmers) at the expense of consumers (or the public exchequer, if consumer subsidies rose). This drove farmers' movements to demand higher support prices (Varshney 1995), but farmers' incomes continued to be dismal, as we note below. This is even more puzzling since the 1990s saw marked growth in regional parties dominated by farmers. Why have farmers been unable to translate their large numbers into more pro-farmer policies and programs?

An obvious explanation of the failure of collective action by farmers goes back to Olson (1965), who famously argued that large and dispersed groups are hard to organize anywhere. And, given the fragmented nature of Indian society, they are more susceptible to cross-cutting religious, caste, and ethnic/linguistic appeals. But two developments of the 1990s appear to have further weakened collective action by farmers. The sharpening of caste-based political cleavages since the late 1980s (following the implementation of reservations under the Mandal Report in 1990) may have caused the glue of common economic interests to come unstuck. A second possibility is the 73rd Amendment to the Indian Constitution, which made statutory provisions for Panchayati Raj as the third level of administration in villages. This was a much-needed effort at administrative decentralization. But by mandating elections at the base of rural society (villages), it appears to have shifted political energies inward—in the form of electoral competition within villages to capture increasing resources coming to villages—and thereby diluted efforts to project collective farming interests outward and upward.

These factors, however, only explain the demand side of the story. They do not explain why politicians have been willing to spend vast resources and efforts on programs aimed at rural India, for which there was pressure from civil society groups, but little from rural voters (for example, NREGA), while remaining unwilling to commit resources and efforts to improve farmer productivity and incomes, whether through rural markets, agriculture research and extension, or better credit and irrigation systems.

Under the Indian Constitution, agriculture is a state subject. One might, therefore, expect considerable inter-state variation in agriculture policies stemming from differences in the politics and political economies of states. But, in fact, differences in the policy approaches of politicians across states in agriculture—be it taxes, subsidies, or trade laws—are quite limited. Why?

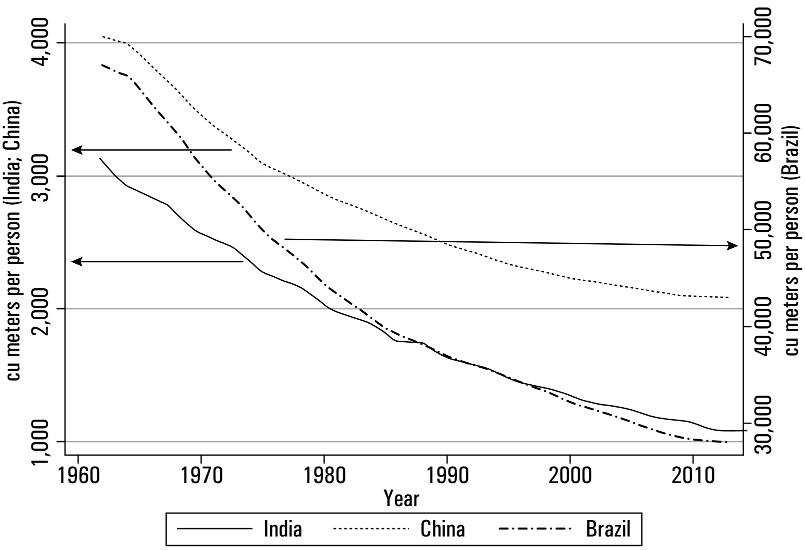
To take one example: reforms to the APMC Act. In 2003, recognizing that the role of the APMCs and the state agriculture marketing boards needed to change from market regulation to market development, which required removing trade barriers and creating a common market, the Central Government formulated a model APMC Act for adoption by the states.

The reality of the reforms carried out by the different states paint a different picture. Maharashtra, for example, went back on the reforms soon after they were announced.[3] UP has not yet adopted any of the main features of the model APMC Act except giving permission to some big players for direct procurement of food grains (primarily wheat), on the condition that their total procurement in a season should be greater than 50,000 tons. Crucially, this notification is issued year to year, and no changes have been made in the legislation, thereby ensuring little private investment (and possibly substantial annual rent seeking). In other states, by putting in large up-front license fees to set up new markets or insisting that traders outside the market still pay market fees, the reforms have been effectively stymied. Even when licenses are awarded, they are for selected crops. For example, in Karnataka, of the 36 licenses awarded at the time of writing, all were either for cotton or fruits and vegetables.[4]

A research agenda on the limited inter-state variation in agriculture policies could investigate two possibilities. First, whether multiple interventions by the Center on different issues have important structural consequences for agriculture that limit what states can do. The National Food Security Act, 2013, for instance, mandated legal entitlements for existing food security programs at a fixed price for specific food grains. Inevitably, this sets certain structural incentives for the states' own procurement efforts and thereby farmers' crop choices, with cascading effects on ecologically sustainable agriculture practices. A second explanation might stem from certain common features of agriculture markets across rural India, namely the layer of intermediaries constituting the trading-cum-moneylending classes. The persistence of interlinked markets in credit and outputs enhances the bargaining power of these intermediaries vis-à-vis farmers, as well as giving them more influence in local politics, thereby making it easier to undermine reform efforts. Research into the political economy of the structure of rents that accrue under the status quo, and whether and why these might affect the incentives of governments to implement reforms, would be valuable.

3. http://tinyurl.com/maharashtra-apmc-reform
4. Data based on interviews with Karnataka state government officials by authors.

FIGURE 6. Per Capita Availability of Renewable Freshwater Resources



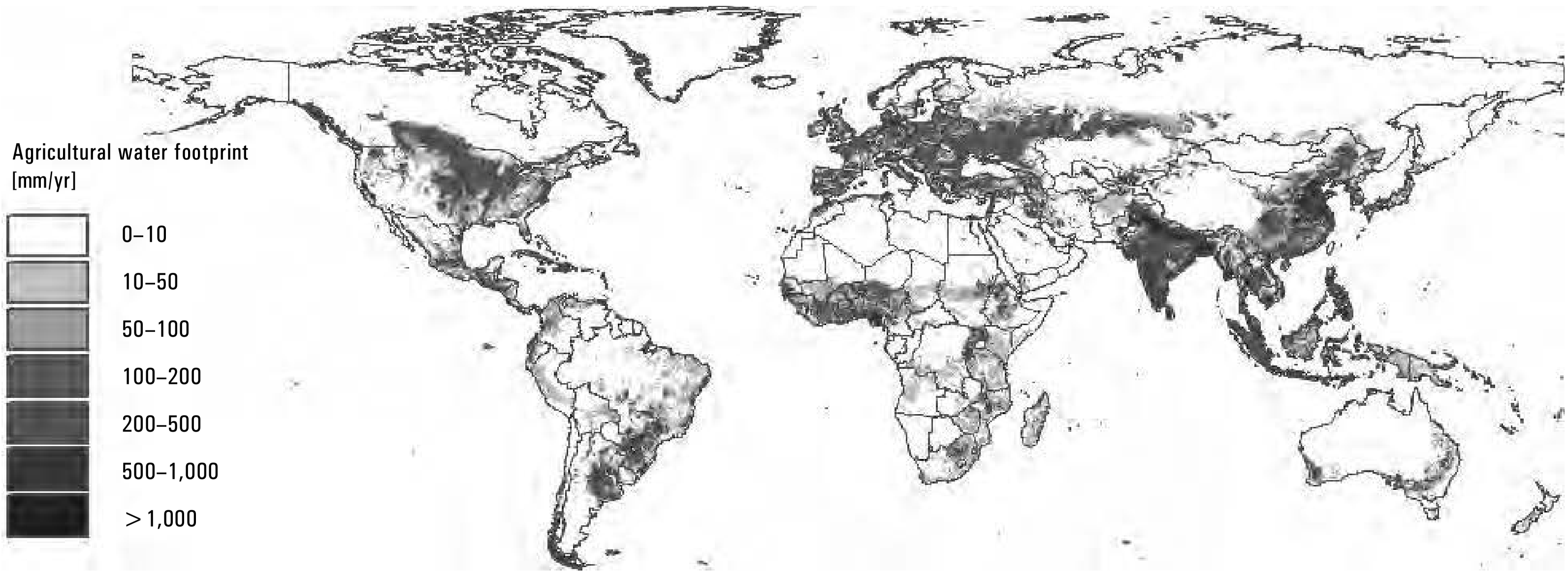
Source: FAOSTAT, http://faostat3.fao.org/

