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Modelling Indian Wheat and Rice Sector Policies

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List of Abbreviations

AAY	Antyodaya Anna Yojana Programme (Poorest of the Poor)
APL	Above Poverty Line
BPL	Below Poverty Line
CIP	Central Issue Price
DAC	Department of Agriculture & Cooperation
DFPD	Department of Food and Public Distribution
FCI	Food Corporation of India
GoI	Government of India
MIP	Minimum Issue Price
MOSPI	Ministry of Consumer Affairs, Food and Public Distribution
MSP	Minimum Support Price
NFSA	National Food Security Act
NSS	National Sample Survey
OMSS or OMSS (D)	Open Market Sale Scheme
OWS	Other Welfare Schemes
PDS	Public Distribution System
RBI	Reserve Bank of India
TPDS	Targeted Public Distribution System
WPI	Wholesale Price Index

Acknowledgements

Abstract

This paper serves to disentangle the complex system of Indian food policies related to wheat and rice procurement, storage, distribution and trade. Using nationally aggregated time series data, these policies are econometrically analysed. Based on the estimation results, their market implications are assessed. Eventually, different scenarios, including the implementation of the National Food Security Act, are simulated with respect to fiscal costs and public stocks.

Executive summary

The study revealed the strong impact of policy measures on production, procurement, stocks and trade. We detected several market distortions and mounting fiscal costs.

Wheat and rice supply strongly and significantly respond to the minimum support price (MSP). Wholesale prices at planting or lagged harvest time prices are largely irrelevant for production. The Food Corporation of India's (FCI's) procurement volume is driven by the production level and the difference between the MSP and market price. The signs of the estimated price elasticities of demand are consistent with the theory; however, for rice they turned out to be insignificant. Rice consumption turned out to be strongly influenced by distribution of subsidised rice, which can be linked to high coverage and subsidy under the public distribution system (PDS). In the case of wheat, the influence of subsidised wheat is much less pronounced, probably due to weaker functioning of the PDS for this grain.

The public stock analysis suggests higher storage losses for rice (10 per cent) than for wheat (2 per cent). Public stocks are found to strongly crowd out private stocks but not to the same extent as public stocks are build up. Total exports are highly distorted by trade regulations. Therefore, there was no correlation detected between exports and domestic vs. international price difference in the case of rice and in the case of wheat, the correlation turned out to be contrary to theoretical expectations. The analysis of intra-year data revealed strong seasonality in prices, procurement and stock levels, in particular, for wheat (this was lower for rice).

Starting from 2006-07, there is a clear upward trend in inflation adjusted costs of operating the public food procurement and distribution system, mainly because of rising procurement volume and MSPs. On the other hand, revenue has declined in real terms, due to lower real central issue prices and only marginal revenue from domestic sales and exports. As a result, the food subsidy has shown an increase in real terms.

The implementation of the NFSA, 2013, will put a lot of pressure on the system – maintenance of ample stock to meet the needs of the distribution system requires increasing MSP (especially for wheat) in real terms and possibly other market interventions in case of negative production shocks. This will inevitably result in growing fiscal costs.

1. Introduction

The food market in India is characterised by a high degree of government involvement, especially in the case of the two staple cereals – rice and wheat. The overall policy comprises elements governing production, procurement, storage, distribution and trade of food grains. The simultaneous presence of the public and private forces resulted in the dual nature of the food market –with the former strongly influencing (often crowding out) the latter. What is more, the system has become very complex and difficult to understand and manage.

The government's official food subsidy bill has been rising steadily from less than 0.4 per cent in the early 1990s to around 0.8 per cent of the GDP in recent years (Figure 1). Apart from this direct cost borne by the government, there are additional costs, which arise from leakages, illegal diversion of food grains, and significant wastage due to poor storage and transport facilities[1] (Shreedhar, Gupta, Pullabhotla, Ganesh-Kumar, & Gulati, 2012). Food, fertiliser, power and irrigation subsides together accounted for 15.1 per cent of agricultural GDP in 2009-10 – up from 7.8 per cent in 1995–96 (Ganguly & Gulati, 2013). The Indian government is also actively involved in regulating international trade, e.g., by imposing selective export bans and zero import duties, which fuels international food price spikes and volatility (Anderson, Ivanic, & Martin, 2013; Anderson, 2013). In fact, this trade policy may also harm Indian farmers – the domestic price, especially of rice, has often been much lower than the international price, indicating a net taxation of Indian farmers and adding to the 'bill' of foregone benefits from trade (see also Anderson, 2013).

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[1]As computed by Swaminathan (2009), in the years 2004-2005, more than 20 per cent of rural poor were excluded from the PDS in some states (in Bihar, this number amounted to 32.1 per cent) and more than 30 per cent of the non-poor were included in the system (41.6 per cent in Andhra Pradesh). According to Government of India estimates (GoI, 2005), in 2001 about 57 per cent of subsidised grains did not reach the targeted group. Currently, estimates for leakage are close to 40 per cent (Mukherjee, 2014). This might be one of the reasons why, despite staples being highly subsidised, nutrition levels among the poor remain low and are a cause for concern (von Grebmer et al., 2013).

Figure 1 Food Subsidy as paid by the Government of India
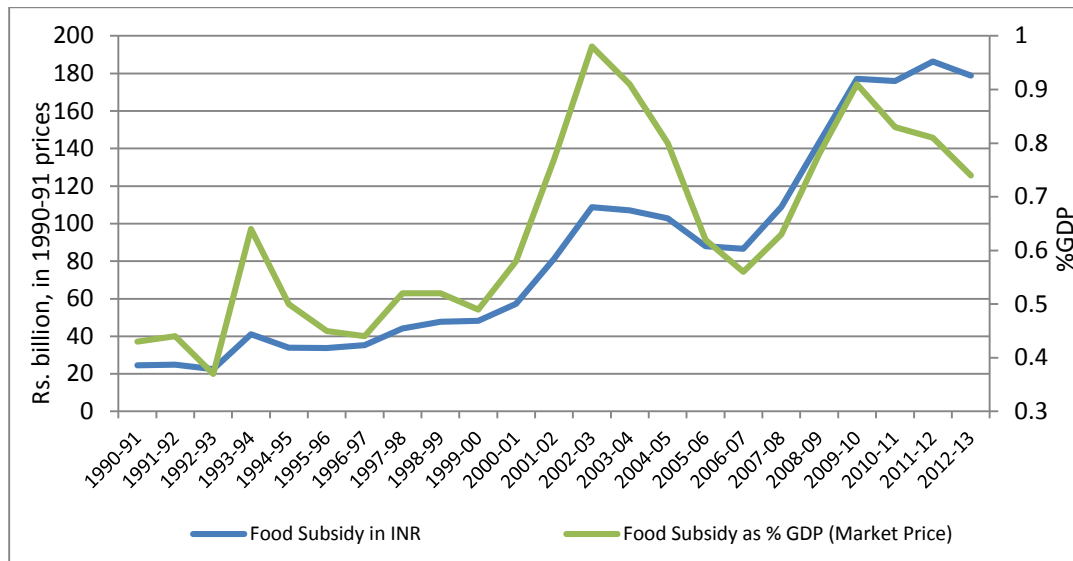
Source: Planning Commission, GoI

Note: Real values obtained by adjusting for the Wholesale Price Index (December of the corresponding year value, Dec 1990=100)

In the light of rising fiscal costs of the food system, its inefficiency and high food inflation[2], there is need to find cost-effective alternatives to the current policy measures. The assessment of costs and benefits is especially important in the wake of the all-India implementation of the National Food Security Act, 2013 (NFSA, 2013). It extends the current public distribution system by the guaranteed provision of subsidised grain to over 60 per cent of the population. This means the distribution of around 61.2 million tonnes (mt) of cereals through the existing distribution system. As a result, buffer stock norms need to be adjusted in order to feed increased distribution needs. As estimated by Gulati and Jain, (2013), the new buffer norm for rice and wheat jointly, as on July 1 each year, needs to be increased to 46.7 mt from the current to 31.9 mt. Higher stock requirements and the legal entitlement to subsidised food grains under the NFSA, 2013, mean that upward deviations from new norms are very expensive (as even fulfilling the norms results in high costs) while falling below the norms implies the risk of being unable to meet requirements under the act.

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[2] Starting from the mid-2009, food inflation accelerated in line with headline inflation and it has been fluctuating around 10 per cent (year-on-year).

There is also international pressure on India to reform its food sector because of its impact on world market prices (Mitchell, 2008). The contribution of Indian export bans on rice and wheat to the world food price spikes during the 2007-2008 world food crisis has been criticised by the international community. The recent prorogation of the implementation of the WTO Agreement on Agriculture (AoA), which limits support for farmers to 10 per cent of the value of production, is only a temporary solution and indicates the inevitable change of the political paradigm towards more a market-oriented approach (Kumar, Bagaria, & Santra, 2014).

This study attempts to unravel the major linkages between policies and markets for wheat and rice and to quantify the impact of policy on the market (and sometimes vice versa).

The policies studied are procurement, storage and distribution (with market sales and exports) policies and the major variables of interest are stock levels, market prices and fiscal costs.

2.   Literature review

An analysis of the Indian rice and wheat sector policies has not received much attention in the last years. A few studies analysed particular aspects or policies in isolation. For example, Jha et al. (2013) studied determinants of real income transfers through subsidised wheat, rice and sugar based on primary data collected in Andhra Pradesh, Maharashtra and Rajasthan. They found several inefficiencies and targeting errors of the TPDS and point at a high probability of exacerbation of these issues with introduction of the NFSA. Sharma (2012) focused on the cost of the system – the food subsidy as generated by the Food Corporation of India (FCI) after 1991. The results suggest that despite the growing cost of food subsidy, there have been improvements in the operational efficiency of the FCI. An earlier study on FCI performance by Swaminathan (1999) also found that FCI improved its efficiency[3] during the 1990s and in many states, it was more competitive[4] than the private sector. A broader policy analysis, evaluating the effects on production, productivity, accumulation of stocks, prices and exports, was conducted by Gaiha and Kulkarni (2005). This study is much more critical of governmental action. One of the findings by the authors was that agricultural subsidies hindered food grain productivity growth by constraining public investments in agriculture. They also found that minimum support prices (MSP) have a positive impact on procurement and stocks of wheat and rice. What is more, a higher MSP increases the wholesale price, which in turn leads to an increase in consumer prices. Umali-Deininger & Deininger (2001) studied a range of wheat and rice sector policies. They used aggregate and household level data to show that the system was costly and generated inefficiencies. What is more, it was not beneficial to a majority of the poor. They proposed several reform options within the current system, i.e., without any significant structural changes. An earlier study by Gulati and Sharma (1990) analysed the impact of procurement price on open market prices, procurement and output. The authors found that procurement prices are the major factor driving market prices while the procurement volume was affected by the output level and the difference between procurement and market prices.

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[3]Two indicators were used to identify operational efficiency of the FCI – the ratio of the economic cost to procurement price and the ratio of subsidy to procurement price.
[4]The economic costs of the FCI were lower than the wholesale market price.

There are several studies that have looked at the demand and supply response to price changes. Mythili (2008) used dynamic panel data model to analyse the supply response of major crops before and after the reforms of the early 1990s. The study revealed that after 1990, production response to prices (farm-gate prices were taken into consideration) has increased and that farmers are more elastic in their non-acreage inputs. Most of the food grain demand analysis in India is based on household consumption estimates based on the National Sample Survey (NSS) data, collected by the Ministry of Statistics and Programme Implementation. Kumar et al. (2011) analysed price and expenditure elasticities of demand for several goods in different income groups in India. They reported that the expenditure elasticity of cereals consumption is very high among the very poor consumers – it is on average equal to 0.5. This number decreases with an increase in income levels and turns negative for the high income group. The average income elasticity for all income groups for rice was found to be rather low at 0.024; it was 0.075 for wheat. The own price elasticities for all groups were estimated to be -0.247 for rice and -0.340 for wheat. The comprehensive study of wheat and rice demand and supply can be found in Ganesh-Kumar et al (2012). The demand model was also estimated based on the NSS data; the results indicated that the expenditure elasticity of demand for wheat and rice is negative. Production was modelled in two ways – as aggregate with the Cobb-Douglas production function and as a product of separately modelled yield and acreage. In both approaches, the ratio of own price to prices of competing crops was one of the explanatory variables.

Since food inflation has been persistently high in the last few years, there have been a few studies that analysed the cause of rising food prices in the context of food price stabilising policies. Dasgupta et al. (2011) conducted an econometric analysis of wheat price formation in India. The results suggest that the domestic price is only "moderately" affected by international prices; in addition, public stocks have virtually no impact on wheat prices in India. The authors conclude that "public stocks are rarely used effectively to stabilise wholesale market prices of wheat in India". Gulati and Saini (2013) found that the fiscal deficit, rising farm wages and international prices had a significant impact on food inflation in India.

Several simulation models have been used to analyse the impact of various policies on rice and wheat. Krishna and Chhibber (1983) built a partial equilibrium model for the wheat

sector to study the consequences of the dual price policy. The model was used to simulate output, government purchases and sales, imports, stocks and market prices of wheat under different scenarios. They showed a very high price sensitivity of wheat production and demand. The authors also found procurement responded strongly to production level changes. Schiff (1993) is another important study that examined the impact of dual pricing of wheat, rice and sugar for producers and consumers with a partial equilibrium model. He distinguished three groups of actors affected by the pricing policy – the urban rich, the urban poor and the farmers and two trade regimes – free trade and closed economy. He found that the effect of dual pricing has, under certain assumptions, a negative impact on prices and harms farmers, although it has a positive short-run impact on the urban poor. However, as the setup of Indian economy has changed a lot since the publication of these two papers, their results may not be applicable any more.

A series of more recent analysis of sector policies within the partial equilibrium model was conducted by Jha and Srinivasan (for example Jha & Srinivasan, 1999). The authors published, jointly with Landes, a report (Jha, Srinivasan, & Landes, 2007) with extensive sector analysis and policy recommendations. The authors recommended more liberal, market-oriented price policies with greater reliance on international markets.

3. Conceptual framework and methods used

The Indian government intervention in rice and wheat production starts before the planting, when the minimum support price (MSP) is announced. Grains are unboundedly procured from the farmers with the guaranteed MSP, which cover the production costs and a 'reasonable' margin for the farmers. The procured grain is stored as buffer stocks consisting of operational and strategic stocks. Grain is distributed to the poor at the heavily subsidised central issue price (CIP) through the targeted public distribution system (TPDS) and other welfare schemes (OWS). The stock norms indicate the needs of the system to meet the requirement of TPDS and OWS and to stabilise supply. Excessive stocks can be released to the market through the open market sales scheme (OMSS) or exported, with exports and imports being concessional. OMSS tenders are floated for bulk orders and/or an over-the-counter sale is executed for smaller quantities for retail traders. The minimum issue price (MIP) is set *ad hoc* for these sales. MIP, to prevent resale, is higher than the current MSP, and usually covers the acquisition cost of grains. Most of the operations are conducted by the parastatal agency, the Food Corporation of India (FCI)[5]. There are also trade regulations and private stock limitations[6] used on an *ad hoc* basis to increase domestic availability, isolate domestic prices from international prices or boost public procurement.

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[5]In case of procurement, the state governments also play an increasingly important role as the decentralised procurement scheme (further discussed in section 0) has been gaining importance.
[6]The Essential Commodities' Act, 1955, restricts the production, distribution, storage, trade and pricing of some "essential commodities", including wheat and rice. More about the evolution and critique of the Indian buffer stocking policy can be found in (Saini & Kozicka, 2014) .

Figure 2 Model Framework of the Indian Food Policy
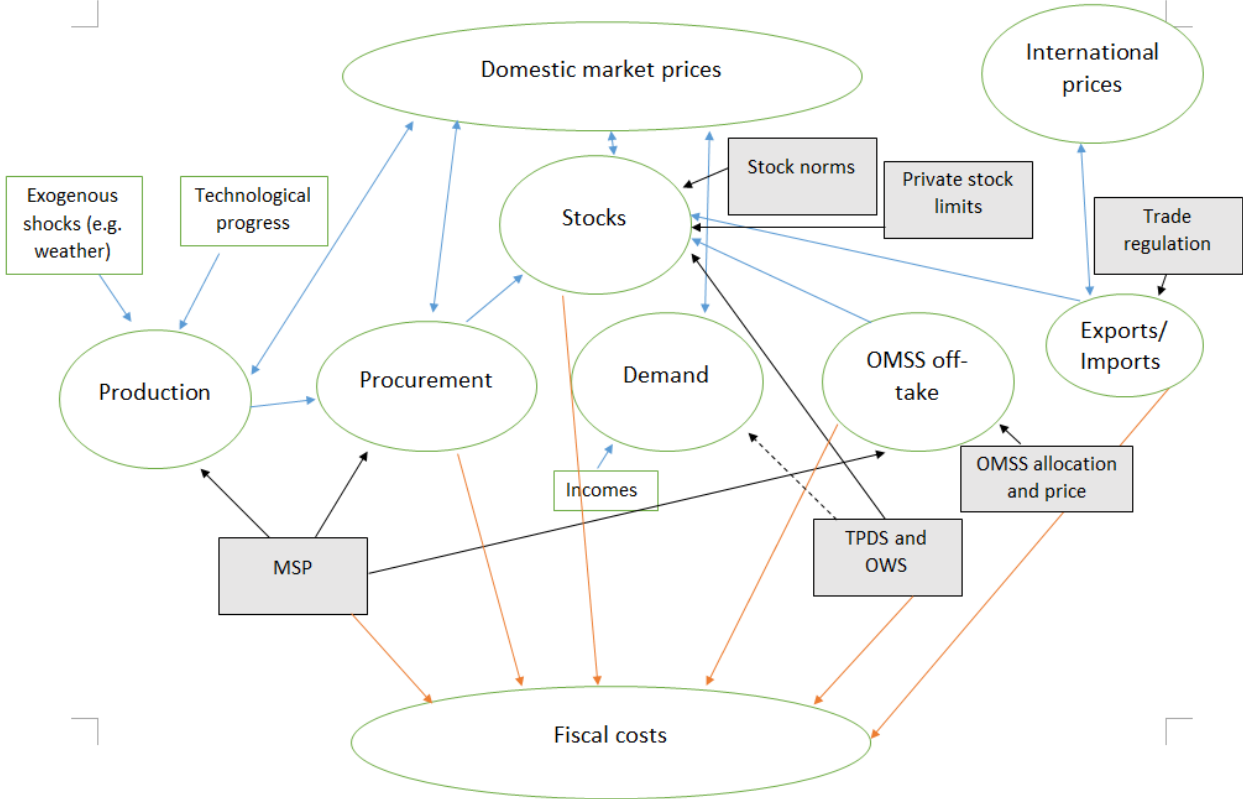
Source: Own design

Note: The oval shapes indicate the endogenous variables in the system, the rectangular shapes are restricted for the exogenous variables and the grey shaded shapes refer to policy variables. Red arrows are related to the fiscal costs, black arrows symbolise the impact of exogenous policies of interest and the remaining interactions between the variables are represented by the blue arrows.

Figure 2 shows a graphical representation of our modelling approach to the Indian wheat and rice sector. As mentioned earlier, even after the necessary simplification, the system is still very complex. The main variables of interest – prices, stocks and fiscal costs – are influenced by several endogenous and exogenous variables and directly as well as indirectly by policy measures.

The current study describes and analyses different fragments of the system to explain the endogenous components in Figure 2. As this model requires a consistent representation of

macro-variables close to Indian reality, we focus on national aggregate variables from 1982 to 2013. Hence, our basic method of analysis will be a time-series analysis of the economy-wide variables indicated as ovals in Figure 2[7].

The two-crop (wheat and rice) model, as described by equations, has the following structure:

- Production

$$\ln Q_{t,i} = \alpha_0 + \gamma \ln Q_{t-1,i} + \alpha_1 \ln p_{t,i}^{MSP} + \alpha_4 \ln t + \alpha_5 R_t + \varepsilon_{t,i},$$

where $Q_{t,i}$ is a yearly production volume of the i-th crop (wheat and rice), p_i^{MSP} is the real minimum support price, t is a trend variable, R is total yearly rainfall (in a calendar year), $\varepsilon_{t,i}$ is stochastic shock.

- Demand

$$\ln D_{t,i}^{net\ cap} = \alpha_0 + \alpha_1 \ln p_{t,i} + \alpha_2 \ln p_{t,i}^{cross} + \alpha_3 \ln PDS_{t,i}^{cap} + \alpha_4 \ln Income_t^{cap} + \alpha_5\ t,$$

where $D_{t,i}^{netcap}$ is per capita yearly consumption of the i-th crop net of consumption through the targeted public distribution system and other welfare schemes, $p_{t,i}$ is a yearly average of the own price of the i-th crop and $p_{t,i}^{cross}$ is the price average of the other crop (cross price), both in real terms. $Income_t^{cap}$ is disposable income per capita and t is a time trend. The variable $PDS_{t,i}^{cap}$ is per capita off take under the PDS.

- Procurement

$$\frac{D_{t,i}^{FCI}}{Q_{t,i}} = \alpha_0 + \alpha_1 \frac{p_{t,i}}{p_{t,i}^{MSP}} + \alpha_2 t,$$

where $D_{t,i}^{FCI}$ is the yearly procurement level of the i-th crop, $p_{t,i}$. Thus, on the left hand side of the equation, there is the share of public procurement in total production and on the right hand side, there is ratio of market price to the MSP and the trend.

- Private stocks

$$\frac{X_{t,i}^{priv}}{D_{t,i}^{trend}} = \alpha_0 + \alpha_1 \frac{S_{t,i}}{D_{t,i}^{trend}} + \alpha_2 B_{t,i} + \alpha_3 \frac{X_{t,i}}{D_{t,i}^{trend}},$$

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[7] Using cross-sectional household data would allow microeconomic analyses of a household's demand and supply dynamics. These data, however, hardly cover economic activities beyond the household level (like trade, commercial storage, processing) and are only available for very few years, which makes it difficult to assess the impact of major policy developments and temporal shocks.

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where $X_{t,i}^{priv}$ is the private stock of the i-th crop in the marketing year t, $D_{t,i}^{trend}$ is the consumption trend, $S_{t,i}$ is a total market supply calculated as $S_{t,i} = Q_{t,i} + X_{t-1,i}^{priv}$ and $B_{t,i}$ is an export ban dummy.

- Exports

$$\frac{Exp_{t,i}}{Q_{t,i}} = \alpha_0 + \alpha_2 B_{t-1,i} + \alpha_3 \frac{p_{t-1,i}}{p_{t-1,i}^{int}} + \alpha_3 t,$$

where $Exp_{t,i}$ is the total volume of export in a financial year, $B_{t-1,i}$ is a lagged export ban dummy, $\frac{p_{t-1,i}}{p_{t-1,i}^{int}}$ is a lagged price ratio – domestic wholesale to international prices converted to rupees.

- Fiscal cost

$$FC_t = \sum_i ((c_{t,i}^p + p_{t,i}^{MSP})D_{t,i}^{FCI} + c_{t,i}^d PDS_{t,i} + k_t X_{t,i} - p_{t,i}^{PDS} PDS_{t,i} - p_{t,i} OMSS_{t,i} -$$
$$p_{t,i}^{EX} NEX_{t,i}^{pub}),$$

where FC_t are yearly fiscal costs, $(c_{t,i}^p + p_{t,i}^{MSP})D_{t,i}^{FCI}$ are acquisition costs of the i-th crop, $c_{t,i}^d PDS_{t,i}$ are distribution costs, $k_t X_{t,i}$ is buffer carrying cost (where $X_{t,i}$ is the average buffer stock of wheat and rice in the central pool in the financial year) and $p_{t,i}^{PDS} PDS_{t,i} + p_{t,i} OMSS_{t,i} + p_{t,i}^{EX} NEX_{t,i}^{pub}$ are sales realisations (revenues) from sales from PDS, OMSS and net export off-take.

- Public stocks – identity equation

$$X_{t,i} = (1 - \delta_i)X_{t-1,i} + D_{t,i}^{FCI} - OMSS_{t,i} - TPDS_{t,i} - NEX_{t,i}^{pub},$$

where δ_i is the public stock deterioration rate.

The following section includes an analysis of the endogenous variables and estimation results.

4. Policies, their measures and outcomes

a. Prices

In order to understand what determines demand, supply and storage, we need to find out the prices paid to and received by different actors in the market. Regulated prices like the MSP, the MIP and the CIP are usually set by the centre and differ only slightly at the state level.[8] They, however, influence market prices due to the high level of government involvement. The market prices include wholesale prices and retail prices. Regulated and market prices can be grouped as follows: the MSP, MIP and wholesale price as producer and trader prices and CIP and retail price as consumer prices.

Market prices differ a lot (price time series from selected markets can be found in Appendix 2) due to the state specific environment (like the efficiency of procurement or state-specific bonuses to the MSP and taxes) and weak market integration (Acharya, Chand, Birthal, Kumar, & Negi, 2007; Baylis, Jolejole-Foreman, & Mallory, 2013). This is important for analysing the relationships between the variables, as production and consumption levels in different states vary significantly. But for the purpose of our analysis, which deals with all-India yearly aggregates, we need to consider a weighted price average that reflects market forces and influences the decisions of different actors.

We, therefore, use commodity-specific wholesale price indices (wheat and rice components of the wholesale price index (WPI)), which capture the overall demand and supply conditions of the food market. Its components are trade-weighted average prices, collected from many markets and it is available on a monthly basis (see Appendix 3 for data sources). Based on this monthly index, we calculate average price dynamics for different periods, corresponding with the times when our endogenous variables are determined. For example, to analyse production determinants, we used averages for harvest months, planting months and

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[8]Unfortunately, these state-level differences are difficult to track, especially in a historical perspective. For example, bonuses to the MSP are sometimes used by local governments but data on them is rarely available. Even bigger issues are the institutional differences between states – like the almost universal coverage of the TPDS in Kerala, or extremely high level of leakages in Bihar. Furthermore, the procurement efficiency of the FCI/state level procurement agencies is not uniform in all states across the country. They function relatively better in a few states (Punjab, Haryana, parts of Andhra Pradesh and in recent years, also in Chattisgarh) but are mostly ineffective in others (Bihar, Orissa, etc.). As the purpose of this study is to assess the impact of central policies on the all India aggregate outcomes, considering these state-wise differences would bring too much complexity to the analysis and the model would lack transparency.

marketing year, which are different for wheat and rice. Marketing year averages are also important for demand analysis.

The disadvantage of using the components of the WPI is that they do not provide the actual price levels, only the price dynamics. This is not an issue for the regression estimation; however, to analyse differences between regulated and open market prices, we needed to reproduce the wholesale price level. To do so, we calculated a production weighted average price of wheat and rice from major markets for the last four years. Next, using the respective WPI components, we reproduced the price levels backwards.[9] As a result, we obtained the monthly all-India wholesale price of wheat and rice. Then, for different purposes, different averages of these monthly prices were created. For production, the prices during the harvest, planting and marketing year were considered, which, in the case of rice, were weighted according to the production share in kharif and rabi seasons.[10] For consumption, the marketing year average price was used. As the representative international price, the International Monetary Fund quoted prices were used. For wheat 'No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico, US$ per metric ton' and for rice '5 per cent broken milled white rice, Thailand nominal price quote, US$ per metric ton', were used. Both were converted to rupees at the current exchange rate. In order to obtain real prices, all nominal prices are WPI deflated.

The comparison of the derived price time series is presented in Figure 3 and Figure 4. An interesting trend observed, both in the wheat and rice markets, is the narrowing gap between the MSP and wholesale prices. This came as a result of an aggressive procurement policy in response to the international price boom in 2007-08. At the same time, market prices remained stable in real terms. However, even though the gap between MSPs and the wholesale prices has narrowed, procurement prices remained clearly below market prices (with one year exception for wheat). This could suggest that MSP successfully protects the lower bound of the prices. Market price should be close to MSP at harvest in net producing states and rise with time and distance due to storage and transportation costs. However, the wholesale price used in this study is the average from different markets across India and so

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[9] The WPI components are less volatile than market prices from major grain-producing states (see Appendix 1 for comparison of price averages).
[10] Harvest months for wheat are March-May and for rice, October-December for the kharif season and March-June for the rabi season.

includes, for example, transportation costs. This is why even the harvest price has been usually well above MSP. In fact, in some states with ill-functioning procurement, the market price often drops below MSP (for example Patna prices in Appendix 2). This fact will be used in analysing procurement level determinants in subsection c.

It is also clear that domestic prices in India were successfully protected from international price fluctuations, avoiding the up and down swings in the mid-1990s and during and after the 2007-2008 food crisis. Domestic wheat prices, except for the few years when the world price spiked, were above international prices, whereas domestic rice prices for most of the time remained below international quotes. For both grains, however, the difference between the domestic and international price was high after the export ban in 2007-08. This could mean that trade policies, on the one hand, protected farmers from the international price fluctuations, but on the other, subdued domestic prices. As a result, procurement was ample, and even excessive, with relatively low MSP. However, for the Indian farmers this policy measure meant foregone benefits from trade.

Figure 3 Wheat producer prices
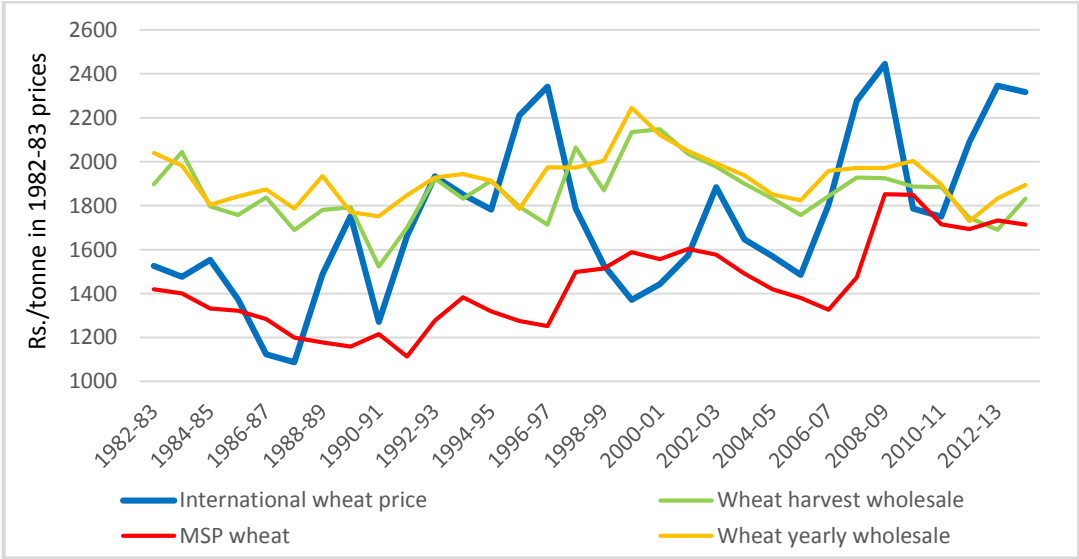
Source: Own design based on data from RBI, DFPD, DAC, IMF and FED

Figure 4 Rice producer prices
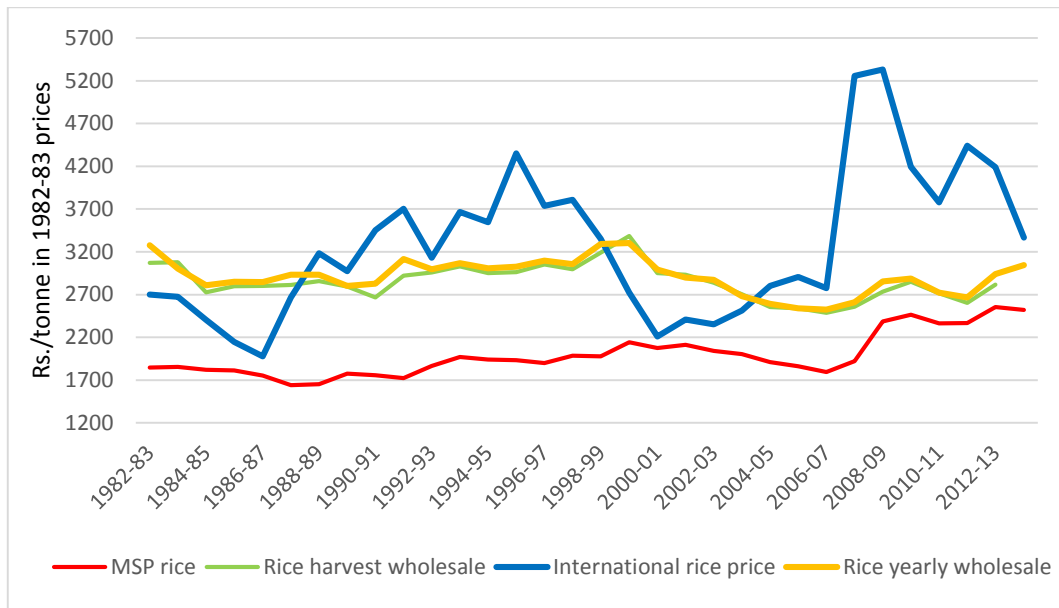
Source: Own design based on data from RBI, DFPD, DAC, IMF and FED

Note: For scaling factor, to convert paddy to rice, we used 0.66. International price is a corresponding marketing year average.

Wheat wholesale market price (both harvest time and yearly average) changes are only slightly correlated with MSP changes (Table 1). For rice, all three prices, i.e., the MSP, and the two market averages are strongly correlated, which can be attributed to better functioning institutions (more efficient procurement, less leakage) in the 'rice' states than in the 'wheat' states (Khera, 2011a, 2011b). Besides, in the case of rice, a higher share of marketed surplus is procured as compared to wheat. This means that the rice market is actually more regulated. In both cases, MSPs are positively but weakly correlated with respective international prices. This is probably because one of the factors considered for recommending the MSP by the Commission for Agricultural Costs and Prices is the international market situation (Saini & Kozicka, 2014). Domestic wholesale prices are weakly positively correlated in case of rice and weakly negatively, in case of wheat market.

Table 1 Correlation matrix of different prices for wheat and rice

	Wheat				Rice			
	MSP	Yearly wholesale	Harvest wholesale	International	MSP	Yearly wholesale	Harvest wholesale	International
MSP	1				1			
Yearly wholesale	0.36	1			0.82	1		
Harvest wholesale	0.32	0.58	1		0.79	0.94	1	
International	0.2	-0.35	-0.21	1	0.31	0.35	0.17	1

Source: Own design based on MOSPI, DAC, DFPD

Note: First differences of nominal prices from 1982 till 2013 were used

The CIP has been very low and it has changed very rarely; therefore, the actual retail price of subsidised grain differs quite significantly among states. The CIP has been kept constant in nominal terms for below poverty line (BPL) and above poverty line (APL) cardholders from July 2002 and for the group of the 'poorest of the poor' (AAY) from the beginning of 2001. As a result, the price in real terms has declined quite significantly.[11]

The dynamics of and changing relationships between prices, especially regulated and market prices, as well as our particular interest in the impact of policies on market outcomes resulted in our decision to estimate the independent system equations (presented in the section 3), rather than use a simultaneous equation model. This also allowed us to test for the relevance of price averages for different period in farmers' decision making. Endogeneity problems were solved with instrumental variables estimation techniques.

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[11] More details can be found in the subsection d.

b. Production

The government uses both input subsidies and output price support (MSP) to boost production. The MSP serves as an instrument of income stabilisation. The MSP for rice and wheat, "which along with other factors, takes into consideration the cost of various agricultural inputs and the reasonable margin for the farmers for their produce" (FCI web portal, n.d.), is announced before each of the two sowing seasons – rabi and kharif.

In 1978-79, the MSP was for the first time announced before planting time. Earlier, the procurement price used to be announced before at harvest time. This change must have strongly influenced the way the MSP shaped farmers' price expectations. This is one of the reasons we start our estimation sample in 1982.

Wheat and rice usually do not compete for area; they are produced in different regions – wheat predominantly in the north and rice in the south.[12] Wheat, as compared to rice, is more often produced by commercial farmers, whereas rice is cultivated mostly by small-scale farmers.[13] There have been higher investments and a greater proportion of irrigated acreage under wheat – the proportion of irrigated acreage has risen from 81 per cent in 1990-1991 to above 91 per cent at present. By contrast, the rise in irrigated acreage under rice has increased from 45.5 per cent to 58 per cent (DAC, Ministry of Agriculture). Hence, rice production is highly dependent on rainfall and is characterised by greater yield variability.

Public procurement plays a very important role in both sectors. Rice is procured directly from farmers in the form of paddy at the MSP (open end procurement) or from millers/traders (with obligatory levy[14] currently ranging from 30 per cent to 75 per cent depending on the state) at the 'levy' price, which is the MSP plus milling cost. Wheat is procured directly from producers at the MSP. The dominant share of the government, especially in recent years, can be traced by the procurement levels (see Figure 5 and Figure

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[12]For wheat the major competing crops are chickpea (gram), rapeseed and mustard and for rice, mostly sugarcane.

[13] Indian agriculture in general is characterised by high degree of fragmentation – 80 per cent of farms are small or marginal.

[14] This is an indirect taxation on rice millers/traders who are required to deliver rice to the government agencies at the prices derived from the minimum support price of paddy, before selling the remaining rice in the open market.

6). For both crops, the share of public procurement in total production has been close to or even above 30 per cent. But if one takes into consideration only marketed grain, the share increases to around 50 per cent, which means that about half of the grain sold by farmers go to the FCI.