5. The Trade Puzzle: Exporting Scarce Resources

One of India's scarcest natural resources is water. Figure 6 provides an international comparison of availability of fresh water resources. The scarcity of fresh water in India is much worse than even what is depicted in the picture since Brazil and China use only 60 percent of their stock of fresh water availability, while India uses a little over 90 percent. In an era of globalization, as the Hecksher–Ohlin trade model would also predict, India should produce relatively more of the commodities that use its scarce natural resources less intensively and should export them. And it should produce relatively less of commodities whose production requires intense use of its scarce resources and should import them.

In aggregate, India's production patterns are the converse. Hoekstra and Mekonnen (2012) compute the water footprint (amount of water used for production) of crop production around the world from 1996 to 2005. Not only is India's water footprint the highest (followed by those of China and Brazil) but also, at 1,047 cu gm per year, it is thrice that of Brazil (329 cu gm per year), despite India having fewer water resources than other countries to begin with. Furthermore, India's production technology and crop choice amplifies the amount of water it uses for production. This can also be seen in Figure 7. Further, globally among all provinces or states, the water footprint

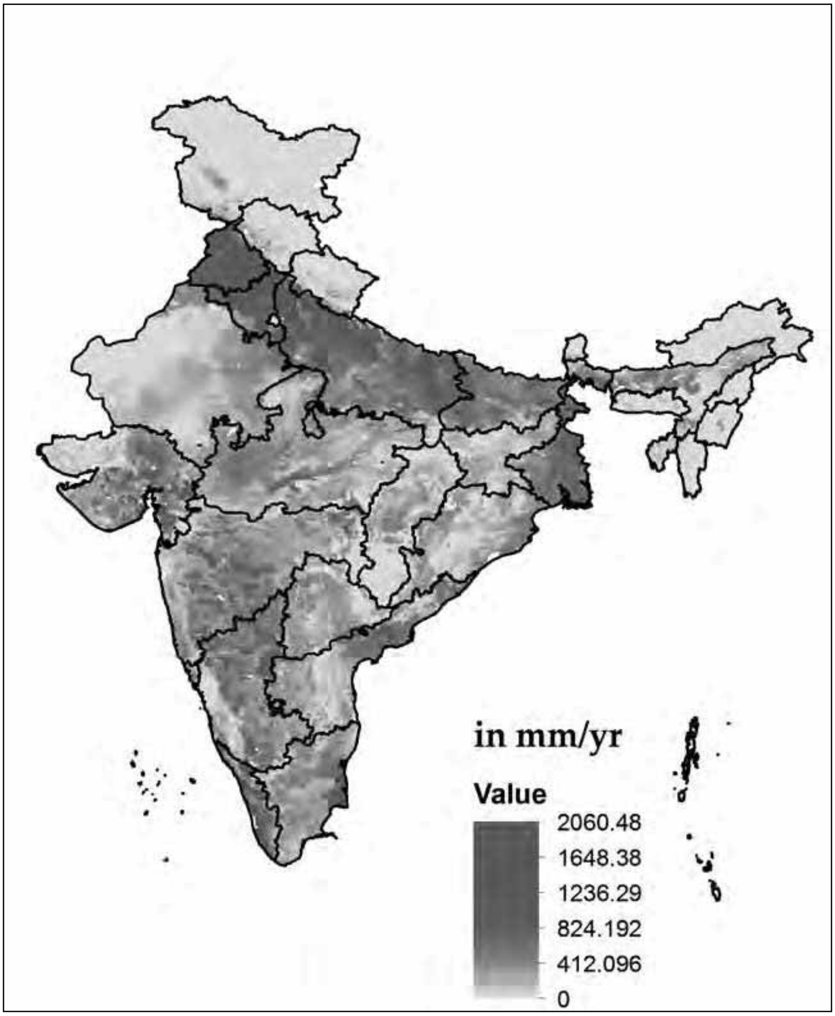
FIGURE 7. Water Footprint of Agricultural Production



Source: Hoekstra and Mekonnen (2012).

is the highest for UP, Maharashtra, Karnataka, Andhra Pradesh, and MP. This, to some extent, reflects the large size of these provinces. Within India, per 5 arc minute by 5 arc minute grid cell, the water footprint is the highest in the Punjab–Haryana region, as can been seen in Figure 8.

FIGURE 8. Water Footprint of Agricultural Production in India



Source: Hoekstra and Mekonnen (2012).

Notes: The map reflects water footprint for every 5 arc minute by 5 arc minute surface of the earth. This is roughly a cell of 100 sq km area.

This map is not to scale and may not depict authentic boundaries.

To understand the trade patterns of water, Goswami and Nishad (2015) estimate water content embedded in crops at the time of trade. This is different from water used in production, which is much higher and partially recoverable. Water "embedded" in crops, on the other hand, is the water content of each crop which, once the crop is exported, cannot be recovered. In 2010, India exported about 25 cu km of water embedded in its agricultural exports. This is equivalent to the demand of nearly 13 million people. India was a net importer of water until the 1980s. With increasing food grain exports, India has now become a net exporter of water—exporting about 1 percent of its total available water every year. The ratio of export to import of virtual water is about 4 for India and 0.1 for China. Thus, China remains a net importer of water.

What might have led to this trading pattern? India's major agriculture exports (by weight or value) are rice and wheat. India exported 11.9 million tons of paddy and 2.9 million tons of wheat in the year 2014–15. In the same year, India's major agriculture import was 4.6 million tons of pulses and 11.5 million tons of edible oils. This pattern has been consistent in the last two decades, ever since the country became self-sufficient in rice and wheat. Since the water content by weight of paddy and wheat is 15 percent whereas that of pulses is 10.5 percent, India's agriculture trade has become a net exporter of water, even as domestic water supplies dwindle.[5]

Thus, India's trade pattern reveals that it is massively over-producing rice and under-producing pulses. The root cause is the distorted relative prices of paddy and pulses, which in this case operates through the MSP. Free (or underpriced) water for irrigation, coupled with a guaranteed MSP for paddy and wheat, incentivizes farmers to overproduce these crops. India's water exports rapidly increased around 1990, coinciding with sharp increases in the MSPs for paddy and wheat (Goswami and Nishad 2015). If prices were to reflect market demand and incorporate the social externalities of water, India's trade pattern in food commodities would reflect the relative scarcities of its natural endowments. If we look at China, for example, which is also a water-scarce country, major imports

5. The water footprint (water required for production) is much higher for pulses (5,354 m^3 per ton) than paddy (~3,000 m^3 per ton). But much of this water is recoverable. In addition, water used for the production of pulses does not use flood irrigation (unlike rice) and comes from closer to the top soil, thereby protecting the water table. The production of pulses also helps fix nitrogen (thereby reducing the consumption of urea). More importantly, the water content in the final grain is 10.5 percent of the weight in pulses, compared to 15 percent in paddy and wheat.

are soybeans, cotton, meat, and cereal grains,[6] and exports are vegetables, fruits, and processed food.

The pernicious consequences of India's MSP policy for water sustainability and availability have been evident for a while, as water tables decline across the country. Analytically, it is important to disentangle the relative roles of MSP and free power and water on declining water tables. In principle, this could be done by comparing regions which have similar water policies but different procurement policies. However, this would require controlling for the underlying bedrock system, which is analytically difficult. Policies meant to help farmers in the short run, such as the MSP for wheat and rice, are having deeply negative long-term consequences for the same farmers, due to the shrinking availability of water. One can argue that both farmers and politicians have high discount rates and are myopic. Hence, they cannot internalize the devastating effects of the MSP in the long run and consequently persist with the current MSP policy. Furthermore, even if this were not the case, high switching costs (from more water-intensive crops to less water-intensive crops) may make them loath to advocate a change in MSP policies. But such an equilibrium persisted for many years in the case of fuel subsidies, and it was eventually addressed by incremental increases in price over a protracted period of time. Under what conditions might something similar be possible in the case of MSP policies is unclear. For instance, what political economy conditions would make it possible to implement annual increases in MSP inversely proportional to the water intensity of the crop, for example, modest increases in MSP for paddy and sugarcane, and more rapid increases in MSP for pulses and oilseeds?

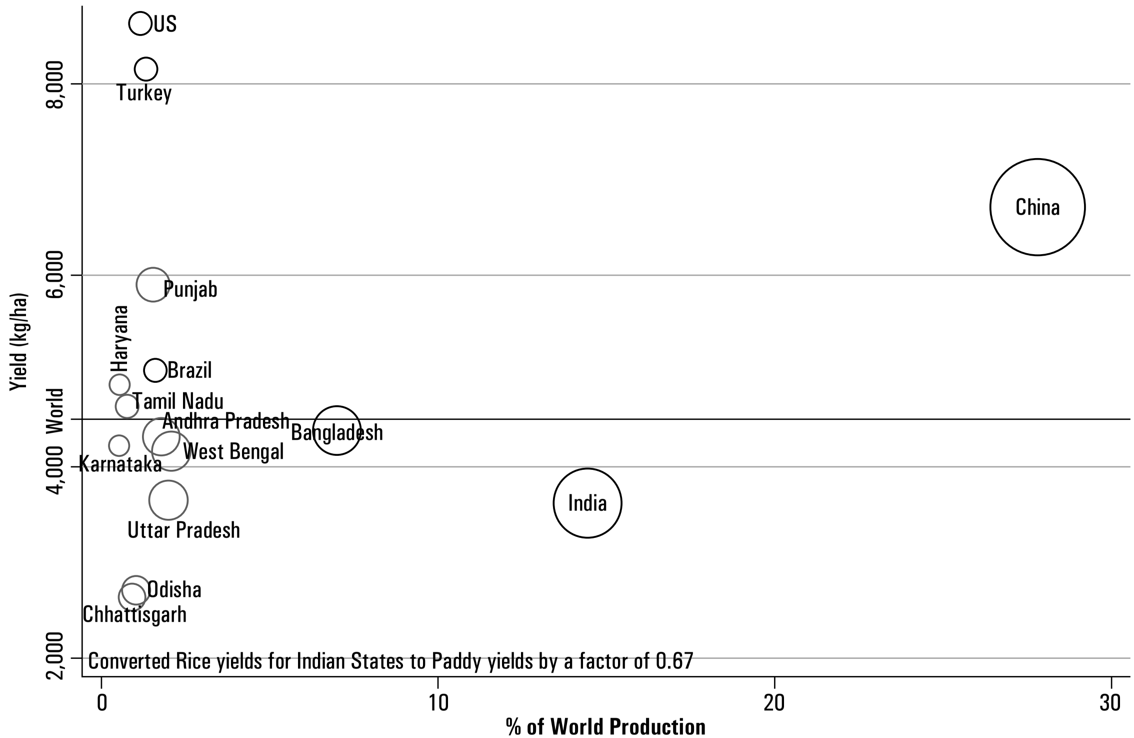
6. The Productivity Gap Puzzle

Geography, availability of natural resources, and endowment of fertile soil make Punjab, Haryana, and the flood plains of the Indo-Gangetic Plain one of the most fertile lands in the world. This can be easily seen in Figures 9 and 10. However, comparing the actual productivity of land in this belt to its own potential raises several important questions.

The Food and Agriculture Organization's (FAO's) Global Agro-Ecological Zones (GAEZ) dataset provides data on actual agricultural

6. See http://www.ers.usda.gov/media/1784488/eib136.pdf and http://www.fao.org/fileadmin/templates/est/meetings/wto_comm/Trade_policy_brief_China_final.pdf

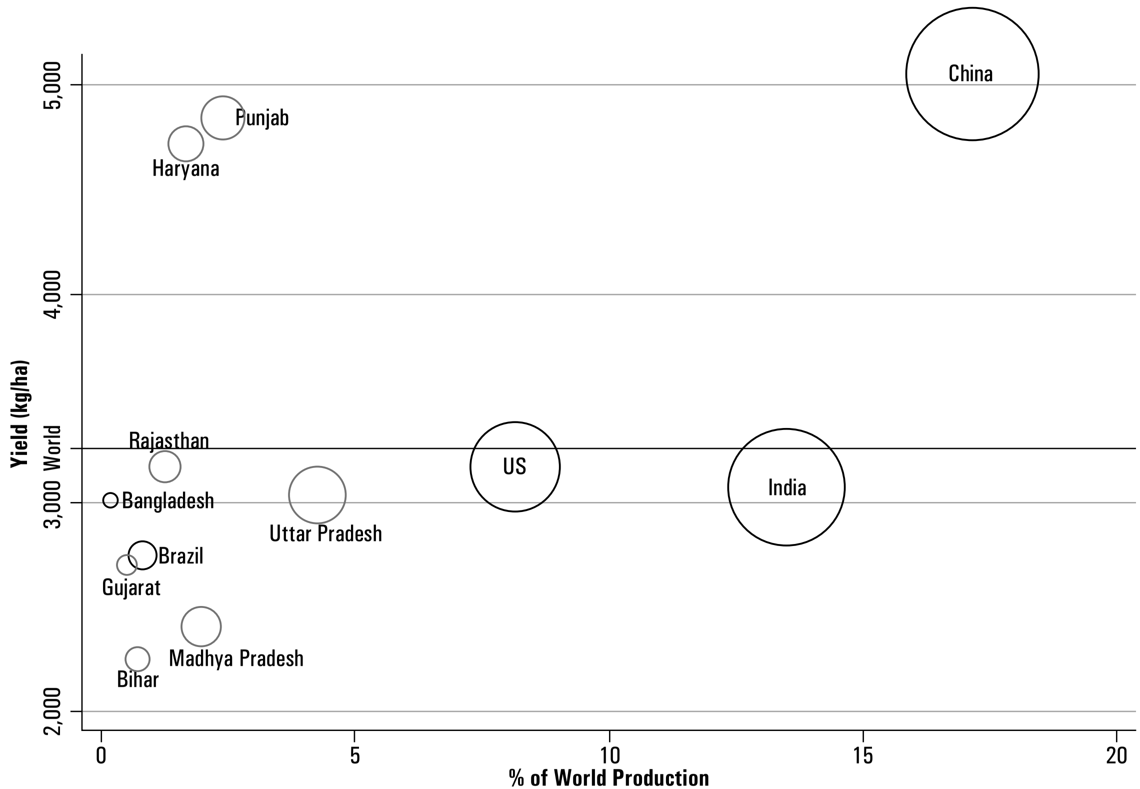
FIGURE 9. Paddy Yields in 2013–14



Sources: FAO STAT for the World and Agricultural Statistics at a Glance, 2014, GoI, for India. All estimates for 2014–15.