Figure 5 Wheat production, marketed surplus and procurement (as part of production)
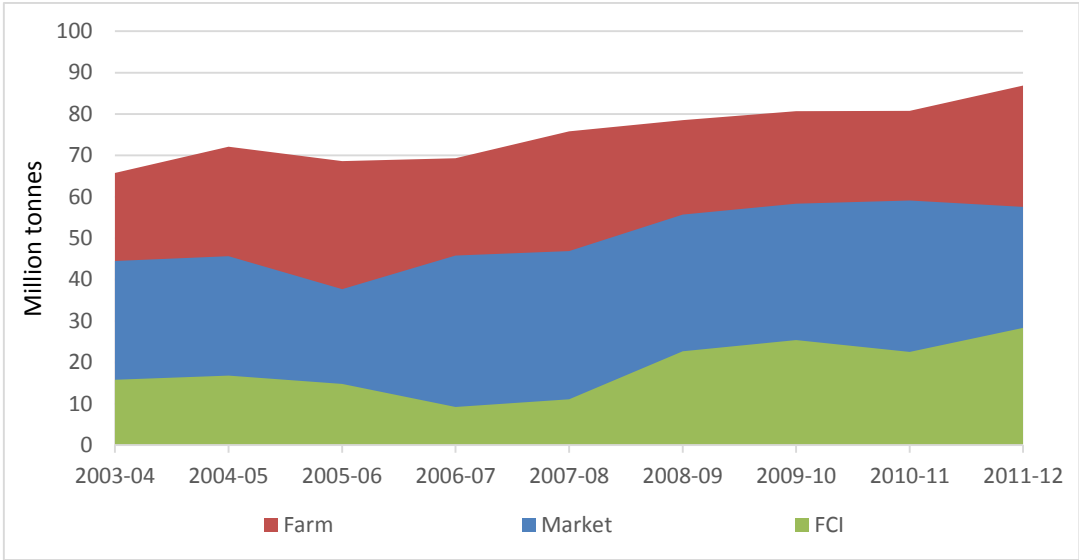
Source: Own design based on data from indiastat.com database

Figure 6 Rice production, marketed surplus and procurement (as part of production)
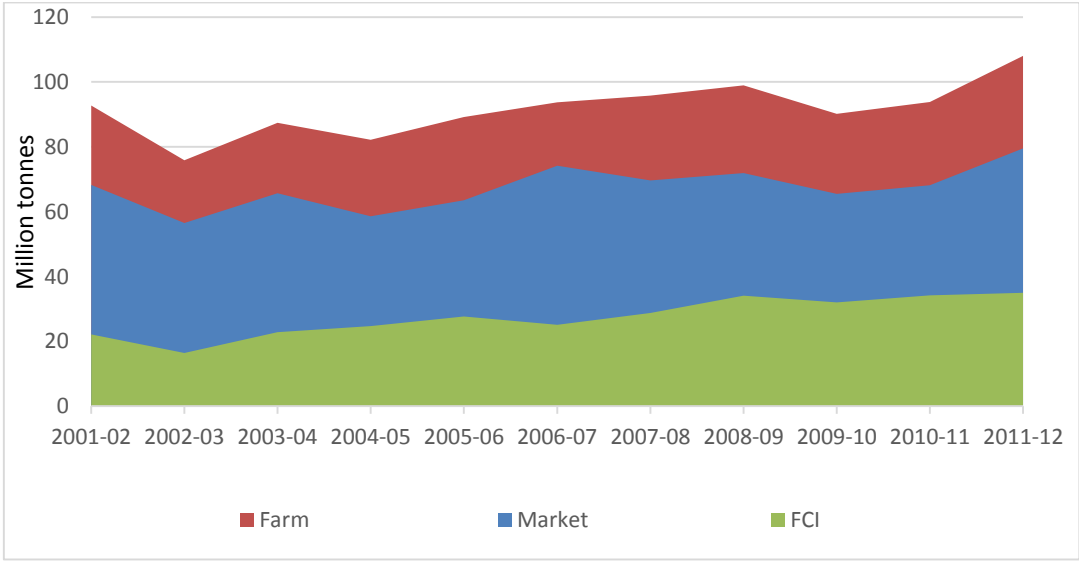
Source: Own design based on indiastat.com database

This strong governmental involvement, as will be further discussed, has serious implications for determining production: not only has the MSP the largest impact on the production level, it has also wiped out the market impact on farmer's production decisions. Agricultural inputs are heavily subsidised and their nominal prices change very rarely; hence, input prices were not included in the production regression.

The general[15] equation for describing production is given by:

1    $$\ln Q_{t,i} = \alpha_0 + \gamma \ln Q_{t-1,i} + \alpha_1 \ln p_{t,i}^{MSP} + \alpha_2 \ln p_{t,i} + \alpha_3 \ln p_{t,j} + \alpha_4 \ln t + \alpha_5 R_t + \varepsilon_{t,i},$$

where $Q_{t,i}$ is yearly production quantity of the *i*-th crop (USDA data), p_i^{MSP} is a real MSP and $p_{t,i}$ is the market price of the *i*-th crop. All prices are WPI deflated. The contemporaneous MSP is considered because farmers know the MSP before planting and there is little uncertainty related to receiving this price. As representative of the market price, lagged harvest time and planting time, as well as lagged marketing year price averages were taken into consideration. The lag structure of the market price reflects the assumption of naïve price expectation – the farmers expect the current year price to be the same as the previous year's price (harvest time and the yearly average prices) or alternatively, the price they observed at planting. Later, we econometrically test whether they really do. We also incorporated the Nerlovian (Nerlove, 1956) price expectation model with adaptive expectations by including lagged production as an explanatory variable. Besides, cross prices $p_{t,j}$ of the respective crops were used as explanatory variables – gram for wheat and maize for rice.[16] *t* is a trend variable, *R* is total yearly (calendar year) rainfall (IMD data[17]). Using the ordinary least square method and data for 1982-2012 gives the following results for different specifications:

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[15] In contrast to the equations presented in the conceptual framework, here we present the most general version of the equation, which combines all the nested specifications we estimated and discussed in tables 2 and 3. In the conceptual framework, we present only those specifications, which describe the phenomena the best according to our empirical analysis.

[16] Wheat and rice do not compete in production.

[17] http://www.imd.gov.in/

Table 2 Regressions for wheat production

	Dependent variable: log wheat production						
	1	2	3	4	5	6	7
Log MSP	0.652***				0.635***	0.474***	0.652***
	(4.14)				(3.55)	(2.78)	(4.04)
Log trend	0.228***	0.329***	0.332***	0.295***	0.230***	0.124**	0.223***
	(12.02)	(8.7)	(9.87)	(8.01)	(12.88)	(2.45)	(11.80)
Lag log rain	0.348***	0.209	0.231	0.081	0.352***	0.408***	0.340***
	(3.23)	(1.65)	(1.62)	(0.52)	(3.31)	(4.76)	(3.11)
Lag log wholesale price (yearly)		0.298					
		(0.76)					
Lag log wholesale price (harvest time)			0.221				
			(0.8)				
Lag log wholesale price (planting time)				0.344	0.101		
				(0.99)	(0.43)		
Log cross price (gram price at the time wheat is planted)							0.037
							(0.79)
Lag log wheat production						0.410*	
						(2.01)	
_cons	-0.642	0.924	0.992	1.799	-0.922	-2.008**	-0.575
	(-0.61)	(0.56)	(0.62)	(1.09)	(-0.83)	(-2.37)	(-0.54)
N	31	30	30	31	31	31	31
R²	0.95	0.9	0.9	0.89	0.95	0.96	0.95

*Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with Newey-West standard error estimation. t-values are given in brackets. Error terms are stationary according to the ADF test.*

Table 3 Regressions of rice production

	Dependent variable: log rice production						
	1	2	3	4	5	6	7
Log MSP	0.392***				0.413***	0.379**	0.364**
	(2.81)				(3.11)	(2.55)	(2.57)
Log trend	0.200***	0.253***	0.252***	0.239***	0.194***	0.187***	0.204***
	(10.25)	(9.37)	(9.47)	(9.64)	(9.9)	(6.37)	(9.60)
Lag log rain	0.498***	0.367**	0.367**	0.405**	0.501***	0.516**	0.498***
	(2.99)	(2.1)	(2.09)	(2.29)	(2.92)	(2.59)	(3.02)
Lag log wholesale price (yearly)		0.013					
		(0.09)					
Lag log wholesale price (harvest time)			-0.014				
			(-0.11)				
Lag log wholesale price (planting time)				0.073	-0.088		
				(0.48)	(-0.54)		
Log cross price (maize price at the time of kharif planting)							0.063
							(0.89)
Lag log rice production						0.061	
						(0.37)	
_cons	-0.657	1.099	1.179	0.694	-0.46	-0.987	-0.592
	(-0.48)	(0.74)	(0.82)	(0.46)	(-0.31)	(-0.52)	(-0.43)
N	30	29	29	30	30	30	30
R²	0.91	0.88	0.88	0.87	0.91	0.91	0.91

Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with Newey-West standard error estimation. t-values are given in brackets. Error terms are stationary according to the ADF test.

Table 2 presents our estimates of the average price elasticities of wheat production in India. Column 1 shows estimates where wheat production is explained by the contemporaneous

MSP, the lagged rainfall[18] and a time trend. Column 7 adds to this regression, the price (average at wheat planting period) of competing crop, gram (chickpea), which has an insignificant impact on wheat production. In both cases, the impact of the wheat MSP on wheat production is strong and significant, implying that on average, a one per cent increase in the MSP significantly increases wheat production in the corresponding marketing year by about 0.65 per cent. Columns 2-5 suggest that the wholesale market prices do not play a significant role in determining wheat production in India. Column 5 shows the regression with both prices – the MSP and the market price (wholesale price at planting – the one with the highest coefficient estimate and lowest standard error). Even when controlling for the MSP, market wholesale price seems to have little impact on the wheat production level – the estimated coefficient is quite low (0.1) and insignificant. An interesting result is reported in column 6, which expands the regression in column 1 with the autoregressive term, which could correspond with the Nerlovain adaptive price expectations. However, in this case, the price, MSP, is certain, so the autoregressive term represents the inertia of wheat production – for example farmers make crop specific investments, which prevent them from switching to competing crops very easily. The MSP coefficient estimate in this specification is significant and equal to 0.47, which can be interpreted as the short-term production response to the increase in the MSP. Lagged production has a positive and significant coefficient estimate equal to 0.41, which yields the long-term price elasticity (the long term response to a 1 per cent sustained increase in the MSP) of production, which is equal to 0.8. This specification has the highest R square of 0.96. In addition to the prices, wheat production is affected by rainfall and technological progress approximated by trend.

In the case of rice (Table 3), production is explained by the MSP for rice, time trend and the rainfall (column 1). Quantitatively, the estimated coefficient implies that on average, a 1 per cent increase in the MSP results in a significant increase in production of about 0.4 per cent. The cross price of the competing crop (maize), however, turned out to be insignificant (column 7). The market price of rice does not show any significant influence on production (columns 2-5). Column 5 gives results of the regression with both prices – the MSP and the market price (average planting time wholesale price – the one with the highest coefficient

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[18] Rainfall variable represents total rainfall in a calendar year; whereas sowing of wheat crops harvested in a calendar year t starts in October of year t-1. This is why the lagged rainfall has been used in the wheat regression.

estimate and lowest standard error). Even when controlling for MSP, the wholesale price seems to have little impact on the rice production level – the estimated coefficient is insignificant. Adding the autoregressive term to the specification 1, as reported in column 6, does not yield a major improvement – the lagged rice production is insignificant.

The price elasticity of rice production is smaller for rice than for wheat, which can be explained by the big share of small-scale farmers in rice production and the more commercial character of wheat production. The short-term price elasticity of production of 65 per cent and 39 per cent for wheat and rice respectively are high relative to estimates of market price elasticities in other countries. For example, in the FAPRI database,[19] the price elasticity of rice supply is usually close to 0.2, with the value of 0.25 in Bangladesh and 0.16 in China (0.11 for open-market price in India). The same database shows that price elasticities of wheat area response are slightly higher, averaging for example to 0.33 in Australia, 0.43 in Brazil and 0.09 in China (0.29 for open-market price in India). The high MSP-elasticity in India might be explained by the low risk related to the MSP.

Gulati and Sharma (1990) used slightly different specifications of the output equation for Indian wheat and rice production. They used lagged output, lagged relative wholesale price, rainfall and irrigation to explain wheat and rice production in India. The estimation was based on data from 1969 to 1986, and hence, preceded the structural change in the 1990s. They found that market prices had a significant and strong impact, with a short-term (one-year) elasticity of 0.28 for wheat and 0.25 for rice. The long-term (three-year) elasticities were 0.83 for wheat and 0.72 for rice. Mythili (2008) found lower short-run price (relative price) elasticity of wheat and rice supply. In the post-reform period (1990-91 to 2004-05), the estimated short-run price elasticity of wheat supply was 0.17 and 0.16 (with two different specifications) and that of rice supply was 0.28 and 0.18 (ibid). In this study, the long-run supply response was also estimated, with the long run elasticity for wheat equal to 0.36 (0.29 with the alternative specification) and rice 0.7 (0.51 with the alternative specification). Neither of these studies used the MSP as an explanatory variable, as the authors focused on market prices.

c. Procurement

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[19] http://www.fapri.iastate.edu/tools/elasticity.aspx

The share of wheat procurement in total production has been fluctuating between 11 and 40 per cent since the beginning of the 1980s, with a steep increase in the past few years (see Figure 5). Rice procurement has been characterised by a more stable trend – from less than 11 per cent in 1982 to an average of 34 per cent in the last five years (see Figure 6). These tendencies strongly coincide with the MSP changes, especially in relation to the market price (see Figure 3 and Figure 4).

The relationship between procurement and prices is modelled as follows:

$$2 \qquad \frac{D_{t,i}^{FCI}}{Q_{t,i}} = \alpha_0 + \alpha_1 \frac{p_{t,i}}{p_{t,i}^{MSP}} + \alpha_2 t,$$

where $D_{t,i}^{FCI}$ is the yearly procurement level of the *i*-th crop by the FCI and via decentralised procurement scheme[20] (DCP) in the marketing year, $Q_{t,i}$ is total production and $p_{t,i}^{MSP}$ is is the MSP of the *i*-th crop, $p_{t,i}$ is the market price (marketing year average) of the respective crop. Thus, on the left hand side of the equation, there is the share of public procurement in total production and on the right hand side, there is the ratio of market price and the MSP and the trend.

Table 4 Procurement regression estimates

	Share of FCI procurement in production	
	Wheat	Rice
Ratio of market price to MSP	-0.393 ***	-0.265***
	(-7.79)	(-6.87)
Time trend	-0.001	0.003 ***
	(-1.5)	(3.99)
Constant	0.772 ***	0.565 ***
	(9.67)	(8,73)
N	31	31
R²	0.72	0.92

Note. *,**,*** indicates significance levels at 10, 5 and 1 per cent, respectively with the Newey-West standard error estimation. In brackets t-values are given .Error terms are stationary according to the ADF test.

The rise of the MSP relative to the wholesale price by 1 per cent increases the share of procurement in the production by 0.39 per cent in the case of wheat and by 0.27 per cent in

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[20]DCP was introduced in 1997-98 and is in place in 11 states. Under the scheme, states procure, store and distribute food grains through the TPDS. The surplus (in excess of the TPDS) is handed over to the FCI for the needs of the other (deficit) states.

the case of rice (all the estimates are significant at the one per cent level). The significant upward trend in rice procurement might be due to the changing levy on rice millers/traders. It could also be caused by decreasing transportation costs due to better infrastructure in rice growing areas, which raises the incentive of farmers to sell to the FCI.

Gulati and Sharma (1990) also estimated a similar procurement equation, allowing, however, for the additive impact of production level (as opposed to the multiplicative specification in our study). Their results indicate a strong procurement response to production, with elasticity equal to 1.37 for wheat and 1.1 for rice. The relative price elasticity (procurement to market price ratio) was estimated 0.85 for wheat and 0.59 for rice. However, these numbers cannot be compared with our estimates due to differences in the specification of the equation.

d. Demand and TPDS/OWS

Rice and wheat consumption comes from the three sources – own produce (only in the case of the rural households), received through the TPDS or other welfare schemes (OWS) and bought in the market. The contribution of individual sources to total consumption plays an important role in the analysis of demand and its determinants (price and income elasticities in particular).

There are 65.2 million BPL families in total[21] (including 24.3 million AAY families) (DFPD, 2013). They are entitled to 35 kg of food grains per family per month at a fixed price – the central issue price (CIP) plus a state-specific fee for BPL and APL recipients. The AAY price cannot be higher than the CIP (DFPD web portal). In practice, some states provide additional subsidy, distributing the grain at a price lower than CIP price (Saini & Kozicka, 2014). The allocation for APL families is based on the availability of food grains in the central pool and past off-take.[22]

The CIP has nominally declined after the introduction of the scheme and from the year 2002, or has remained unchanged, which means a significant drop in the real price (see Figure 7 and Figure 8). OWS comprises different schemes, such as the mid-day meal scheme and

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[21]The requirement of food grains and subsidy requirements are decided on the basis of poverty estimates, based on a survey conducted by the Planning Commission in the year 1993-94 and year 2000 population estimates or the number of such families actually identified and ration cards issued to them by the state/UT governments, whichever is less (DFPD FAQ).
[22] These allocations have been changed under the NFSA, 2013.

wheat-based nutrition programmes and the amount allocated does not usually exceed 10 per cent of that for the TPDS. Special additional allocations of food grains are also made, depending on grain availability (based on DFPD Food Grain Bulletins for different years).

Figure 7 Wheat CIP and wholesale price
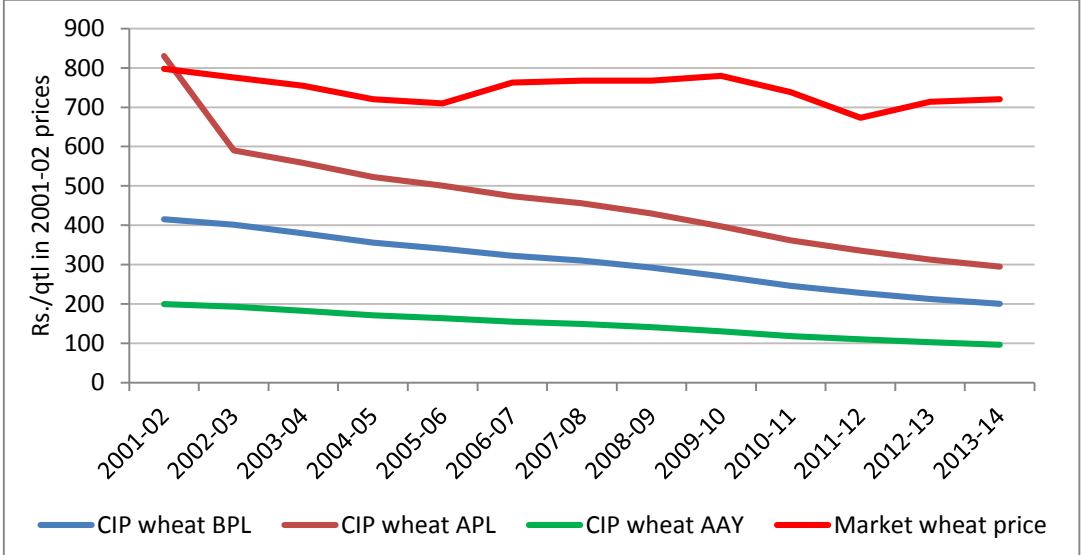
Source: Own design based on DFPD data

Figure 8 Rice CIP and wholesale price
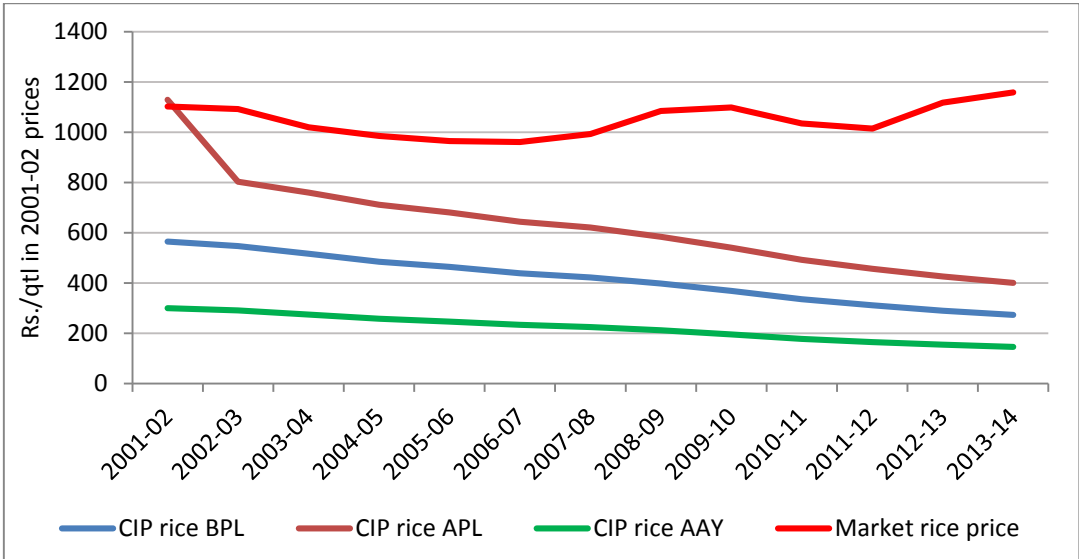
Source: Own design based on DFPD data

Leakages[23] from the TPDS are a major challenge in estimating the 'market' consumption of wheat and rice. The 'leaked' grains are sold on the market at market price or exported to neighbouring countries, e. g., Bangladesh. Twenty-two per cent (1.2 kg/capita/month) of the total consumption of rice and 12.3 per cent (0.5 kg/capita/month) of wheat came from the TPDS in 2009-10 (NSS data). These numbers have increased from 1999 (13.1 per cent and 4.5 per cent respectively). This can be attributed to lower leakages (there is no consistent historical data on leakages from the TPDS available) and increased TPDS allocations and off-take (Figure 9). However, it is still much less than the TPDS entitlements (discussed above) and per capita off-take – 1.9 kg/capita/month for rice and 1.5 kg/capita/month for wheat.