Note: Size of the bubble is proportional to the quantity of total production in the state/country.

FIGURE 10. Wheat Yields in 2013–14



Sources: FAO STAT for the World and Agricultural Statistics at a Glance, 2014, GoI, for India. All estimates for 2014–15.

Note: Size of the bubble is proportional to the quantity of total production in the state/country.

productivity on any piece of land as well as the potential productivity that could be realized if inputs were used optimally, conditional on the crop that is being currently grown there. The data are available for every 5 arc minute by 5 arc minute grid cell of the earth, roughly equal to 10 km by 10 km blocks.

Therefore, if a district in Punjab and another in eastern UP grow paddy, we can estimate their current and potential productivity. Since the potential productivity takes into account the crop choice and local agro-environmental conditions, the gap between actual and potential productivity should only be due to spatially specific distortions. In other words, in the absence of local distortions, all districts should produce at their true potential and there should be no difference between the actual realized and potential productivity.

From the data, however, it is clear that this is not the case. Table 8 notes the fraction of all districts (in percent) whose productivity gap is less than 10 percent, 25 percent, 50 percent, and more than 80 percent for rice, wheat, sorghum, and millet. The productivity gap is calculated as (1 – actual productivity/potential productivity) × 100: if actual productivity was equal to potential productivity, the gap would be zero. The larger the number for the fraction of districts in the < 10 percent productivity gap column, the more India's districts are closer to their true potential for that particular crop.

There are about 27 percent paddy-producing districts and 39 percent wheat-producing districts where the productivity gap is less than 25 percent. Similarly, about 5 percent paddy-producing districts and 6 percent wheat-producing districts have a productivity gap of more than 80 percent. These are the districts with the potential for the largest gains because they are so below their potential. Comparing across crops, whereas in paddy and wheat about 18 percent and 32 percent, respectively, of all districts operate within 10 percent of their potential, this number is starkly low for sorghum (4.2 percent), a dryland crop.

TABLE 8. Distribution of the Agricultural Productivity Gap of Indian Districts

	< 10%	*< 25%*	*< 50%*	*> 80%*
Rice	18.5%	27.3%	62.6%	5.1%
Wheat	31.9%	38.6%	80.9%	5.7%
Sorghum	4.2%	5.0%	6.7%	79.5%
Millet	30.5%	31.5%	34.4%	2.9%

Source: FAO Global Agro-Ecological Zones Database.

Notes: % of districts within × % of their potential.

Productivity gap = (1 – actual productivity/potential productivity) × 100.

What is probably happening is that Punjab, Haryana, and parts of UP are operating close to their potential, and these are the regions that dominate paddy and wheat production and have also been seen to optimize their productivity potential. In other parts of the country, farms are operating far from their productivity potential and there is substantial scope for improvement through better resource allocation alone.

The evidence also strongly suggests that the use of inputs is distorted. Table 9 provides evidence on inter-state variation in the use of nitrogen, phosphorus, and potash per hectare. The proportions in which the fertilizers are used are also skewed. A lower absolute consumption does not necessarily imply that fertilizer use is sub-optimal. The proportions also need to be balanced. While the correct proportions are context-specific, measuring deviations from the accepted rule of thumb of N:P:K in the ratio of 4:2:1 is revealing.

Table 9 also presents deviations from the optimal N:P and N:K ratios (with respect to N). It is clear that fertilizer use is disproportionately tilted toward the use of urea (the principal source of N) as compared to other fertilizers. These distortions—more in N:K than N:P, indicating extremely low application of potash—are significantly higher as compared to those in China, Bangladesh, Vietnam, and Thailand.

Most states use almost twice the amount of nitrogen as compared to phosphorus than they should using the rule of thumb. These include the most productive states such as Punjab, Haryana, UP, and Gujarat. The distortions are less in Maharashtra, Karnataka, and Kerala, which consume close to the optimal ratio, although this could simply be the result of different crop mixes. The overuse of urea as compared to potash is even more perverse. Relative to the accepted rule of thumb, Bangladesh uses only 4 percent more urea than potash, whereas Indian states such as Punjab and Haryana use over 1,300 percent more urea as compared to potash.

Understanding the reason for such large distortions in fertilizer use is important not only because of their impact on current productivity but also because of their impact on future productivity due to their long-term effects on soil health. While the structure of fertilizer subsidies might be the obvious suspect, the fact is that fertilizer subsidies are a national policy, and prices are broadly similar across the country. While variances in fertilizer inputs may be due to varying agricultural production functions, we do not have careful estimates to see if this is the case. It is also important to note that the productivity gap across space is at least in part due to differences in the intensity of use of inputs, but further work is needed to understand why that is the case.

TABLE 9. Fertilizer Consumption and Distortion in Use of Urea (N), Phosphorus (P), and Potash (K), 2014

	Nitrogen (N)(kg/ha)	*Phosphorous (P)(kg/ha)*	*Potash (K) (kg/ha)*	*Total*	*N:P Distortion*	*N:K Distortion*
Delhi	93.33	0	0	93.33		
Nagaland	2.26	1.48	0.72	4.45	–47%	–22%
Mizoram	30.31	2.37	2.99	35.67	1079%	153%
Meghalaya	10.35	3.07	0.8	14.22	137%	223%
Manipur	22.66	3.75	3.18	29.59	404%	78%
Himachal Pradesh	35.03	8.69	9.03	52.74	203%	–3%
Assam	36.24	9.99	19.19	65.41	163%	–53%
Rajasthan	37.97	11.51	0.21	49.69	130%	4420%
Jharkhand	65.72	13.79	2.94	82.45	277%	459%
Thailand	68.4	19.2	22.5	110.2	156%	–24%
Uttarakhand	118.89	19.24	5.67	143.8	418%	424%
Tripura	28.73	21.27	11.73	61.73	–65%	–39%
J&K	57.83	21.87	9.37	89.07	64%	54%
Odisha	63.05	23.71	11.37	98.13	66%	39%
Gujarat	88.52	24.09	6.92	119.52	167%	220%
The United States	74.1	24.8	26.7	125.6	99%	–31%
World	69.5	26.3	17.9	113.7	64%	–3%
Kerala	51.06	26.42	43.55	121.03	–7%	–71%
Bihar	124.88	27.44	12.55	164.87	255%	149%
West Bengal	74.09	28.11	28.97	131.17	64%	–36%
Madhya Pradesh	53.76	28.17	2.5	84.43	–9%	438%
Chhattisgarh	63.08	28.72	8.43	100.22	20%	87%
India	85.79	28.85	10.75	125.39	97%	100%
Uttar Pradesh	115.18	29.63	4.06	148.86	189%	609%
Haryana	146.49	30.58	2.41	179.48	279%	1420%
Tamil Nadu	93.27	33.47	27.03	153.76	79%	–14%
Maharashtra	72.41	35.29	19.37	127.07	5%	–7%
Karnataka	78.37	36.67	21.01	136.06	14%	–7%
Punjab	172.55	41.14	3.04	216.73	219%	1319%
Brazil	42.6	48.8	56.1	147.5	–113%	–81%
Bangladesh	140.7	53.9	33.9	228.5	61%	4%
Andhra Pradesh	153.55	54.32	18.85	226.72	83%	104%
Vietnam	127.5	66.7	43.1	237.3	–9%	–26%
China	267.6	91	41.2	399.8	94%	62%

Source: Agricultural Statistics at a Glance, 2014, Ministry of Agriculture, Government of India.
Note: Distortion is relative to rule of thumb of using N:P:K in the ratios of 4:2:1.