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[23] Currently, the estimates for leakage are close to 40% (Mukherjee, 2014).

Figure 9 Off-take from public stocks for the TPDS and OWS
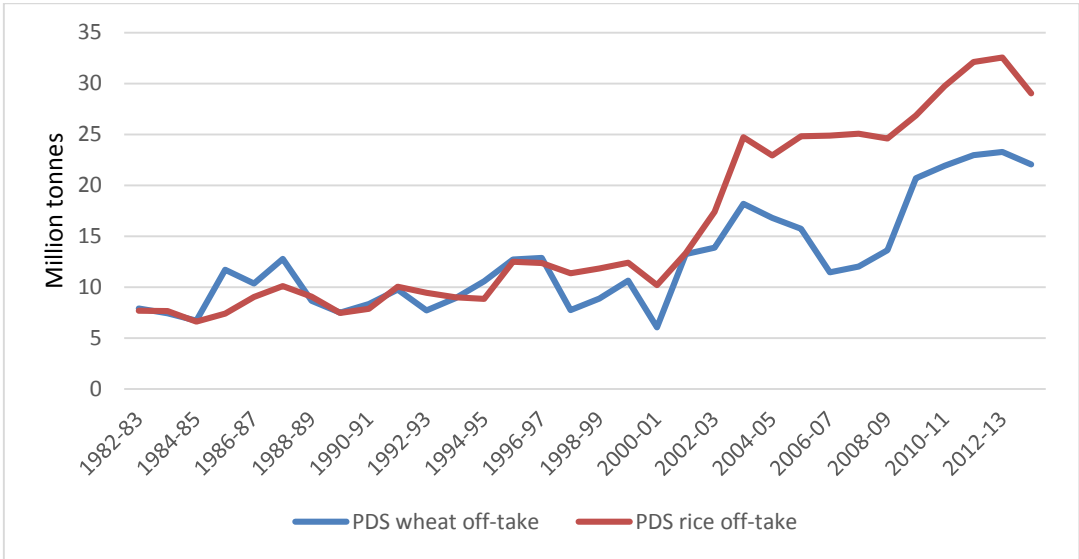
Source: Own design based on Food Grain Bulletin data, dfpd.nic.in

Twenty-five per cent and 37 per cent (1.2 kg and 1.5 kg per capita per month) of rice and wheat respectively of the total consumption of rural households came from home grown stock in 2009-10 and 30 per cent and 40 per cent in 2004-05, which was a drought year (NSS data). As discussed earlier in this paper, rice is mostly produced by small-holders, whereas wheat is a more commercial crop. This fact is reflected not only in the production function, but also in the quantity of grain retained on farm (and marketed surplus) in response to price changes.

Figure 10 Wheat price and quantity retained on farm
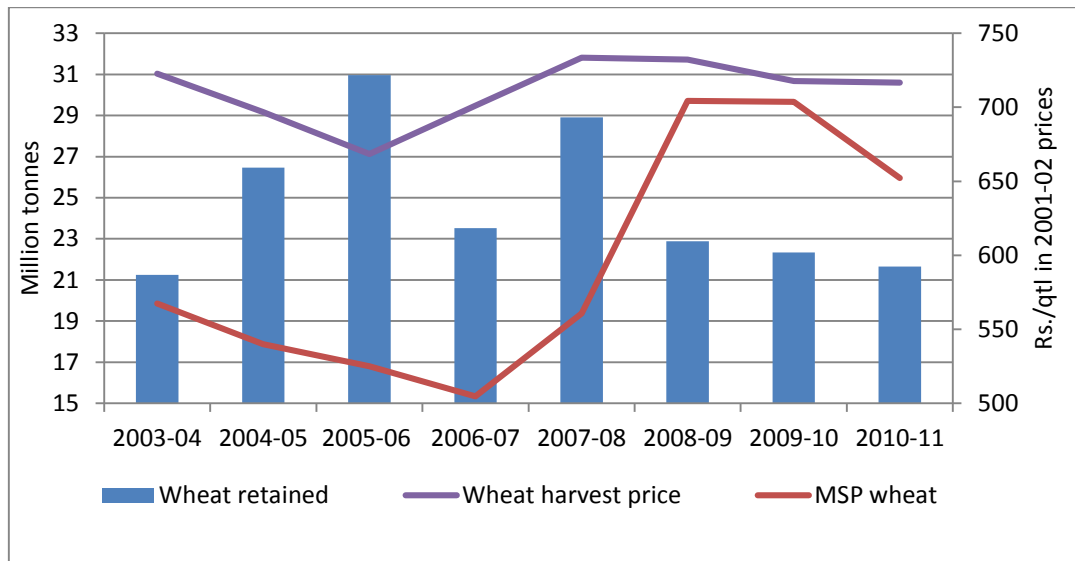
Source: Own design based on http://agricoop.nic.in/agristatistics.htm and RBI data

Figure 11 Rice price and quantity retained on farm
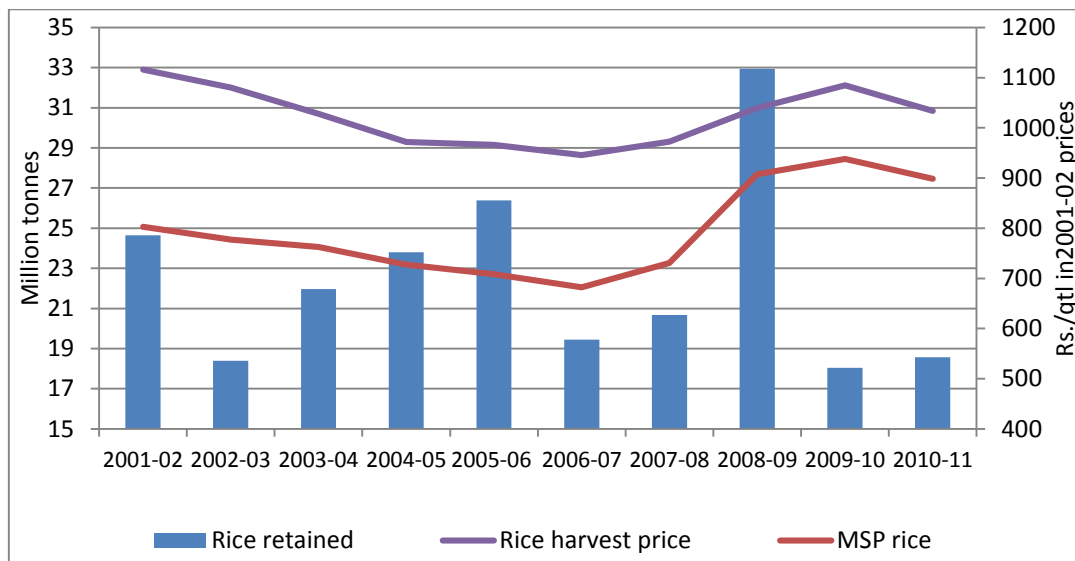
Source: Own design based on http://agricoop.nic.in/agristatistics.htm and RBI data

Wheat reacts more like a cash crop (Figure 10) it is sensitive to harvest time average wholesale price and the MSP – with the correlation equal to -0.54 in both cases. This might mean that farmers decide to sell more in times of high market prices during the harvest.

In the case of rice (Figure 11), market prices do not seem to affect the amount consumed from own stock. Correlation with both prices (harvest and the MSP) is close to 0. This might be because rice is produced, for the most part, by poor smallholders, who produce mainly for own consumption and do not get affected by market price developments. However, it is not clear then, why rice consumption from own stock fluctuates so much. If it was to cover the basic needs of the farmers, it should be quite stable in its volume. In reality, it varied significantly between 18 and 33 million tonnes. There are probably other factors influencing the consumption from own produce – for example, PDS supplies. However, with the available dataset (10 observations for rice and 8 for wheat), it is not possible to test this hypothesis.

The general equation for estimating demand is given by:

$$3 \qquad \ln D_{t,i}^{cap} = \alpha_0 + \alpha_1 \ln p_{t,i} + \alpha_2 \ln p_{t,i}^{cross} + \alpha_3 \ln PDS_{t,i}^{cap} + \alpha_4 \ln Income_t^{cap} + \alpha_5 \, t,$$

where $D_{t,i}^{cap}$ is yearly (marketing year) per capita consumption for the i-th crop (based on the USDA data for domestic utilisation), $p_{t,i}$ is yearly (marketing year) average of the own price of the i-th crop and $p_{t,i}^{cross}$ is price average of the other crop (cross price), both in real terms. $Income_t^{cap}$ is disposable income per capita and t is a time trend. The variable $PDS_{t,i}^{cap}$ is per capita off-take for the TPDS and OWS (PDS), which is treated in two different ways. First, it is assumed that grains from the PDS are imperfect substitutes for grain available in the market (due to the lower quality of the PDS grains sometimes and the greater difficulty in terms of access through fair price shops). In this case, the constant portion[24] of the PDS grain is subtracted from the total consumption (left hand side of the equation) and the total PDS off-take used as an explanatory variable. Second, it is assumed that grain from the PDS is a perfect substitute for grain available in the market. In this case, only the total consumption is considered and α_3 is set equal to zero.

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[24]This constant portion should represent the grain actually delivered through PDS and hence is equal to off-take minus leakage. In reality, the leakage portions fluctuates; however, this number is a controversial matter and differs significantly depending on the source of the data. Reliable estimates are based on the comparison of actually consumed grain from the PDS, based on the National Sample Survey results, and the off-take, as reported by the FCI (Khera, 2011b). However, the survey is not conducted yearly. In addition, the question on PDS consumption has been asked only in a few recent rounds; consequently, there are only three available observations. The amount of leaked grain used in this study is an average of these numbers, which is 25 per cent for rice and 61 per cent for wheat.

Because the market price is endogenous to consumption, instrumental variable (two stage least square estimation method) regressions were used in order to estimate equation 3. MSP, rainfall and international prices (in years when there was no export ban) were used as instruments for the market price.

Table 5 Regressions of wheat demand

	Dependent variable: log wheat consumption		
	1	2	3
Log market price own	-0.880*	-1.069***	-0.820*
	(-1.68)	(-3.12)	(-1.84)
Log market price cross	0.613**	0.730***	0.712***
	(2.11)	(3.99)	(2.76)
Log PDS per capita off takes	-0.085	-0.104**	
	(-1.22)	(-1.97)	
Log income	-0.021		0.145***
	(-0.21)		(3.17)
Log time trend	0.139***	0.136***	
	(3.25)	(4.61)	
_cons	2.741***	-2.688***	3.010***
	(-3.52)	(-3.50)	(-3.74)
N	28	30	28
p-value of underidentification LM statistic	0.03	0.08	0.09
p-value of Hansen J statistic	0.08	0.43	0.53

Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with robust standard error estimation. t-values are given in brackets. For column (1) and (2), PDS consumption is assumed to be an imperfect substitute (subtracted from the per-capita consumption); in column (3), PDS consumption is a perfect substitute.

Table 6 Regressions of rice demand

	Dependent variable: log rice consumption		
	1	2	3
Log market price own	0.260	-0.112	0.311
	(1.14)	(-0.53)	(1.41)
Log market price cross	-0.170	0.02	-0.153
	(-0.72)	-0.09	(-0.70)
Log PDS per capita off takes	-0.222***	-0.332***	
	(-2.81)	(-7.71)	
Log income	-0.113		-0.010
	(-1.54)		(-0.42)
Log time trend	0.092***	0.043**	
	(2.78)	(2.09)	
_cons	-3.732***	-3.969***	-2.974***
	(-5.90)	(-5.87)	(-6.31)
N	29	30	29
p-value of underidentification LM statistic	0.08	0.12	0.11
p-value of Hansen J statistic	0.04	0.04	0.09

*Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with robust standard error estimation. t-values are given in brackets. For column (1) and (2), PDS consumption is assumed to be an imperfect substitute (subtracted from the per-capita consumption); in column (3), PDS consumption is a perfect substitute.*

In the case of wheat, market prices have a strong and significant impact on consumption (Table 5): they are negative for own price and positive for the cross price (rice). Own price elasticity estimate is between -1.07 and -0.82 and cross price elasticity is between 0.61 and 0.73. It is not clear how PDS wheat affects total wheat consumption. According to the second specification (column 2, table 5), PDS wheat is an imperfect substitute for the open-market wheat – an increase in subsidised wheat delivery by 1 per cent decreases market consumption only by 0.1 per cent (column 1 suggests that it does not change market consumption at all). Hence, if we consider the amounts consumed from the both sources –

very little actual consumption from PDS and consumption mainly from the market – the conclusion is that an increase in PDS wheat delivery results in increase in total wheat consumption (as on the left hand side of the equation, there is wheat consumption net of PDS consumption). What is more, the additional consumption will be almost equal to additional distribution. This small effect of PDS distribution on total consumption might be due to a few reasons. First, wheat distribution is quite small – around 60 per cent is leaked (GoI, 2005; Khera, 2011a). Second, the dependent variable is total wheat utilisation, and hence, includes consumption for different purposes. A big share of it is consumed in a ready-made form (like noodles) or outside homes (in canteens or restaurants). This part of consumption is not responsive to PDS deliveries. There might also be some positive impact of the income transfer effect (as discussed below) reflected in a higher total consumption of wheat.

In the case of rice, consumption seems to be mostly driven by a trend and PDS deliveries (Table 6). The reason for this might be that PDS is functioning much better for rice. Since the beginning of the millennium, there has been much more rice than wheat allocated for the PDS (Figure 9). Also, as discussed above, leakage of rice is much lower; therefore, much more rice is delivered effectively through the PDS. What is more, many 'rice consuming' states provide additional subsidy for TPDS rice. For example, BPL and AAY rice in AP, Karnataka, Kerala and Odisha is priced at only 1 Rs./kg. And Tamil Nadu has a unique universal PDS, delivering rice to everyone free of cost (DFPD, 2014, p. 54).[25] This massive subsidisation of rice might have led to the distorted price and income response of aggregate rice demand.

Kumar et al. (2011) and Ganesh-Kumar et al. (2012) analysed price and expenditure elasticities of demand for several goods in India based on NSS household survey data. Their results are difficult to compare with those reported above as our dependent variable is total domestic utilisation and, unlike NSS consumption data, includes grain bought in a processed form, consumed in canteens and restaurants and used for purposes other than consumption (e.g. feed). The average income elasticity for rice was found 0.024 and for wheat 0.075 in the former study and food expenditure elasticity was 0.21 for rice and -0.13 for wheat in the

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[25] Limited to 20 kg per household, and 35 kg in case of AAY cardholders (http://www.tncsc.tn.gov.in/html/pds.htm, accessed on Sep, 25th, 2014).

latter study. The own price elasticities were estimated in Kumar, Kumar, Parappurathu, & Raju (2011) at -0.247 for rice and -0.340 for wheat.

Income elasticity of wheat and rice demand are reported to be close to zero (0.024 and 0.075 for rice and wheat respectively) on average across all income groups in India (Kumar, Kumar, Parappurathu, & Raju, 2011). However, it is much higher for the poorest – equal to 0.182 for rice and 0.102 for wheat in the 25th income percentile (ibid). So if PDS is properly targeted, the major subsidy should be received by the poorest part of the population and as a result, there might be a significant increase in wheat and rice consumption due to the income effect.

e. Stocks and OMSS (Domestic and Exports)

The public stock level ($X_{t,i}$ is end of year t stock level) is a result of the carryover stocks (less the deterioration rate, δ), the grain inflow from domestic procurement($D_{t,i}^{FCI}$), imports and outflows to the TPDS/OWS, OMSS for domestic market (OMSS D) and net exports:

4 $$X_{t,i} = (1 - \delta_i)X_{t-1,i} + D_{t,i}^{FCI} - OMSS_{t,i} - TPDS_{t,i} - NEX_{t,i}^{pub}.$$

However, fitting the data to the above equation is difficult because of the different reporting periods for different data. Procurement is reported for the marketing year, whereas all the off-take data is for the financial year. In the case of wheat, financial year (April to March) and marketing year (March to February) are almost identical, but for rice, the difference is quite significant, as its marketing year lasts from October to September. Stock levels are available on a monthly basis so we used the closing stocks of financial years.

Figure 12 Wheat stock change as estimated from equation 4 and change in actual stock
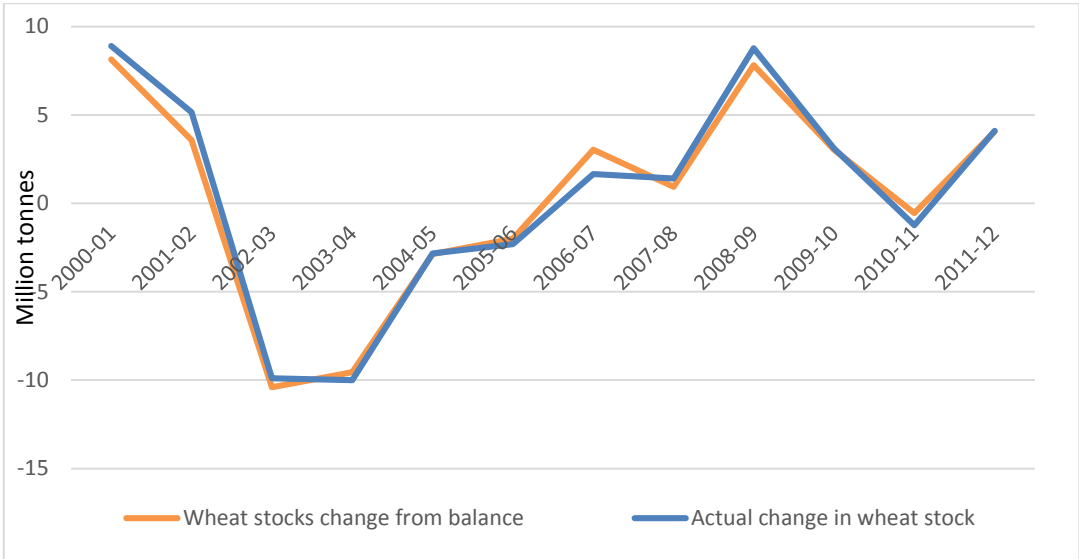
Source: Own design based on FCI data

Note. Stock changes were calculated between financial year closing stocks, between March values of consecutive years.
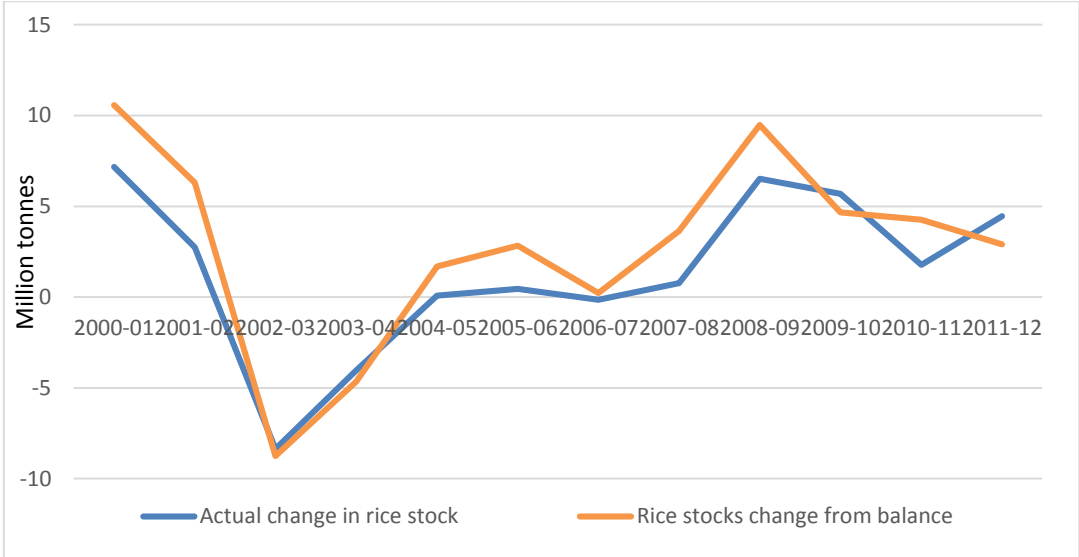
**Figure 13 Rice stock change as estimated from equation 4 and change in actual stock**

Source: Own design based on FCI data

Note. Stock changes were calculated between financial year closing stocks, between March values of consecutive years.

The calculated wheat stock change from grain flow (similar to the equation 4), $D_{t,i}^{FCI} - OMSS_{t,i} - TPDS_{t,i} - NEX_{t,i}^{pub}$, has been fluctuating around the difference between the ending stocks in consecutive financial years $X_{t,i} - X_{t-1,i}$ (Figure 12). In the case of rice, the difference between the estimated and actual stock change is large (Figure 13). This can be attributed partially to the discrepancy in the data reporting periods; however, this would only result in the time series interweaving with each other (one fluctuating around another). In reality, except for a few years, the estimated change from the grain flow balance stock change has been persistently above the actual change in stock. In principle, the former less the deterioration rate should be equal to the latter, as in equation 4. Therefore, the low actual stock change might be due to high losses. Based on equation 4, the average wheat stock deterioration rate from 2000-01 to 2012-13 is equal to 2 per cent and for rice, 10 per cent. But this number should be interpreted as the average unexplained change in stock level between marketing seasons as the deviations were both positive and negative. Unfortunately, there is a lack of reliable estimates on storage losses in India to compare with. Different estimates quote aggregate losses (post-harvest annual loss of grain), starting from 16-17 million tons up to 55 million tons, which roughly means 7 per cent to 23 per cent of total production (Artiuch & Kornstein, 2012). FCI reports are much below any of these numbers – around 0.3 million tons for wheat and rice wasted in storage and transit in recent years (as reported on http://fciweb.nic.in/). Approximately half of this amount was lost in storage, which gives not more than 0.4 per cent of the average stock level in the central pool in the corresponding years.

Buffer stock norms define the amount required to meet operational and strategic stock needs. The open-end character of the procurement, relatively high MSP and trade limitations (e.g. temporary export bans) result in very high stock levels – periodically exceeding the norms.

Figure 14 Wheat stocks, off-take and prices
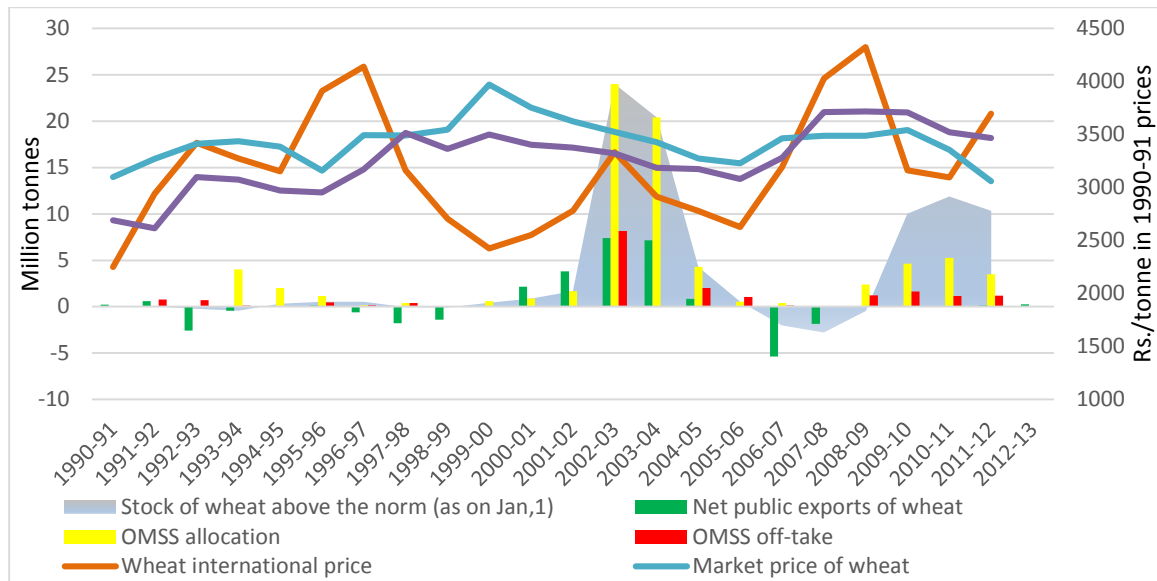
Source: Own calculation based on from FCI, IMF and indiastat.com

Figure 15 Rice stocks, off-take and prices
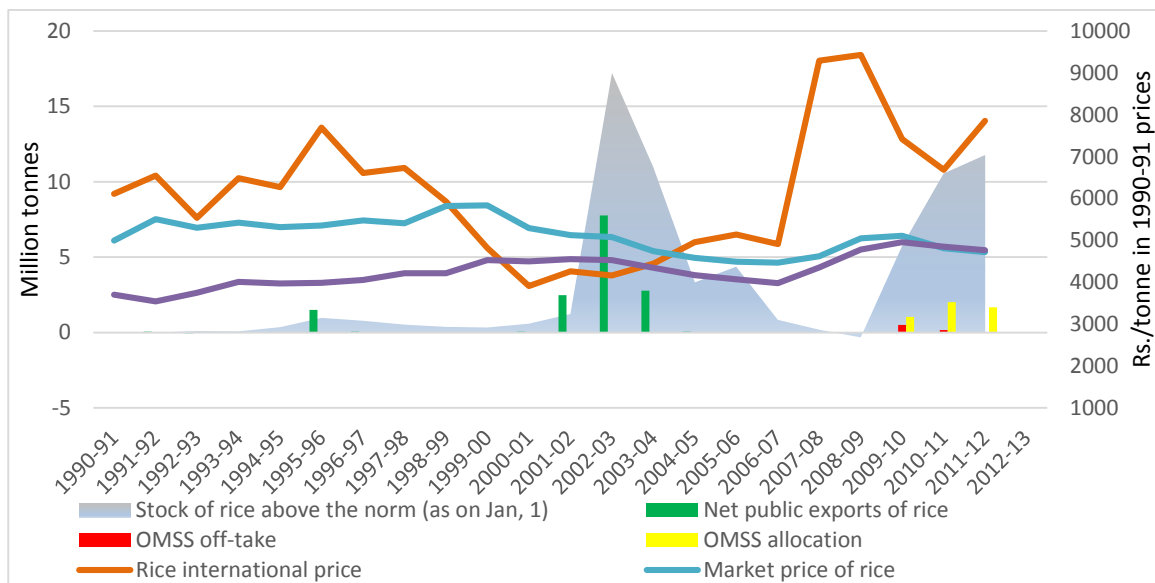
Source: Own calculation based on FCI data, IMF and indiastat.com

OMSS (D) for wheat is mostly used to stabilise market supply and release stocks before the new harvest arrival (Figure 14). For rice, the seasonality of supply is almost absent, so OMSS was usually not used (Figure 15). However, in the last years (from 2009-10), small amounts

were allocated for the OMSS (D) but they were mostly not absorbed by the market (off-take was lower than allocation).

Both OMSS (D) and export allocations are *ad hoc* decisions. Although they are correlated with stock levels and stock norms, there are no rules for this. The issue price of grain – the minimum issue price (MIP) – is usually based on acquisition cost[26] from the previous marketing year (plus the freight), but sometimes, it is lower than that (however, it is never below the current MSP as it could lead to 'reselling' of grains by the traders). It is sold through tenders, so the actual price received is close to the market price. The amount actually released through these channels is not a simple outcome of difference between the market price and the CIP as there are several limitations – sometimes the quality of the released grains is low (because of poor storage facilities[27] and grain is being stored for a few years); there are also logistical limitations (Thukral & Bhardwaj, 2013).

The difference between the minimum issue price (MIP) and international market price could work in favour of exports, especially for rice. Prolonged export restrictions resulted in a much lower domestic rice price in comparison with the international price (Figure 15). Export off-take has been used sometimes in order to balance the stock level (often in the form of humanitarian aid (non-commercial)); however, this has apparently not been enough in the recent years – despite the huge stock pile-up starting from 2008-2009, there were hardly any exports and attempts to release through the OMSS were rather unsuccessful.

f. Private stocks

In order to identify the determinants of private storage, data on the amount of private stocks is needed. The Food Corporation of India provides monthly public stock data for both wheat and rice and the USDA and FAO provide data for the total closing rice stocks (private + public in October), which enables one to derive private stocks for rice. For wheat, there is no estimation of private or total stocks from USDA, only from the FAO. However, the FAO data on wheat stocks seems to be questionable as their reported public stocks significantly differ from the public stocks reported by FCI and their total wheat stocks are sometimes lower

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[26]Acquisition cost consists of cost of grain, statutory taxes, storage and interest charges, etc., at acquisition stage.
[27]Stock level is often above not only the stock norms, but also the storage capacity, which results in storing grain in the open (Bhardwaj, 2012).

than the public stocks reported by FCI. Therefore, the drivers of private stocks were estimated only for rice. Figure 16 shows the public and private rice stocks.

Figure 16 Public and private rice stocks according to different sources
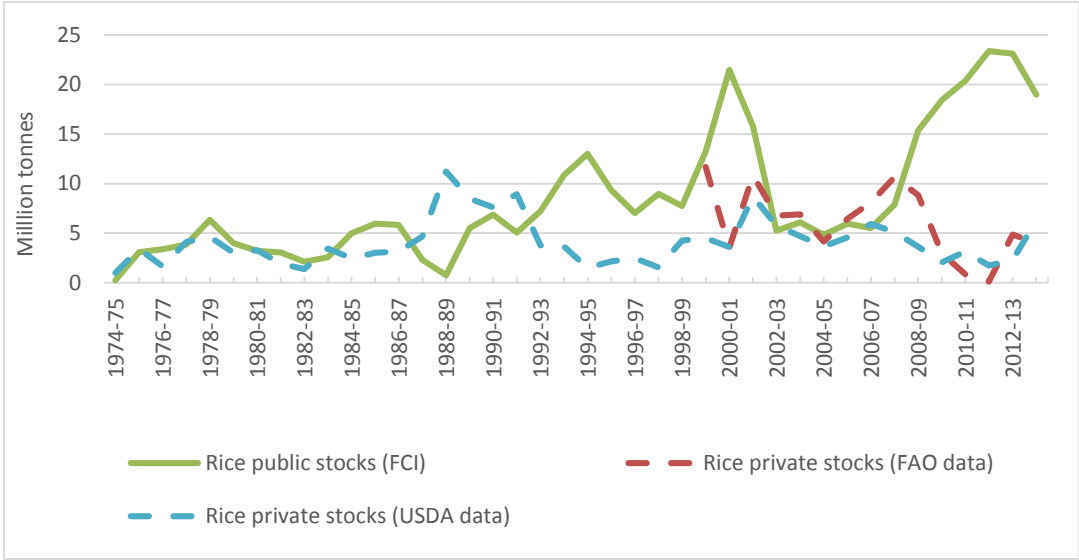
Source: Own design based on data from the FCI, USDA and FAO. The FCI data for the public rice stocks in October are only available from 1989 onwards. For the years before (and 2014), the October stocks were estimated from the January and April stocks (see table below).

Note. Stocks are reported for end of marketing year levels – closing stocks.

As the public October stocks – i.e. the closing stocks – from the FCI are only available from 1989 onwards, they were estimated for the years before based on the January and April rice stocks, which are available from 1974 onwards.

Table 7 Results of the public October stock level estimation

Dependent variable:	October rice stock
January Stocks	-0.647
	(-1.59)
April Stocks	1.326 ***
	(3.54)
Constant	-1.356
	(-1.58)
R²	0.8747
N	24

*Note. *,**,*** indicates significance levels at 10, 5 and 1 per cent, respectively with robust standard errors, t-values are given in brackets.*

In theory, we expect the amount of private stocks to be driven by price expectations of stockholders. However, in India, policies that limit the amount of private storage allowed may play an important role. It is difficult to control for these effects[28], which is why they are not considered here. Price expectations are – if rational expectations apply – based on total supply and demand. Therefore, we consider production, last year's closing stocks with the private sector, export opportunities to meet demand on the world market and closing stock with the public sector to be the relevant drivers of closing private sector stocks. Public storage can be important because large amounts may increase government's OMSS off-take, PDS distribution and exports from public stocks and may, therefore, affect the price expectations of private stockholders.

The general equation describing the private stocks is given by:

$$5 \qquad \frac{X_t^{priv}}{D_t^{trend}} = \alpha_0 + \alpha_1 \frac{S_t}{D_t^{trend}} + \alpha_2 \frac{X_t}{D_t^{trend}} + \alpha_3 B_t + \alpha_4 \frac{L_t}{D_t^{trend}} + \alpha_5 B_t \frac{L_t}{D_t^{trend}},$$

where X_t^{priv} are the private stocks in the marketing year t, D_t^{trend} is the consumption trend, S_t is the total market supply calculated as $S_t = Q_t + X_{t-1}^{priv}$ and B_t is an export ban dummy.

For our analysis, we applied a Hodrick-Prescott time-series filter to the USDA demand data in order to obtain a smooth demand trend. Afterwards, the production (USDA), the previous year's privately held stock, and the closing public sector in that year were de-trended by the

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[28] The limits on private stocks are imposed at the state level and they vary over time.

demand trend and then used as explanatory variables. The previous year's private stocks and production were then combined to get the "total supply". To account for export opportunities, an export ban dummy, a variable for the surplus of the rest of the world (RoW), and an interaction term of the two variables were used. All of these may affect private stock levels through price effects through ongoing and expected future trade. To calculate the surplus, the demand trend was subtracted from the total supply. The surplus variable is calculated as the worldwide supply minus the demand trend. As closing public sector stocks were considered for the same marketing year as the estimated closing private stocks, endogeneity problems may arise. Hence, the regressions were estimated using the instrumental variables technique (two-stage least square estimation method). The closing public stocks were instrumentalised by the exogenous MSP, which is responsible for the procurement level (see section c) – the main driver of change in public stock (see section e). An under-identification test and a weak identification test were conducted to ensure that the MSP is a valid instrument. Furthermore, different other criteria have been adopted to evaluate the validity of the instrument. P values for underidentification are below 0.05 in all specifications except when FAO data is used. This, in comparison with the high adjusted R^2 and the high LM test and F statistics, shows that the MSP is a good instrument.

The results of the regression are shown in Table 8 for different specifications. The first column shows the regression for wheat, the second and third for rice using the FAO and the USDA private stock data respectively. The fourth and fifth column show the results for the panel using FAO data for both, wheat and rice, and using FAO data for wheat and the USA data for rice respectively.

Table 8 Regression for the private rice stocks

	(1)	(2)	(3)	(4)	(5)	(6[1])	(7[1])	(8)
Priv. stock data	USDA	USDA	USDA	USDA	USDA	USDA[1]	USDA[1]	FAO
Gov. Stocks	-.62***	-.626***	-.585***	-.504***		-.627***	-.616***	-.752***
	(.129)	(.127)	(.15)	(.158)		(.125)	(.143)	(.233)
Supply	.358***	.42***	.396***	.326***	.024	.386***	.338***	.56**
	(.103)	(.107)	(.148)	(.124)	(.093)	(.095)	(.088)	(.225)
Export Ban			.026**			.027***		
			(.012)			(0.009)		
Surplus RoW	.161***							
	(.048)							
Surplus RoW if ban		.38**						
		(.161)						
Constant	-.301***	-.391***	-.373**	-.283**	.021	-.356***	-.281***	-.538**
	(.113)	(.12)	(.168)	(.134)	(.114)	(.105)	(.091)	(.255)
LM test stat/UI	5.34	5.44	5.22	5.2	-	8.3	7.94	2.65
p-value/UI	0.021	0.02	0.022	0.023	-	0.004	0.0048	.103
F stat/WI	18.8	22.8	23.5	34.3	-	38.1	47	6.98
BIC	-104	-103	-100	-100	-98.5	-131	-128	-52.3
Adj R² 1.stage	0.688	0.626	0.665	0.62	-	0.7	0.468	0.638
F stat 1.-stage	39.3	25.6	52	45	-	72.1	60.7	29.2
Observations	24	24	24	24	24	32	32	14

Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with the robust standard errors estimation. The instrumental variable regression was used. Closing government stocks were instrumented with the MSP. LM test statistics and p-values are for underidentification (UI), F statistics for weak identification (WI) (Kleibergen-Paap); All independent variables are detrended as described before.

1 Government ending (Oct) stocks, if unavailable, are estimated from Jan and Apr stocks, see table above (R²=0.8747)

We find that total (market) supply is one of the main drivers of private storage, which is in line with the theory of competitive storage (as for example in Williams & Wright, 2005). More grain is stored in years of excess supply. In all specifications, the total supply is significant at the 1 per cent level except in specification 5, where government stocks are not included. As a result, this specification has no explanatory power. Government stocks have a

negative and significant impact in all specifications and turn out to be the most important factor. Hence, public storage seems to crowd out private storage. Again, this finding is in line with our expectations as detailed above and with results obtained by Gouel (2013) in his theoretical rational expectations storage model. However, public storage is no perfect substitute, i.e., it only partly crowds out private storage as the coefficient is significantly smaller than one in all specifications. The export variable coefficient is positive and significant as well as the surplus in the rest of the world variable and the interaction term, i.e. the surplus in the rest of the world when exports are banned. As a result, banned exports or a worldwide surplus both lead to higher stocks. These findings are in line with theoretical expectation; as profit margins from trade decrease, speculative private storage in hope of a future harvest failure becomes more attractive.