7. The Exit Puzzle

Adamopoulos and Restuccia (2014) document that the typical farm size in the 20 richest countries is 34 times greater than that in the 20 poorest countries. The average farm size in rich countries is 54 hectares, while in poor countries, it is only 1.6 hectares. The median farm size in India is

1.5 hectares, while the mean is much lower. Diego Restuccia, in a series of papers with different co-authors, has estimated the gains of approximately 3 to 4 times in productivity if land is reallocated to the most productive farmers in developing counties such as Malawi, Ethiopia, and China.[7]

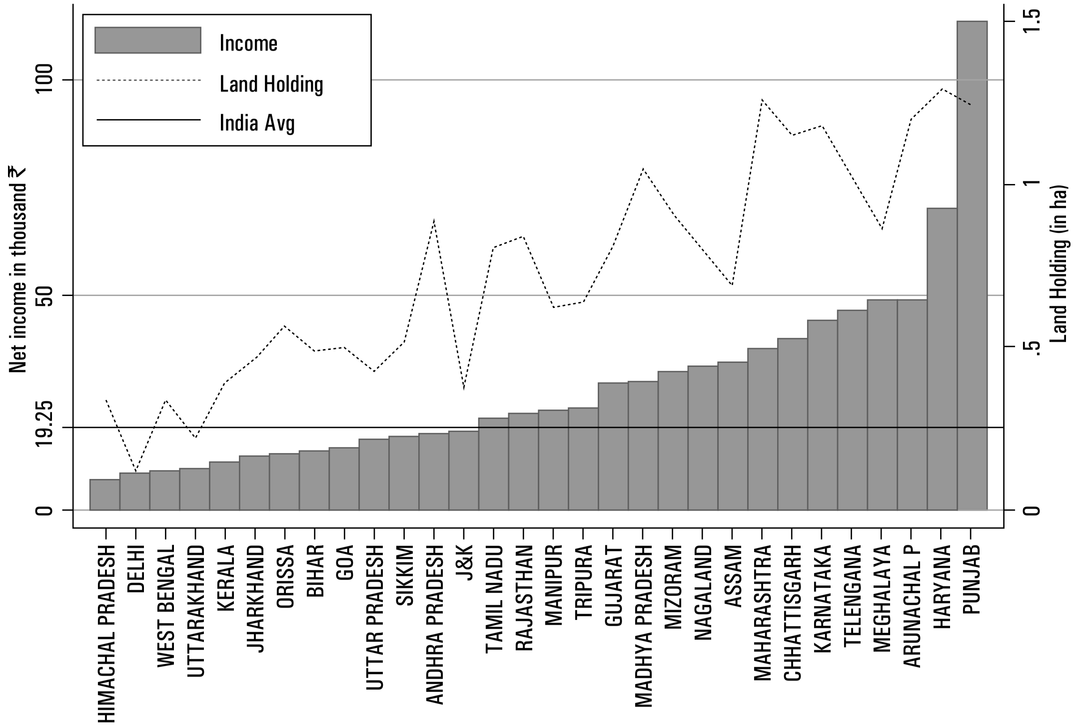
A critical reason for the underlying misallocation of land is distortions in land markets. Agricultural land in India is a peculiar asset. Its rental value for farming purposes (a proxy for farming income that may be derived from it) is a fraction of a risk-free stream of income that would accrue from its sale (that is, its capital value), which in turn is a fraction of the price if it is converted to non-agricultural land (for commercial use) if in proximity to an urban area. Yet farmers are reluctant to sell their land. Understanding the effects of these distortions in land markets on agriculture productivity and the reasons why farmers seem reluctant to follow economic logic are two fruitful areas for further research.

There are several potential reasons why agriculturalists may not be exiting farming. First, there might be high opportunity costs of exiting. Figure 11 shows that this is not likely to be the case. Our analysis of NSS data suggests that the average annual income from cultivation of the median farmer (net of production costs) is less than ₹20,000 in 17 states. This includes produce that farmers did not sell valued at local market prices. Given the large wedge between retail and farm gate price, this might underestimate income, but it is still very low. Some farmers who own cattle, for example, might substitute this income with allied-agriculture income. Even then, a vast majority of farmers live very close to the poverty line.

A second—and perhaps key—factor may be the paucity of other livelihood options. India's failure to industrialize has meant that the classic ladder of occupational mobility—from farms to factories, as has been the case with China—has been foreclosed, leaving low-end service jobs in severe urban environments or modest self-employment opportunities as the only options facing someone who exits farming. With 72 percent of India's farms below 1 hectare, the investment required to increase productivity in these tiny farms is unlikely to be readily forthcoming. Exit would allow for land consolidation, and increases in farm size would, in turn, allow for more investments and productivity. But that requires the sort of labor-intensive manufacturing growth that has simply not been taking place. Research on rural–urban linkages in factor and product markets is needed to improve our understanding of its effects on farm productivity.

7. For a comprehensive survey, see Restuccia (2016).

FIGURE 11. Net Annual Income for Indian Farmers in 2012–13



Source: Data from NSS SAS Round 70.

Notes: Sample restricted to households surveyed in both Rabi and Kharif. Income only from cultivation net of costs. Unsold produce valued at local market rate.

8. Conclusion and Directions for Future Research

Sectoral policies need to draw on research that is generalizable and offers feasible policy options. Even if the research is micro, it is imperative that we uncover mechanisms that are more general, at least if the goal is to help formulate national level policies. Although the random and quasi-random experimental literature has been insightful, it has its limitations for policy counterfactuals when formulating sector-level policies owing to external validity, general equilibrium effects, and other statistical challenges (Cartwright 2007; Deaton 2010; Deaton and Cartwright 2016; Monte, Redding, and Rossi-Hansberg 2015; Redding and Rossi-Hansberg 2016). Here we illustrate this point with specific examples.

The literature analyzing the effects of information provision has mostly relied on randomization and quasi-randomization techniques and remains inconclusive (Fafchamps and Minten 2012; Goyal 2010; Mitra et al. 2015). First, it is unclear whether the literature suggests traders are already offering competitive prices conditional on trade costs, or whether farmers are unable to utilize this information to improve their bargaining position. Second, the provision of price information seems to "work" in certain regions and not in others, and the literature has not reconciled what underlying factors may explain these differences. Third, we do not know what happens in general equilibrium. For example, once farmers have more information, how do traders respond? Do they exit because their margins shrink? If some traders quit, does that eventually concentrate market power further? Therefore, we do not know the macro-implications of information frictions in the Indian agriculture sector. Consequently, we need studies like Allen (2014) for the Philippines, who, through a more macro-trade approach, found that half of the price dispersion in that country was due to information frictions. This approach, however, requires time series and regionally disaggregated data on (a) cellphone penetration and (b) time series data on efforts made by the government to relay price information to farmers. We tried to obtain this data for India from the Telecom Regulatory Authority of India but were told that this data does not exist.