However, only closing private stocks were analysed and no conclusions about intra-annual effects can be drawn due to lack of data on the total stock level.
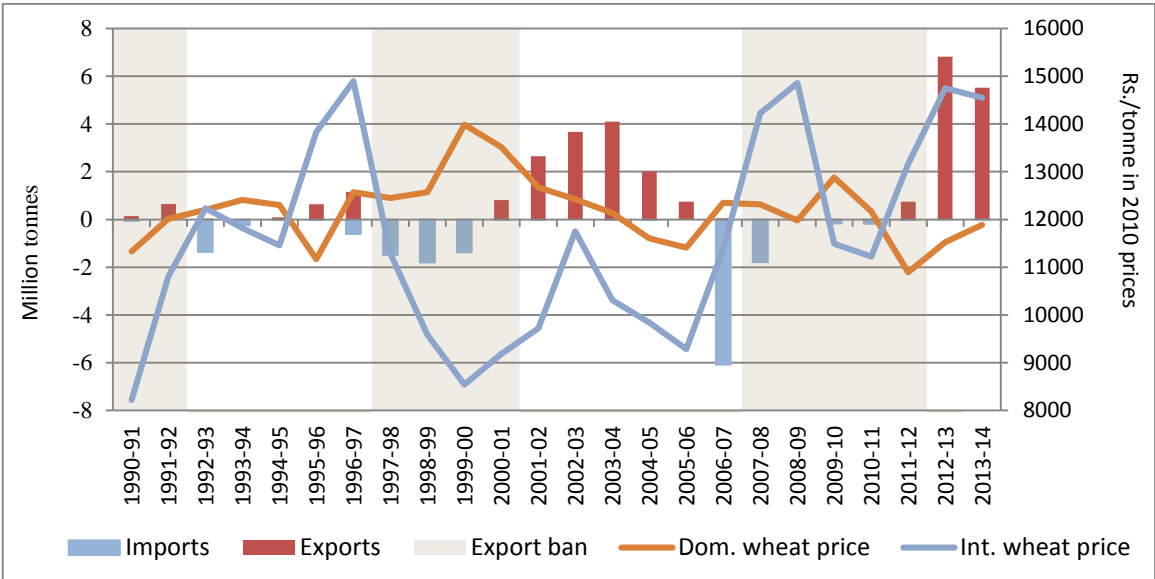
g. Trade

International trade, like other activities within the wheat and rice sectors, is heavily controlled by government and there are several regulations on private exporters, including frequent export bans, tariffs and minimum export prices (Figure 17 and Figure 18). Before the early1990s, India had a closed economy. Exports of common rice were banned until 1994 and the country was dependent on import of wheat – importing a few millions of tonnes yearly. This is why we mostly restrict our analysis of wheat and rice exports to the period after 1990.

It is difficult to estimate actual public exports – the reported numbers by FCI for public exports are in some cases higher than total exports from India of these commodities.[29] The reason for high public export values might be because they include issue of grain stocks for export to private parties, and these might have been partly released on the domestic market. The large share of public trade in total trade affects the calculation of the price elasticity of exports – public exports include food relief gifts, World Food Programme contributions and other non-market based operations.
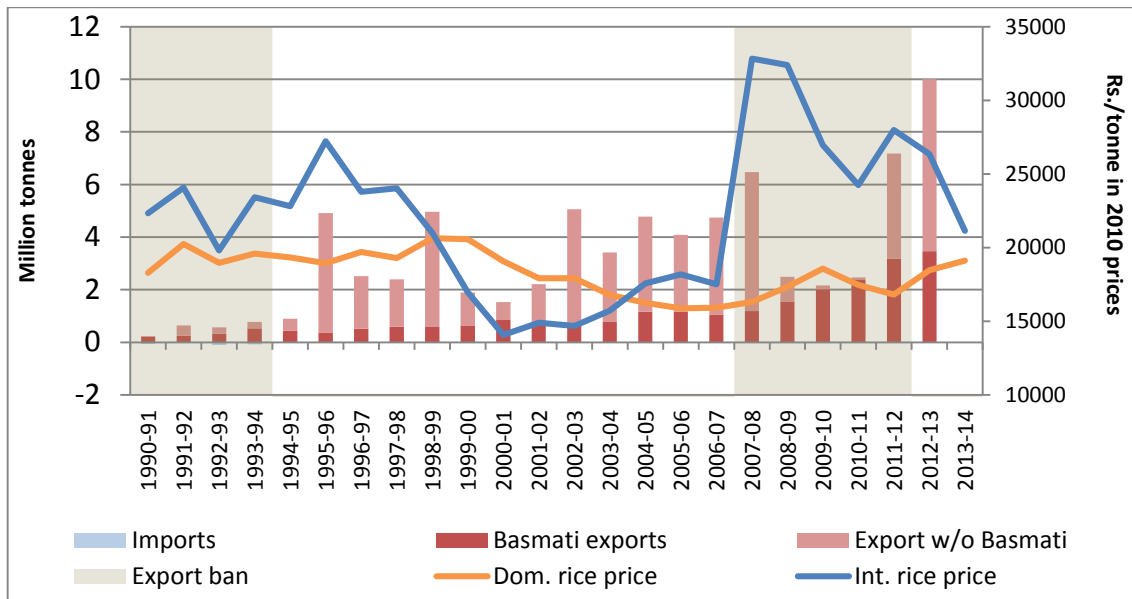
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[29] This would result in negative values for private exports when estimated as the difference between total (as reported by Directorate General of Commercial Intelligence and Statistics) and the FCI off-take for exports.

Figure 17 Total wheat trade in India

Source: Own calculation based on FCI data, DGCIS and IMF

Figure 18 Total rice trade in India

Source: Own calculation based on FCI data, DGCIS and IMF

As a result, the relationship between export volume and the ratio of domestic to international price has become positive, which means that a rise in domestic price with respect to the international price can be associated with higher exports. The estimation results of the regression of wheat and rice exports (as a share of production) on the ratio of domestic to international prices and export bans confirms this hypothesis.

The following regressions were estimated:

6
$$\frac{Exp_{t,i}}{Q_{t,i}} = \alpha_0 + \alpha_2 B_{t,i} + \alpha_3 \frac{p_{t-1,i}}{p_{t-1,i}^{int}} + \alpha_3 t$$

where $Exp_{t,i}$ is total volume of exported in a financial year, $Q_{t,i}$ is production of the respective grain, $B_{t,i}$ is an export ban dummy, $\frac{p_{t-1,i}}{p_{t-1,i}^{int}}$ is a lagged price ratio – domestic wholesale to international, converted to Rs., *t* is a time trend. The lagged price ratios are due to the delay in the realisation of export contracts and price expectation formation (in this way, we assume naïve price expectations). The estimation results are presented in Table 9 below.

Table 9 Foreign trade regression estimates

Dependant variable (as a total production share)	Net wheat exports	Wheat exports	Net rice exports	Rice exports
Export ban	-0.020	-0.023**	-0.021**	-0.020**
	(-1.60)	(-2.68)	(-2.39)	(-2.27)
Lagged ratio of market price to international price	0.065*	0.049*	-0.011	-0.004
	(1.71)	(1.95)	(-0.63)	(-0.25)
	0.002*	0.001**	0.002***	0.002***
Trend	(1.94)	(2.12)	(3.15)	(3.09)
_cons	-0.054*	-0.017	0.023	0.016
	(-1.74)	(-0.81)	(0.94)	(0.67)
N	31	31	31	31
R²	0.26	0.48	0.70	0.67

*Note. *,**,*** indicates significance levels at 10, 5 and 1%, respectively with Newey-West standard error estimation. t-values are given in brackets. Most of the dependent variables, according to the ADF test, are non-stationary. However, inclusion of a trend variable in the explanatory variables resulted in stationary residuals.*

For both wheat and rice, export bans significantly influence export volume. Years with export bans have on average lower exports by more than two per cent of production. The price ratio has a strong significant impact on wheat exports, and has no influence on rice exports. However, as discussed above, the direction of the impact of the price ratio is the reverse of what economic theory would suggest (Helpman & Krugman, 1989). An increase in the domestic price relative to the international price of wheat significantly increases the export volume of this crop. What is important is that neither of the regressions explains the variability of exports volume well –a maximum 48 per cent for wheat and 70 per cent for rice.

These results can be explained by the distortive character of trade policies in India. For example, in 2007-2009, rising international prices were not accompanied by increased exports and domestic prices for either wheat or rice. Skyrocketing international prices with stable domestic prices resulted in a widening gap between the two. However, due to the

export bans, there were only basmati rice[30] exports and no wheat exports registered. This phenomenon indicates high market distortion, but can be explained by Indian trade policies. Whenever international prices rise, the government intervenes with export restriction. This, in turn, leads to lower domestic prices, which drives the price ratio down with a simultaneous decrease in exports.[31] The opposite happens when high MSPs result in very high public stocks and relatively high domestic prices. The government's decision to release stocks for exports leads to higher exports with unchanged market availability (only the public stock level decreases) and market price. Consequently, we observe an increase both in the domestic market price and exports.

h. Fiscal costs

Analysis of the fiscal cost is based on data starting from 2001 because there were major changes in 1997, when the TPDS was introduced and in 2001, when the AAY group was defined and introduced.

Fiscal costs, as we define them in our framework, are based on the amount of wheat and rice handled by the FCI and states under the DCP within a fiscal year.[32] We use the cost and volume of procurement, storage and distribution as reported by the FCI. However, it is impossible to compare the estimated fiscal cost with the food subsidy incurred by the government. The food subsidy provided to FCI by the Ministry is in the form of consumer subsidy and buffer subsidy. For the quantity distributed, the difference between the acquisition cost and distribution cost incurred by FCI and the CIP realised is reimbursed as

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[30] Export bans were only for non-basmati rice. In 2007 and 2011, there were also non-basmati exports registered despite the export bans in these years. There are a few reasons for this. First, the export ban periods were not identical with the financial years. In 2007, after the introduction of the export ban, existing export contracts could be executed and in 2011, the export ban was lifted before the end of the financial year for which export data is quoted. Second, there were some exemptions to the bans. For example, there were exports of non-Basmati rice under government-to-government contracts to Bangladesh, Bhutan and Sri Lanka (Dave, 2010).

[31] The same conclusions were reached in Dasgupta et al., 2011

[32] The exception is the amount of grain procured as it relates to the marketing year. In the case of wheat, the financial year (April to March) and marketing year (March to February) are almost identical, but for rice, the difference is quite significant, as its marketing year last from October to September. However, most of the rice is procured from October to March; so, within the financial year, the cost of residual procurement from the previous rice marketing year and the major part of the current rice marketing year is captured. As a result, the consequence for fiscal costs is negligible in the case of wheat while in the case of rice, this means small deviations of the estimated cost from the actual cost.

consumer subsidy. According to the instructions issued, three months[33] average sales quantity is treated as operational stock. Stock over and above the operational stock is treated as buffer stock. For buffer stocks, the cost of holding and maintenance of the stock (i.e. interest, storage etc.) is reimbursed in the form of buffer subsidy.'(FCI, n.d.). So the food subsidy is calculated for grains distributed, not handled (this does not capture the total cost of procurement in the current year, which is claimed only after the grain is released). As a result, the volume of grain for which the fiscal cost and food subsidy are calculated is different. For further simulation purposes, we need to endogenise the fiscal cost and for the clarity of the procedure, we need to define the cost of operating the system based on procurement, stock and distribution level within the same financial year. The per unit cost of these operations is approximated by the numbers reported by the FCI.

The formula for the fiscal costs is given below.

7 $\quad FC_t = \sum_i ((c_{t,i}^p + p_{t,i}^{MSP})D_{t,i}^{FCI} + c_{t,i}^d PDS_{t,i} + k_t X_{t,i} - p_{t,i}^{PDS} PDS_{t,i} - p_{t,i}OMSS_{t,i} - p_{t,i}^{EX}NEX_{t,i}^{pub}),$

where FC_t are yearly fiscal costs, $(c_{t,i}^p + p_{t,i}^{MSP})D_{t,i}^{FCI}$ are acquisition costs[34] (proportional to the procurement level, includes the MSP) of the *i*-th crop, $c_{t,i}^d PDS_{t,i}$ are distribution costs[35] (proportional to the amount distributed through the PDS and OWS) of the *i*-th crop, $k_t X_{t,i}$ buffer carrying cost, $X_{t,i}$ is buffer stock (an average in the financial year stock in the central pool minus the operational stock) and $p_{t,i}^{PDS} PDS_{t,i} + p_{t,i}OMSS_{t,i} + p_{t,i}^{EX}NEX_{t,i}^{pub}$ are the revenues from sales with the average CIP and market price for OMSS (D) and net exports. Most of the components of the equation come from FCI reports (see Table 10).

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[33]The currently used definition of operational stock uses four months' off-take (CAG, 2013). Further, we will be using this definition in our estimates.

[34]As incurred by the FCI. It consists of freight, interest, handling and storage charges, transit and storage losses and administrative overheads (FCI)

[35] As incurred by the FCI. It comprises freight handling expenses, storage charges for operational stock, interest charges, transit shortages, storage shortages, establishment charges and wage revision arrears. (FCI)

Table 10 Categories as included in the Fiscal Cost equation

Variable	FCI Category	Source	Unit
$c_{t,i}^{p}$	Procurement incidentals (as proportional to the procurement level)	FCI (can be also estimated as 21% of the MSP)	Rs./quintal, WPI deflated
$D_{t,i}^{FCI}$	Total procurement	FCI	Million tons
$p_{t,i}^{MSP}$	MSP	FCI	Rs./quintal, WPI deflated
c_1	Distribution cost	FCI	Rs./quintal, WPI deflated
$PDS_{t,i}$	TPDS and OWS off-take	FCI	Million tons
k_t	Annual rate of buffer carrying cost	FCI	Rs./quintal, WPI deflated
$X_{t,i}$	Buffer stock	Estimated based on reported monthly stock positions in the central pool	Million tons
$p_{t,i}^{PDS}$	CIP	Estimated CIP weighted by off-take for different categories (APL, BPL, AAY and OWS) average	Rs./quintal, WPI deflated
$p_{t,i}$	Market price	Price based on the WPI index	Rs./quintal, WPI deflated
$OMSS_{t,i}$	OMSS off-take	FCI	Million tons
$p_{t,i}^{EX}$	Export price	Estimated as international price	Rs./quintal, WPI deflated, converted from the USD to the rupee using the then exchange rate
$NEX_{t,i}^{pub}$	Total net off-take for exports	FCI	Million tons

Source: Own design

Acquisition costs consist of the two components – the MSP plus a bonus (pooled cost of grain)[36] and procurement incidentals. Procurement incidentals are the additional costs like statutory charges, transportation charges and labour charges. The rest of the cost – distribution costs and buffer carrying costs – are also approximated by the past cost per unit reported by the FCI, multiplied by the PDS off-take and stock levels.

Total grain cost (acquisition, distribution and buffer carrying cost) in real terms have risen in the last seven years when compared to the period 2000-2006, mostly due to higher acquisition costs. They rose by around 12 per cent in real terms between 2000-2006 and 2007-2013. Distribution costs and buffer carrying cost for both grains decreased in real terms, so the total grain cost increase was subdued to 4 per cent for wheat and 5.4 per cent

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[36]The FCI definition of pooled cost of grain differs slightly – in their method, it is the weighted average cost of the opening stock at previous year's MSP and procurement of current year's crop at current year MSP.

for rice. After 2007-08, the total cost started rising dramatically (Figure 19). This is due to both growing procurement levels and stock levels.

On the revenue side, there are three components – the OMSS, the TPDS with the OWS and net exports. Both the OMSS allocation quantity and the MIP are *ad hoc* policy decisions, which are difficult to model.[37] However, the OMSS is sold through tenders, so we use the market price as a proxy for the price received for OMSS grains. Revenues from OMSS were estimated by multiplying (estimated or reported) quantity released by the market price. TPDS and OWS revenues were approximated by the off-take for different programmes (income groups – APL, BPL, AAY) with the relevant CIP (both quantity and CIP as reported by the FCI). The difficulty is that there are usually additional allocations, such as for flood relief or festival allocations, sold at different prices. So the difference between the total PDS off-take and off-take for APL, BPL and AAY is sold at different prices. It was assumed, that on average, this price was equal to the APL CIP. Finally, net export revenues were calculated based on the reported net export quantity and international price. However, this method will have an upward bias as a large share of public exports was in a form of humanitarian aid and the transportation cost of exports is not considered. In general, the estimate of revenue is based on several assumptions and is subject to errors. However, our goal is to produce a simple and transparent but detailed enough method for assessing the total cost of the implementation of the set of policy measures.

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[37] Even the authority making the decision has not been constant over time – sometimes it is the Ministry of Consumer Affairs, Food and Public Distribution and sometimes High-level Committee of the FCI (information obtained from the Ministry of Agriculture).

**Figure 19 Fiscal cost and food subsidy**
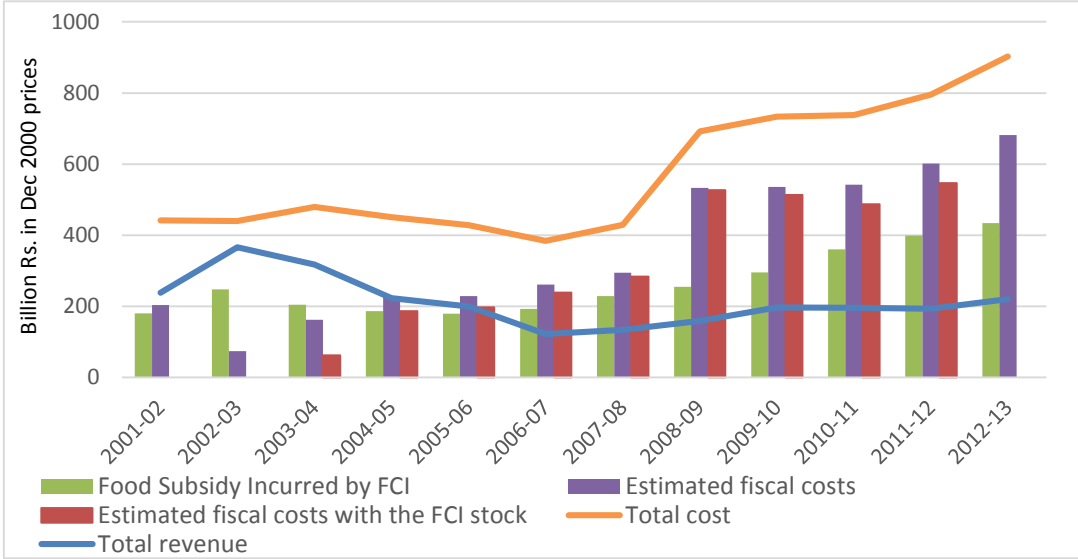
Source: Own calculation based on FCI data

The estimated fiscal cost has risen dramatically in real terms from the financial year 2001-02 (even more as compared to the value in 2002-03, which seems to be an outlier though) – by 235 per cent until 2012-13 (Figure 19). This number seems to be large as compared with the 80 per cent increase in the TPDS and OWS off-take in the same period. In 2001-02, the fiscal cost incurred per ton of distributed grain (wheat and rice on average) was Rs.7654 and in 2012-13, it rose to Rs.14204 (in Dec 2000 prices). In the same period, the average stock level in the central pool has increased by 35 per cent and procurement volume by 69 per cent. Food subsidy has also increased quite significantly – by 141 per cent in real terms.

The estimated total fiscal cost has been usually above the food subsidy incurred by the FCI (Figure 19). Except for the years 2002-03 and 2003-04, the fiscal cost fluctuated between 13 per cent and 109 per cent above the food subsidy. This difference can be explained by several factors. One is the way buffer stock carrying cost is accounted for by the FCI. The average buffer stock, as reported by the FCI in its annual reports, has been always much below our estimates based on the monthly stock levels as reported by the FCI (Figure 20). The estimate of fiscal costs with the FCI reported buffer stock slightly decreased the figure; however, the difference is quite small (Figure 19).