We know from micro-experiments that traders in some *mandis* of western UP collude (Banerji and Meenakshi 2004, 2008). However, we do not know whether we are likely to find collusion even in other *mandis* and, if so, whether this would necessarily require a similar set of economic factors. This limits generalizability. Furthermore, even when there is collusion within a *mandi*, we do not know if other *mandis* can be a source of competition, and how spatial (distance) or other considerations (for example, transport) would affect the results. The latter channel would be particularly important because that helps us better estimate the welfare effects of new *mandi* construction. Again, this requires studying forces that have been present for some time when the economy is in equilibrium. Introducing random variation in micro-regions could lead us to false conclusions when in reality, the local economy might just be in transition. Moreover, studying spatial competition requires variation of market power in space, which is inherently a macro-problem.

As a final example, consider the policy of making India "one market." This is an important and pivotal policy that the Central Government has been trying to implement through its initiative on the National Agricultural Market. However, the policy has faced severe road blocks from states. Since agriculture is a state subject, implementation requires states to reform their respective APMC Acts. However, for various reasons, states have not been interested and instead appear intent on trying to protect the monopoly power of the *mandis*. There are three points to note here. First, even though this is a critical policy issue with huge potential benefits, there is dearth of academic research (especially in economics).[8] Second, understanding the issue requires unearthing the political economy of the *mandi* structure in the internal politics of the states. Third, general equilibrium counterfactuals that policy makers would be interested in, like changes in economic welfare due to the removal of inter-state trade barriers, require understanding the sources of monopoly power of the *mandis*, how their market power would change once border restrictions are removed and then a model to estimate welfare changes.

A notable exception in the literature is Allen and Atkin (2016). Using four decades of micro-data for the entire country, they find that the creation of highways integrated Indian districts and made farmer revenues more volatile by breaking the negative correlation between local prices and productivity shocks. Increase in farmers' revenue volatility made them switch toward crops with less risky yields. This shift in production amplified the gains from integration for farmers. We can draw many lessons (without having to worry about external validity and missing general equilibrium effects) from such research. For example, greater market integration is likely to negatively impact the production of riskier crops like pulses unless supported with insurance policies. Many more studies of this type are needed to understand the many puzzles and principal challenges facing Indian agriculture.

8. We could only find and cite news articles. As an example, see: http://indianexpress.com/article/business/business-others/farm-marketing-reforms-not-in-name-alone-2884499/ (accessed June 15, 2017).

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Comments and Discussion*

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Variations in agriculture prices impact the livelihoods of many people in India, as in other countries (Swinnen and Riera 2013). Chatterjee and Kapur employ an innovative methodology to understand these price swings. The existing literature uses structural models that show how prices are determined (see, for example, Gopakumar and Pandit 2014; Gupta 2013). This paper, for the first time, uses high frequency price and quantity data (from the AgMarknet portal of the Government of India), in contrast to the annual data used earlier. This has not been attempted to my knowledge in India, except by Dasgupta, Dubey, and Sathish (2011), and I hope others will follow. The paper tries to develop a general theory of price formation in Indian agriculture and employs advanced econometric tools to control for unobserved heterogeneity. The significance of this paper is in the innovation in the conceptual framework and methodology and the use of high frequency data.

This analysis brings forth some interesting results that can be of immense significance, though some of them can be questioned on the basis of the existing known or stylized facts. There are four key results. First, the variation in prices both within and among states is very high as compared to that in other developing countries. Second, this substantial price variation persists despite the adoption of new information and communication technologies that should have led to price signals converging during the years 2005 to 2014 being studied. This is a cause for concern. The authors have tried to show how much of the variation is due to district-fixed effects and that 39 percent of it is unexplained, which could be attributed to the time- and location-varying factors.

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Third, a counter-intuitive result is that procurement increases the price of paddy by 4 percent above minimum support price (MSP) while it reduces the price of wheat by 2 percent below MSP. Fourth, the paper finds that lack of marketing infrastructure reduces prices by as much as 5 percent. These could all be important findings against the backdrop of the government's intention to deepen the national agricultural market, but as the authors themselves note, they are also puzzling and difficult to understand. A possible answer might have to do with the much greater international trade after the easing of quantitative restrictions, forcing the Government of India since about 2006 to procure wheat at very high prices in order to build stocks. This was a factor creating a wedge between the MSP, cost of production, and therefore wholesale prices (Chand 2009; Dev and Rao 2010).

I have a wish list of variables that would be useful to consider in the modeling of agricultural price variations and the underlying conceptual framework, not that this would be easy. First, the model could control for the overall growth momentum of the economy, which several studies have argued is percolating to the rural and agriculture sectors (Sharma and Rodgers 2015; World Bank 2014). The NSS data also show the growth of rural non-farm opportunities and the diversification of farm incomes. Second, issues such as lagged incomes, production lags, prices of substitute commodities, productivity differences, may all need to be examined in explaining price formation. As the Economic Surveys have pointed out, variation in taxes across states may also have an important bearing on prices, particularly if they are acting as barriers to free trade.

Third, as soon as agricultural prices rise, the government's first reaction is to ban future markets (Chand 2016). Although the Abhijit Sen Committee found that future markets have no significant impact on agricultural prices, several studies, including Dasgupta, Dubey, and Sathish (2011), suggest that there is a large impact. Fourth, while *mandis* do exist, many offer hardly any physical or marketing facilities. Do price variations have anything to do with this or with the level of regulation? Purohit (2016) recently came up with an index of regulation on which states were ranked. These issues should be looked at in explaining price variations.

States like Chhattisgarh are pursuing a "procurement plus" approach, giving crop-specific bonuses beyond the MSP. What is its impact on price variation and the prices farmers are getting? Market and monopsony power may not merely arise across states but is also seen within states as farmers are not allowed to sell in nearby *mandis* if they are in adjoining states or have to incur a cost even if allowed to sell. As a recent *Economic Survey* of the government points out, there are 2,200 agriculture markets in India; Europe effectively has one market.

Examining the impact of private sector participation and its scaling up on price variation would be very useful for policy. I would also suggest the authors going beyond the exclusive focus on paddy and wheat and considering price formation in other crops, such as vegetables and fruits. Before ending, it is worth mentioning that the geographical concentration of procurement centers is not a puzzle and can be explained by the manner in which the Green Revolution unfolded in India.

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The paper by Shoumitro Chatterjee and Devesh Kapur analyzes the spatial variation in the prices of wholesale rice and wheat at the first point of farmer sale, the primary wholesale markets called *mandis*, and focuses on two important government interventions, the minimum support price (MSP) at which the government procures, and the regulation and physical location of *mandis* and their influence on price formation. The paper uses high frequency data available on the Government of India's AgMarknet portal which provides data on weekly and monthly prices and market arrivals by commodity across all Agricultural Produce Market Committees (APMCs). Since the authors mention that it is work in progress, I will suggest a few important analytical issues to be considered while revising the paper.

Let me start with some data issues and problems in the descriptive analysis of the impact of government procurement on prices and in seeing APMCs that run the *mandis* as local monopsonies.

The authors have selected wholesale rice and wheat markets in 16 major states for their analysis. It is not clear why they have selected these 16 states as not all of them produce rice and wheat, so that in some states there would be limited or no government procurement operations. This could be a factor in the contradictory regression analysis results they get for rice and wheat. Some criteria should have been adopted in selecting states that would adequately capture government interventions in procurement and MSP, and thereafter help in analyzing the impact of market location on wholesale prices. A combination of factors such as the level of production, marketable surplus, and procurement should have been used as the key factors in selecting states.