**Figure 20 Stocks of wheat and rice**
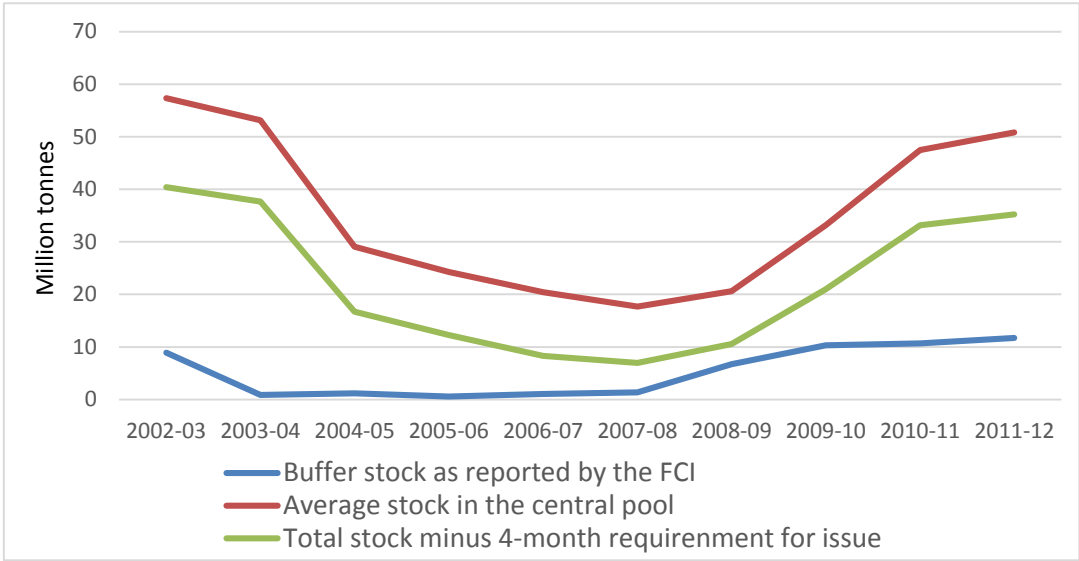
Source: Own calculation based on FCI data

Note: The FCI stock is own stock and held by the state governments under the DCP.

Second, the food subsidy, as reported by the FCI, related to the grain released, not held, as already discussed. And the procurement levels were usually higher than the total off-take (Figure 21), especially after 2006-07, which corresponds to rising difference between the estimated fiscal costs and claimed food subsidy. This might mean that the difference between the cost of procurement and revenue realised upon distribution is being reported in the next year, when the stock are released.

**Figure 21 Wheat and rice procurement and total off-take***
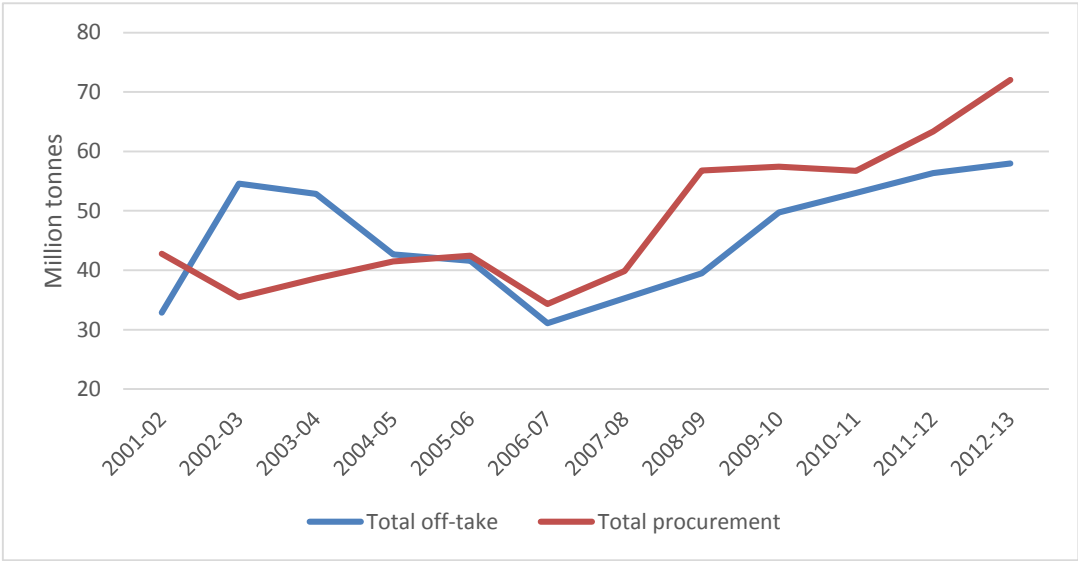
Source: Own calculation based on FCI data

**For TPDS, OWS, relief and defence, OMSS and net exports*

Finally, the fiscal cost estimation method is based on many assumptions and should be used to analyse the dynamics and composition of the costs of operating the system rather than comparing it with the food subsidy.

Figure 22 Composition of estimated expenditures
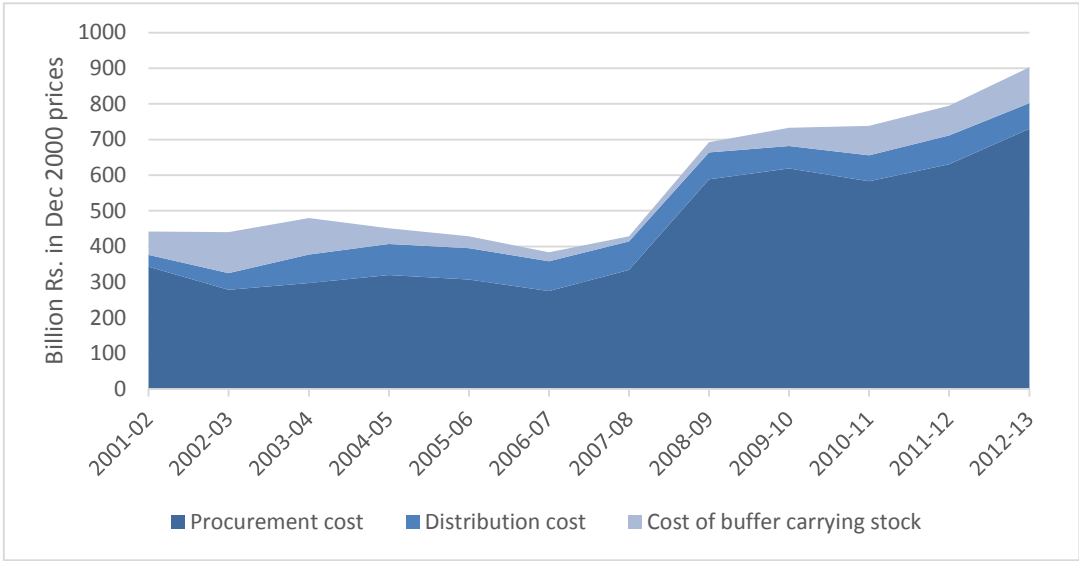
Source: Own calculation based on FCI data

Figure 23 Composition of estimated revenues
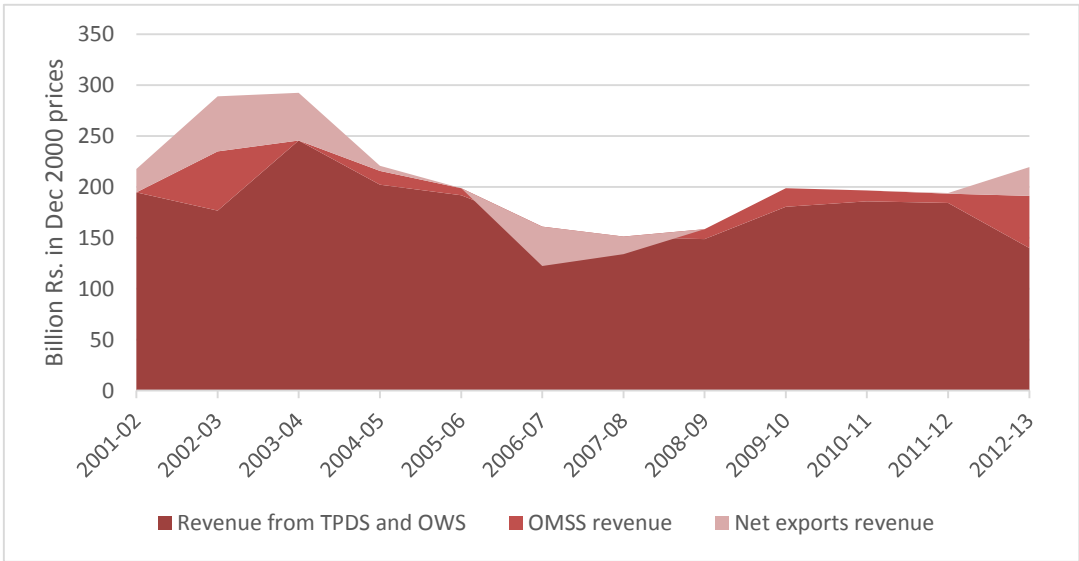
Source: Own calculation based on FCI data

Note: In case net exports are negative, net export revenue also becomes negative, meaning net losses from trade.

The major component of fiscal cost (Figure 22) is the cost of procurement, which consists of the MSP and acquisition costs. The considerable share in total costs, especially in recent

60

years has been the cost of carrying the buffer stock. The rising trend in costs is mostly due to increasing volume of grain that is procured, distributed and stored. On the revenue side (Figure 23), a dominant role is played by revenues from the TPDS and OWS. Interestingly, it has declined in real terms, even though the volume of distribution has increased. This is because the CIP has been constant in nominal terms, which implies a sharp decline in its real value. Both export revenues (except for the beginning of the millennium) and OMSS revenues have usually had a negligible share in total revenue.

### i.   Seasonal dynamics of prices and stock inflows and outflows

The seasonality in the production of wheat, with one production season per year, and rice, with two seasons – the smaller rabi and the major kharif – finds reflection in the respective seasonal patterns in procurement (see Figure 24 and 25). Most of the procurement is done around the major harvesting months. In the case of wheat, most of the grain is procured in two months – April and May. In the case of rice, the peak month is October; however, supplies come throughout the year, except for July and August. On the other hand, off-take under the TPDS and OMSS is steady throughout the year; as a result, stock levels are characterised by a pronounced seasonal pattern that reflects the seasonality of procurement. Another reason for fluctuations in the level of wheat stocks, not captured in the Figure 24, are OMSS releases, which usually happen, in case there are excessive stocks, before the arrival of the new harvest. As discussed before, OMSS does not apply in the case of rice.

Figure 24 Seasonal pattern of wheat procurement, off-take, stocks and prices
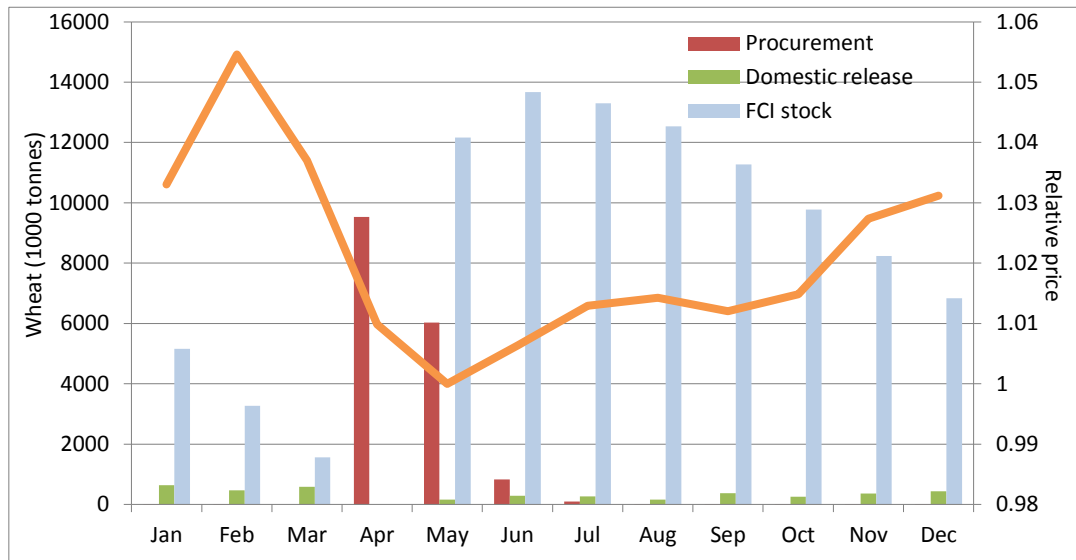
Source: Own calculation based on the data from various DFPD Food Grain Bulletins

Figure 25 Seasonal pattern of rice procurement, off-take, stocks and prices
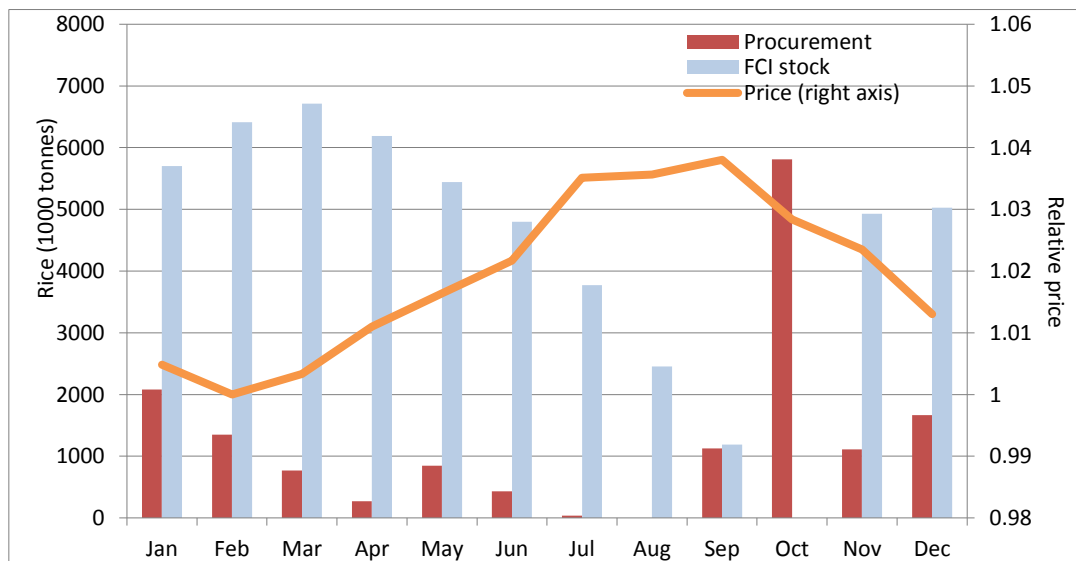
Source: Own calculation based on the data from various DFPD Food Grain Bulletins

Note. Seasonal dynamics based on X12-Arima RSA3 filter using Demetra Plus software. For wheat and rice prices: Log-transformed monthly WPI prices for 1990 to 2013 have been used; FCI stocks from 2000 to 2012; domestic release (i.e. sum of off-take for TPDS, welfare schemes and OMSS open tender sales) for 2000 to 2006 (only wheat); procurement for 1998 to 2002. Differences in estimation spans stem from restricted data availability.

The seasonality in procurement and stocks described above is reflected in the seasonal fluctuation in prices. Figures 24 and 25 show the normalised (to minimum value adjusted) seasonal component. Along with the new harvest arrival that coincides with the lowest public stock level, market prices drop and later rise gradually through the year. Wheat prices before harvest are more than 5 per cent higher than after harvest; for rice, the gap is almost 4 per cent.[38]

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[38] Note that these figures underestimate the seasonality as the underlying commodity WPI shows less fluctuation than the weighted average of wholesale market prices (see Appendix 1).

5. Simulations

The results obtained in the current study could be used for simulating the quantitative impact of several policies within a partial equilibrium model at a later stage. However, at this stage, simulation of simple scenarios with *exogenous prices* and without obtaining equilibrium were used to estimate the implications for fiscal costs and stock levels of some possible minor changes in current policy variables. Results of this exercise are presented below.

We developed five different scenarios projecting the exogenous variables over the next ten years until 2020-21.[39] The baseline scenario consists of the following projections of the exogenous variables:

Variable	Scenario
MSP	2% yearly real growth
Rainfall (R)	Moving average of past 22 observations
Population (POP)	Growth at 1.3% y-o-y (as in the last years)
PDS off-take	For 2013-14, as estimated for the NFSA obligations (based on DFPD (2014 p.27) estimates for the TPDS and own estimates for the OWS, total wheat and rice off-take is 59.97 million tonnes, with 33 million tonnes related to rice and 27 million tonnes to wheat), in the following years 1.3% yearly growth - the same as population growth
Real disposable income	In 2013-14, 4.8% growth, 2014-15, 5.7% growth, 6.5% growth from 2015-16 onwards (from the OECD GDP growth estimates and forecasts)
WPI	In 2014-15, 10%, equal to 6% from 2015-16 onwards (WEO (October 2014) projects declining CPI from 7.5% in 2015 to 6% in 2019)
Market wheat and rice prices	2% yearly real growth, the same as the MSP
Trade regime	No export bans
Total net exports	Wheat 4% of total production, rice 7% of total production
Public net exports	Set to zero for wheat and to 2 million tonnes for rice annually from 2015-16
OMSS wheat	2.5 million tonnes in 2014, 2 million tonnes in 2015-16 and 2016-17 and no off-take from 2017-18 onwards
OMSS rice	Set to zero
Acquisition costs, distribution cost, annual rate of buffer carrying cost	2% real yearly growth

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[39] In the case of some variables, the official data was available only until 2012-13, so they needed projection also for 2013-14.

Central issue price	Nominal as stated in the NFSA (2 Rs./kg for wheat and 3 Rs./kg for rice)
International prices in Rs.	3% yearly real growth

The alternative scenarios are the following:

- Scenario 1 – Drought scenario – with a drought in 2014-15 (rainfall equal to the record in 2009-10, the rest as in the baseline scenario)

- Scenario 2 – Constant MSP scenario – the MSPs and acquisition costs constant in real terms, the rest as in the baseline scenario (with the 2% growth in real terms in market prices, this results in a decline in the relative MSP)

- Scenario 3 – No NFSA scenario – without the NFSA, 2013 – TPDS and OWS off-take grows at the 1.3 per cent rate starting from 2013-14, the rest as in the baseline scenario

- Scenario 4 – Converging stocks scenario – the MSPs and acquisition costs change with a varying growth rate – between 0 and 5 per cent y-o-y in real terms, so that the public stock level for both wheat and rice converge to the stock norms by the end of the projection horizon. The rest as in the baseline scenario.

In all five scenarios, we assumed the same OMSS and export policy. Off-take through these two channels is similar to the past. In addition, we assumed that it does not respond to stock level changes. So, for example, even if the stock level is very high, the OMSS off-take does not increase. This may result in extremely high or negative stock levels, which is unrealistic or impossible. However, the purpose of this exercise is to isolate the impact of the MSP changes with and without the NFSA, 2013, on public stocks and fiscal costs. We also want to demonstrate how the stock levels are sensitive to small MSP changes and why, under the current policy, it has been so difficult to stabilise them.

The implications for public stocks and fiscal costs[40] (as defined in section e and h) of the above scenarios differ quite significantly.

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[40]All the other endogenous variables were simulated and used as inputs for the stock level and fiscal cost estimation.