Why is the selection of states important for addressing the research issues raised in this paper? In the case of rice, 10 states—Andhra Pradesh, Punjab, Chhattisgarh, Odisha, Haryana, West Bengal, Uttar Pradesh, Bihar, Tamil Nadu, and Karnataka—accounted for about 86 percent of India's

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rice production (Government of India 2016). However, the first five states taken together account for about 80 percent of rice procurement. This will influence the overall results from the sample. Some states in the sample may not even have participated in government rice procurement. Furthermore, even in states where rice procurement takes place, the procurement is not necessarily evenly distributed across all districts and *mandis*. This is because marketable surplus and consumption patterns vary across regions and also within states (Government of India 2016). In the case of wheat, 90 per cent of the production comes from six states—Punjab, Madhya Pradesh, Haryana, Uttar Pradesh, Rajasthan, and Bihar. The first three states account for 91 percent of procurement (Government of India 2016).

These figures imply that procurement taken as a dummy variable in the regression model at the district level will have few ones and many zeroes. This may be the reason why the regression model gives contradictory results for rice and wheat. Local production patterns, marketable surplus, and consumption will affect price formation at the *mandi* level. Production may be high in some places but the entire quantity may not reach the market because local consumption might be very high. For instance, West Bengal is the highest rice-producing state, but its marketable surplus is low (Government of India 2016), and hence the arrival of food grains in the market is an important measure to be considered in thinking about what influences local price formation.

The paper uses an interesting equation to analyze the differential effect of government procurement on market prices. It hypothesizes that procurement operations create a wedge between farm gate, *mandi*, and retail prices. Procurement is a dummy variable, which shows the presence or absence of procurement. Unfortunately, the regression model provides inconsistent results; the coefficient of procurement is positive and significant for rice, while it is negative and significant for wheat. Problems in the data and possible omitted variables may be responsible for this inconsistency. It may be useful to measure the procurement variable in a quantitative form with procurement measured as a ratio of market arrivals, which could have been a better explanatory variable.

The location of *mandis* relative to nearby villages can be important. By design, APMC *mandis* are generally located near *tehsil* (district) headquarters, with jurisdiction over a specific number of villages or a specific geographical area. The AgMarknet portal does not provide complete information about the geographical coverage of *mandis*. So it is not clear how the authors have geocoded villages with *mandis*. It is important to let the readers know this because geocoded villages have been used for the subsequent analysis to understand the degree of competition and the price variation within markets and between markets in neighboring states. Further, it would be useful to provide the number of rice and wheat markets covered across the 16 states in the study. The characteristics of the states and markets selected for analysis will certainly influence the results considerably. In fact, studies have shown that wholesale markets for rice and wheat are integrated to some extent within the states, while integration between regions is not very significant (Acharya et al. 2012; Jha, Bhanu Murthy, and Sharma 2005).

Many studies have analyzed the geographical spread of APMCs, poor infrastructure facilities, problems of marketing inefficiency, and so on (Acharya 2004). I am puzzled to see the paper mention that "the number of *mandis* grew commensurately as the Green Revolution took off, but investments in market infrastructure slackened in more recent decades even as output continued to grow." It is very hard to get investment data on agricultural markets; it is usually not available, and there is no supporting citation in the paper.

The AgMarknet data does provide the stock of infrastructure facilities built across *mandis* and APMCs, and one can build an infrastructure index across the *mandis* and correlate it with market performance indicators such as commodity arrival, number of market participants, timely payment, and so on. Further, the effect of telecommunication technology on spatial variation in price also warrants empirical testing based on field level data.

A major contribution of this paper could be in explaining the factors that contribute to spatial variation in wholesale agricultural prices. However, the decomposition analysis in the paper does not provide many insights and it also needs to be explained in context. There are alternative analytical approaches, such as those followed by Chand (2003) and Liefert (2011), to decompose producer prices with useful results that have a lot of policy relevance.

Figure 8 shows a positive relationship between MSP awareness and procurement, while Figures 9 and 10 show a negative association between procurement and production. As I have noted, procurement need not necessarily be evenly spread across districts and *mandis*. It is quite possible that farmers are aware of the MSP in a few states because of procurement operations taking place in those states. The Food Corporation of India (FCI) has the mandate of procuring a fixed quantity of the grains for buffer stock operations. But when the prices fall below the MSP, some state governments intervene under the market intervention scheme to buy whatever quantity is offered by the farmers. It may be useful to relate procurement to the marketable surplus to understand why some districts have high procurement and others have low procurement. Marketable surplus and market arrivals are highly correlated and tend to influence procurement operations.

There is a strong political economy operating in the food grain procurement. It would be useful to analyze how farmers' lobbies in states such as Punjab and Haryana influence their state governments, who in turn put pressure on the central government to procure whatever quantity and quality the farmers would like to offer in the *mandis*. It would be interesting, for example, to examine quantitatively how the "fair average quality" specifications against which the FCI procures grain has been tweaked periodically under the influence of these state governments. Taking these considerations into account in the analysis would enrich the discussion on the political economy of grains procurement.

The functioning of APMCs has been a subject matter of intense debate in recent years for reasons such as poor service delivery, lack of adequate infrastructure, high transaction cost, and collusion among traders (Acharya 2004). With the implementation of a Model APMC Act in 2003, many states have amended their state agricultural marketing acts to facilitate greater transparency, freedom to sell outside the *mandi*, establishment of private markets, and so on. With the push toward greater liberalization of domestic markets, APMCs can no longer be considered local monopsonies. Despite the introduction of market reforms, collusion among traders continues to exist, which tends to affect the efficient price discovery in the markets (for details of the effects of collusion, see Banerji and Meenakshi 2004).

In the paper, the authors maintain that there is collusive behavior among traders within the *mandis*, but assume the absence of such collusion between the markets. With improvements in telecommunications, it is difficult to assume that the traders do not collude between markets, and a potential problem in the formulation of an econometric model to explain price variations through local market power and distance to the *mandi*. Further, dense markets need not necessarily result in better prices for farmers.

To conclude, this is a very interesting paper. However, there is much that can be done to improve its analytical approach. There is also need to discuss the policy implications of the results for the current debate on shifting away from price support to an income support policy for farmers. It would also be useful to throw light on the unified National Agriculture Market and its likely impact on farmers' income and variation in prices.

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General Discussion*

Sandip Sukhtankar asked the authors to explain their finding on variance decomposition that suggested that rainfall shocks contributed only about 4 percent to price variation, since rainfall shocks were used as an instrument for basically all kinds of regressions in India.

Rajnish Mehra asked if the formation of *mandis* was actually not endogenous, since the paper had found that every additional *mandi* led to a higher

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price: if the prices fell in some region, *mandis* would come up there and raise prices, which would then tend to limit price dispersion. Second, he said that futures markets were among the most efficient in the US, and wondered if they were actually quite efficient in India as well. Mehra pointed to the tight links between storage costs, current prices, spot prices, and futures prices, implying that arbitrage would clear markets whenever an opportunity arose. He felt that what the paper was observing had more to do with regulation and institutional factors. If there was free entry of *mandis*, and well-operating futures markets, one would still get a certain dispersion in prices. Properly anticipated prices do fluctuate randomly, and in stock markets the rule of thumb is a standard deviation in prices of about 20 percent, and a little less in bond markets, mainly to do with the arrival and processing of information.

Dilip Mookherjee first noted that procurement is endogenous, so that the paper's finding that wheat prices go down with higher procurement may simply be procurement kicking in when prices are low. So procurement itself should be a primary topic of analysis. The paper looks at spatial variation in the levels of prices, but the huge list of omitted variables—distance, storage facilities, transport costs, and so on—makes that not very credible. Much better to look at the spatial variation in price *changes* over time. Industrial organization and international finance provide nice methodologies that can help gauge market imperfections by looking at the covariation of prices across locations rather than in the level of prices. Transport costs and storage costs may still move in tandem with other factors such as oil prices, bur the level of omitted variable bias would be much less.

Second, Mookherjee noted that while the paper was focusing on spatial variation between *mandis*, his work on agriculture in West Bengal suggested that there was huge price variation within *mandis*. And if one was interested in the prices farmers got, then his work had revealed that the farm gate price was less than half the *mandi* price, and only about 20 percent of this gap was accounted for by transportation and storage costs. The rest was margins going to traders who buy from farmers and sell in the *mandi*s. When you look at the pass through, *mandi* prices co-vary very closely with retail prices, but farm gate prices do not. Hence, the real imperfections seem to be within the *mandis*, rather than between *mandis*.

Third, while Mookherjee agreed that competition is a key issue for APMCs, going into questions—such as the desirable number of *mandis* and competition between them—raised in the paper entail very complicated cost-benefit analysis since we know so little about the cost of creating markets. What would be much easier to do would be to focus on regulation and competition within *mandis*: for example, who has access to the *mandis*? He cited the very interesting ethnographies that Mekhala Krishnamurthy and Jeffrey Witsoe had done that showed the differences between Madhya Pradesh and Bihar, and the role that politics played in the working of *mandis*. He felt therefore that more work needed to be done on the politics of procurement.

Karthik Muralidharan commented that researchers can write two types of papers: a "dependent variable" paper, where the authors discuss a left-hand-side variable they care about and just document the facts and evidence about outcomes in that variable, without making any causal claims. Or they could write a "right-hand-side variable" paper and pin down the identification of one causal factor, even if it cannot explain much of the variation. Currently, the paper was struggling between the two types, and ending up not doing either satisfactorily. The paper could perhaps be more of the first kind, an agenda-setting paper for research, as opposed to one seeking to answer questions about causality, where it runs into a lot of problems with omitted variables. Since the authors have chosen price variation as a theme, they could concentrate on documenting the facts about this, including variation within states, within districts, and within other tiers for which data exists. The paper could then set out proximate right-hand-side variables that might help explain the price variations at different levels, and provide a road map for future research.

Mekhala Krishnamurthy said that there was no question about private sector buyers entering into the markets since they have been there for a very long time. Everybody in the *mandi* is a private actor, except for the government that is procuring. From her ethnographic work, she reported that it does not help the analysis if we think of the private sector as only corporate commercial entities buying outside *mandis*, because large corporates like ITC or Cargill are wherever they choose to be, buying directly from farmers through commission agents with a license, entering *mandis*, using their own single market yards, and entering the futures market. They employ diversified buying strategies. So thinking of them as suddenly entering a market is a bit of a misunderstanding of these markets.

Again, based on her work in Madhya Pradesh and Chhattisgarh, Krishnamurthy pointed to the interesting temporal and seasonal variation in prices for crops that the government procures, and for others that it doesn't, and how competition between *mandis* comes in. The government bought wheat in Madhya Pradesh and Chhattisgarh only in the immediate post-harvest season, and at topped-up bonus prices. This affected prices in the off-season. In the market procurement season, all the *mandis* bought at about the same price, but in the off season, when there was no procurement effect, prices varied. Competition between *mandis* became much more important in the off season, with *mandis* with greater access to flour mills offering higher prices due to the higher offtake than the other *mandis*. In sharp contrast to wheat, in soybean, where there was no government procurement, farmers staggered their sales across the year, effectively hedging for higher prices. There are also interesting instances of possible natural experiments when *mandis* switch licensing or auctioning procedures that could be used to study how competition works: she cited the example of the Gulbarga *mandi*.

Karthik Muralidharan followed up by noting that this showed how important it was to understand the behavior of intermediaries because most of the farmers were not directly selling to the *mandis*.

Indira Rajaraman asked a question about how the authors had dealt with spatial variation in *mandi* fees and taxes, since these revenues don't accrue to the consolidated fund but are supposed to be used locally for improving market infrastructure.

Rohini Somanathan referred to a 1971 paper by the British historian E. T. Thomson, called "The Moral Economy of the Crowd in the 18th Century", which talks about a period when people were protesting the rapid rise in grain prices in England. This was because not enough grain was coming on to the markets due to the signing of forward contracts for grain exports to America with farmers selling the grain before it was harvested. Thomson's paper talked about people blocking grain wagons and forcing sales in the spot market in protest against the violation of laws that stipulated the bringing of all produce to the market after harvest. All this suggested how important it was to model the choice set of the farmer and the different actors involved. But given how complex that could be, it would be hard to come up with a causal story. Rather than looking for causality, she suggested simpler approaches looking at prices and quantities, so that if both were going down then it was a demand effect, and if only prices were going down then it was a supply effect. Using such simpler approaches would still lead to a very provocative paper, even if it did not address causality.

Rajesh Chadha noted that state governments impose different levies on rice, and asked if this had been taken into consideration in looking at price variations. In recent years, in some states procurement had been decentralized to state agencies, with FCI buying from these agencies. He wondered if this had been taken into account in looking at price variation.

The Chair Ramesh Chand concluded by congratulating both authors for taking the research on agriculture marketing in India to a higher level since most other studies were largely descriptive and not analytical, and they did not use quantitative techniques. However, in light of the points made by discussants and participants he suggested using different data sets since the AgMarknet data may not be entirely appropriate. The key question in the paper, as he saw it, was whether government procurement prevented the market price from falling below MSP, i.e., what was the impact of procurement on price variations. The troubling aspect of the paper was that it seemed not to matter for wheat, but mattered for rice. He suggested looking at surplus markets (with procurement) and deficit markets (with little procurement) separately, with procurement keeping prices at MSP only in surplus areas. Wheat prices in the harvest season in the deficit districts of Maharashtra invariably did not fall below MSP even in the months of April and May but they did fall below MSP in Uttar Pradesh. Therefore, procurement affected prices only in surplus districts and not in deficit districts.

Second, Chand emphasized that procurement mattered for prices only in the harvest season. During the lean season, prices were generally half the MSP; otherwise arbitrage would not take place. If after the harvest grain was bought from Punjab and Haryana, market charges would be 14 percent, plus loading and unloading and transport charges, so that there would be a price spread. He referred to a 2003 study by the National Centre for Agricultural Economics and Policy Research that had nicely calculated the normal price spread between a surplus state and a deficit state over all the 12 months of the year by taking into account transportation costs, marketing costs, and normal profit margins for intermediaries.

Chand suggested the use of the farm harvest price rather than the market price when comparing with MSP. Farm harvest prices were available district-wise for major production areas and referred to a particular period, not all the months of a year. Using market prices could be misleading. The market price spread for wheat could be much higher in Punjab than in a deficit state since lean season prices in the latter would in any case be generally higher.

He pointed to a large number of studies, many by Raghavendra Jha, on India's agriculture markets, and Jha's conclusion that wholesale markets were integrated across India and had developed to a point that precluded the need for government intervention.

Finally, Chand advised extreme caution in the use of NSSO data for situation assessments, rich and reliable as the data was for household consumption expenditures and employment. For instance, the NSSO data quoted in Table 1 in the paper suggested that the highest figures for the percentage of wheat and paddy sold by farmers to government agencies was somewhere between the numbers for small and large agricultural holdings of 11 percent and 4 percent, respectively. But, it is a well-known fact that at least 30 percent of paddy and 35 percent of wheat was procured by the government. This clearly highlighted the serious limitations with NSSO data, which is why he felt the authors needed to utilize data from other sources.