**Figure 26 Closing public stock simulation under the baseline scenario**
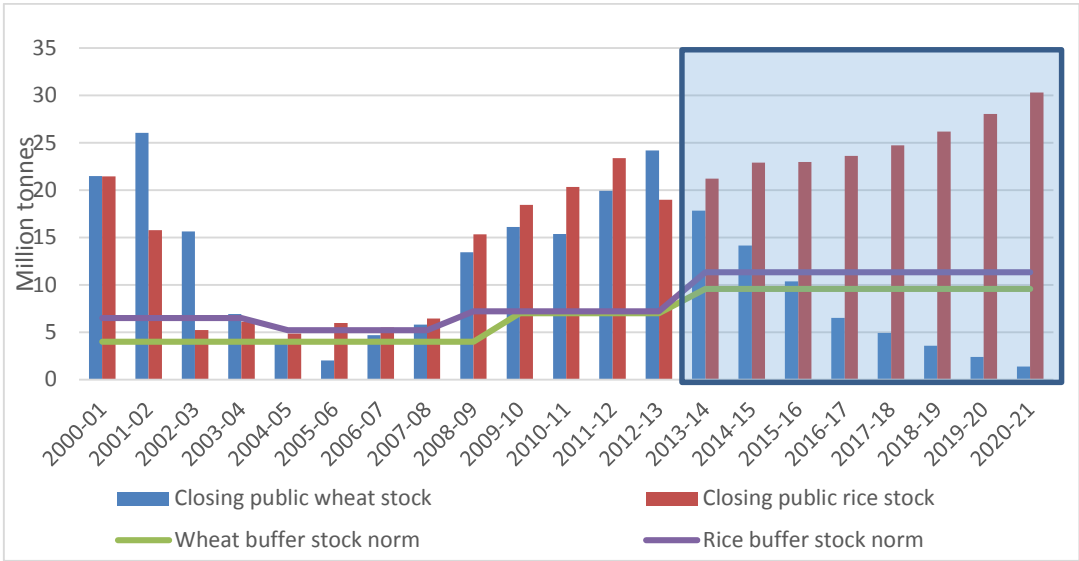
Source: Own calculation

The implementation of the NFSA means higher off-take; so, to ensure enough procurement, we assumed a steady, arbitrary rise in MSP in real terms – by 2 per cent annually for both wheat and rice. As a result, rice stock rises gradually over the projection period whereas wheat stock dips almost to 0, falling below the stock norm as early as in 2016-17 (Figure 26).[41] This difference between the two crops is due to a bigger change in wheat off-take brought about by the NFSA (the same problem repeats in other scenarios with the NFSA and no MSP diversification – the drought scenario and the constant MSP scenario) – rice off-take in 2013-14 is projected to remain almost the same as in the previous year, equal to 33 million tonnes while wheat off-take is projected to increase from 23 million tonnes to 27 million tonnes. At the same time, procurement of rice is well above 35 million tons, which, with no OMSS releases, results in mounting stock levels. Wheat procurement, declines even below 27 million tonnes in 2015-16 and gradually grows till 29 million tonnes in 2020-21, which, combined with a few more years of OMSS releases, leads to a fast decrease in stock levels.

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[41]Stock norms under the NFSA, 2013, as estimated in (Gulati & Jain, 2013).

Figure 27 Fiscal costs nominal and real under the baseline scenario
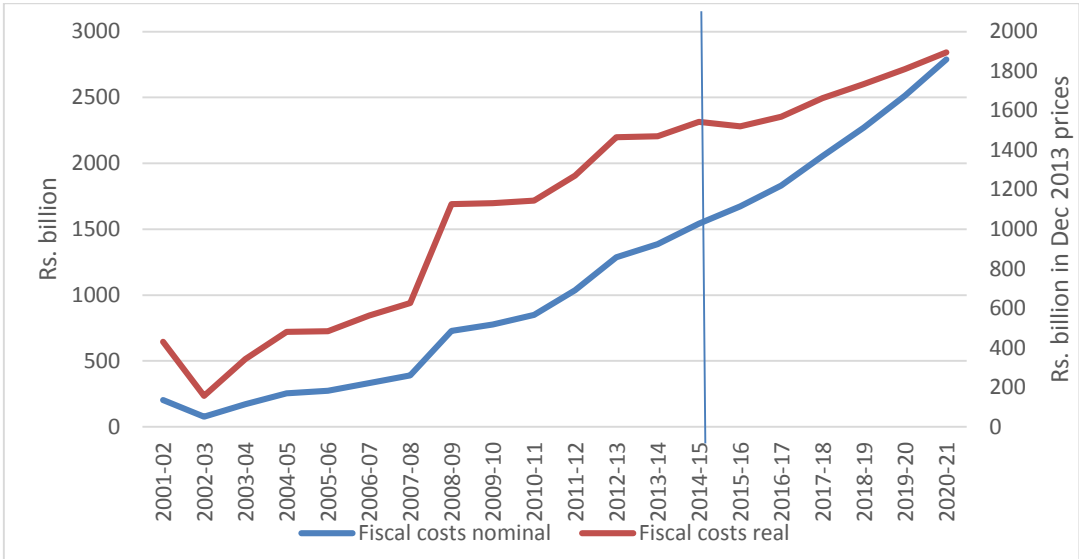
Source: Own calculation

The fiscal costs grow steadily in real terms under the baseline scenario (Figure 27) with the average growth rate equal to 3.7 per cent (inflation adjusted). The rising costs of procurement due to higher MSP and increased scope of coverage with decreasing CIP under the NFSA, 2013, is slightly moderated by revenues from OMSS (D) of wheat and rice exports.

Figure 28 Closing public stock simulation under a drought scenario
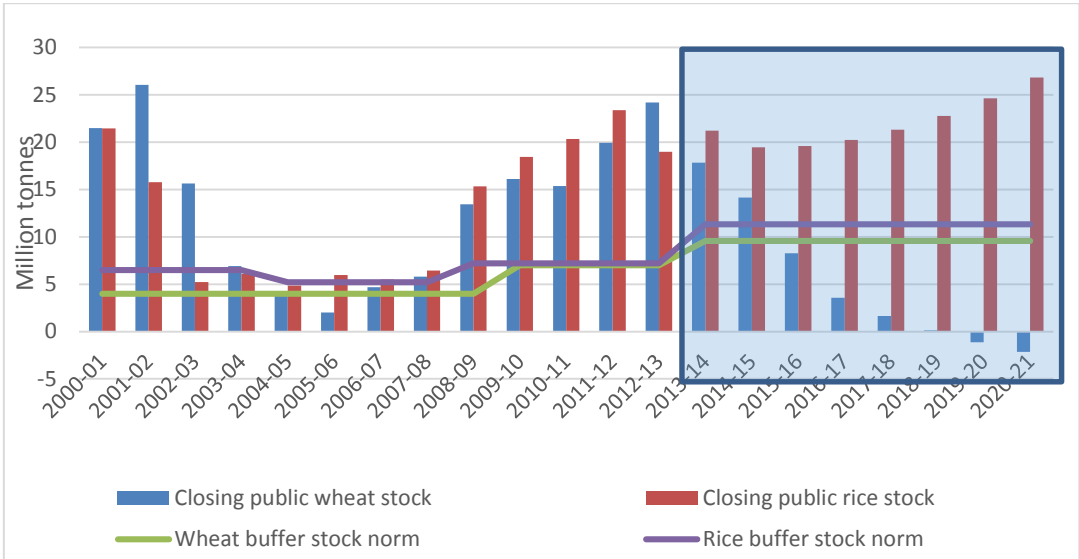
Source: Own calculation

In the case of a drought in 2014-15 (Figure 28), wheat supplies are endangered – the wheat stock level plunges below 0, which practically means introduction of an export ban or initiation of imports within the projection period since it is physically not possible to hold a negative stock; the government is also likely to take action as soon as the stock reaches the minimum stock limit (which means before 2015-16). In this scenario, the fiscal cost is underestimated. The heavy underestimation will also be true in the case of the constant MSP scenario. In both scenarios, rice stocks remain ample.

Figure 29 Fiscal costs nominal and real under the drought scenario
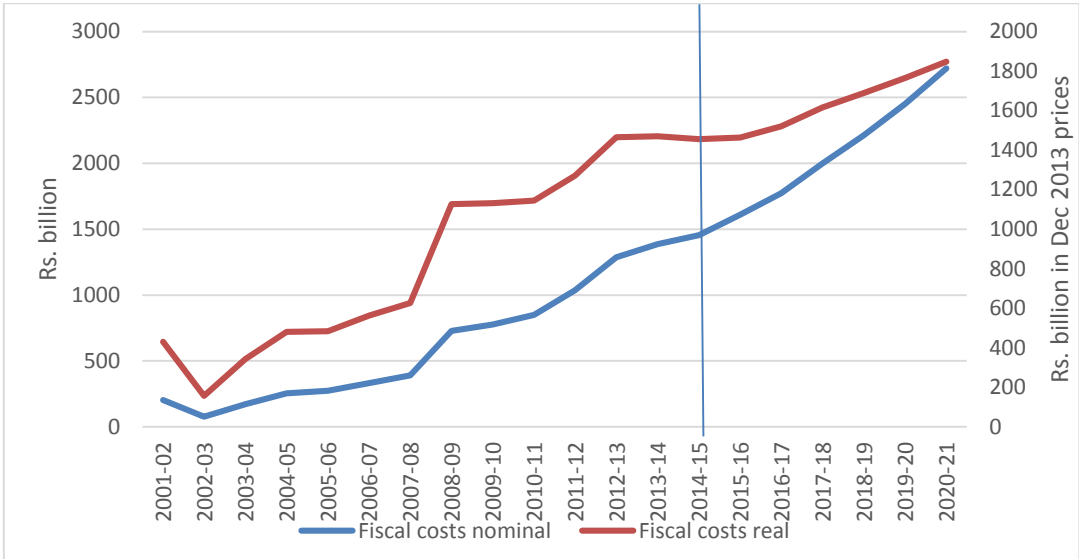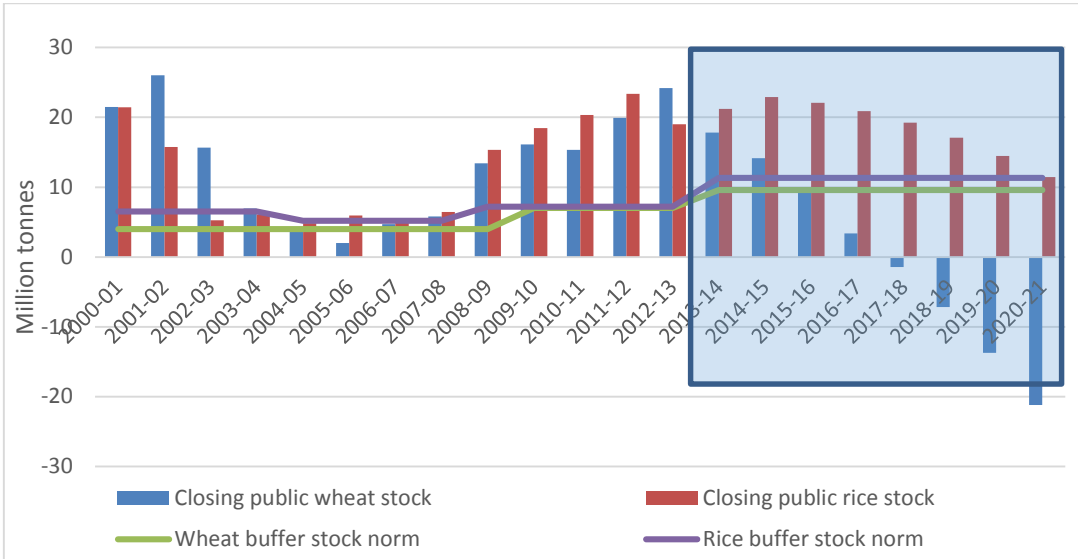

Source: Own calculation

Fiscal costs in real terms decrease under the drought scenario (Figure 29) in 2014-15 by 1 per cent and start growing only after 2016-17. This is because of the decline in production and, as a result, procurement.[42] The average growth rate of fiscal costs under this scenario is 3.3 per cent. However, as mentioned above, fiscal cost in this scenario is underestimated.

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[42] As the price ratio remains constant, the share of procurement is unchanged; hence, with lower production, absolute procurement declines.

**Figure 30 Closing public stock simulation under the constant MSP scenario**

Source: Own calculation

Freezing the wheat MSP in real terms at the 2014 level seems to be possible only for a few years. As in the drought scenario, wheat stock levels drop below the norm in 2015-16 (Figure 30). Even with ongoing exports and constant MSP, the rice stocks remain ample. It is interesting that wheat and rice stock balances have very different dynamics and respond differently to the same policy measures.

Figure 31 Fiscal costs nominal and real under the Constant MSP scenario
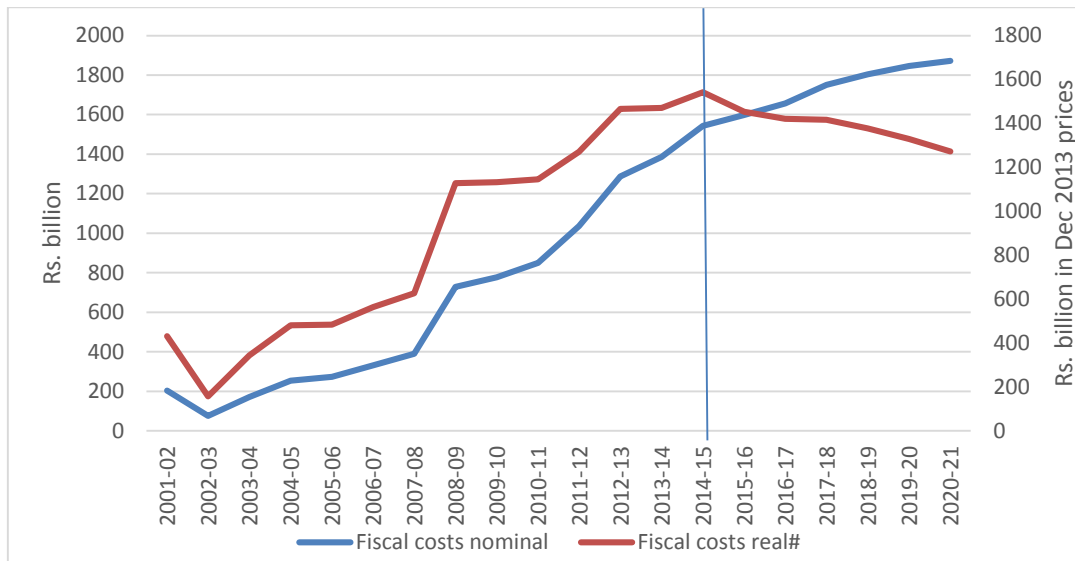
Source: Own calculation

Under the constant MSP scenario, the fiscal costs decrease significantly in real terms (Figure 31). Starting from the year 2015-16, the average annual growth rate is -3.2 per cent. But importantly, as in the drought scenario, the actual cost would be much higher as there would be a need to feed the TPDS. This can be done by imposing an export ban in order to deflate market prices and increase procurement or alternatively import or raise the MSP.

**Figure 32 Closing public stock simulation under the No NFS scenario**
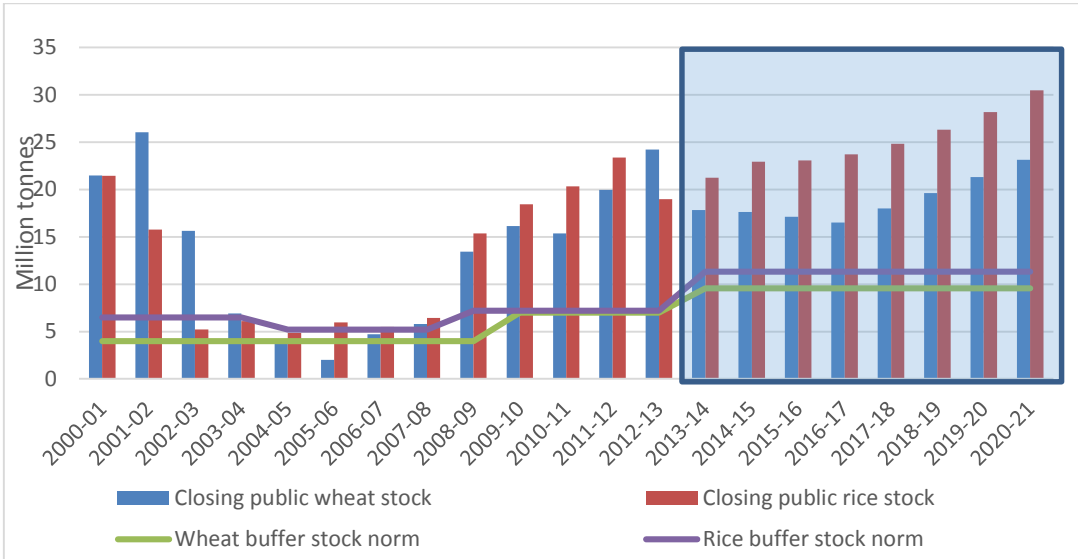
Source: Own calculation

Eventually, the steady increase (2 per cent y-o-y) in the MSP combined with no NFSA implementation (keeping the off-take per capita at the current level) results in mounting stocks, exceeding stock norms many times over).[43] The total closing stock climbs up to 54 million tonnes in 2020-21 under the no NFSA scenario. This approximately means an average stock level in 2020-21 of close to 65 million tonnes (based on section i seasonality analysis).

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[43]In this scenario, due to unchanged TPDS, the stock norms remain unchanged relative to the current ones.

**Figure 33 Fiscal costs nominal and real under the no NFSA scenario**
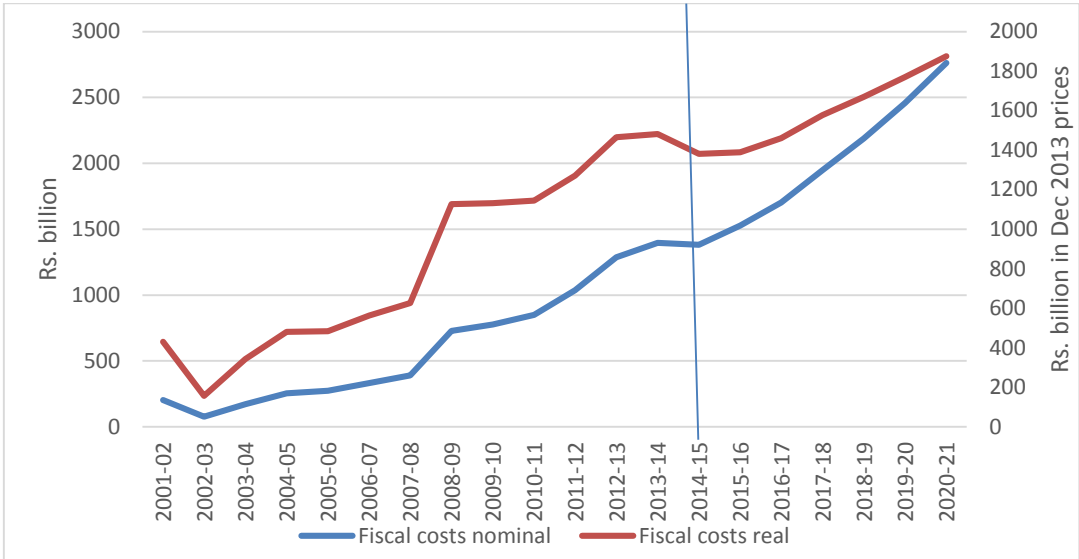
Source: Own calculation

The fiscal costs under the no NFSA scenario are moderated by higher (than in the baseline scenario) CIPs, as they are assumed to remain constant in nominal terms at the 2012-13 level (Figure 33). In 2014-15, there is a decline in the fiscal cost in nominal terms due to the lower buffer carrying costs (it can be seen in Figure 32 that the closing stock in 2013-14 is lower than in 2012-13, which implies a lower average stock in the following year). This comes as a result of increased off-take of wheat for OMSS in recent years.

 In this scenario, the fiscal costs might be overestimated since higher stocks enable more OMSS and exports, thus generating revenue.

Figure 34 Closing public stock simulation under the converging stock scenario
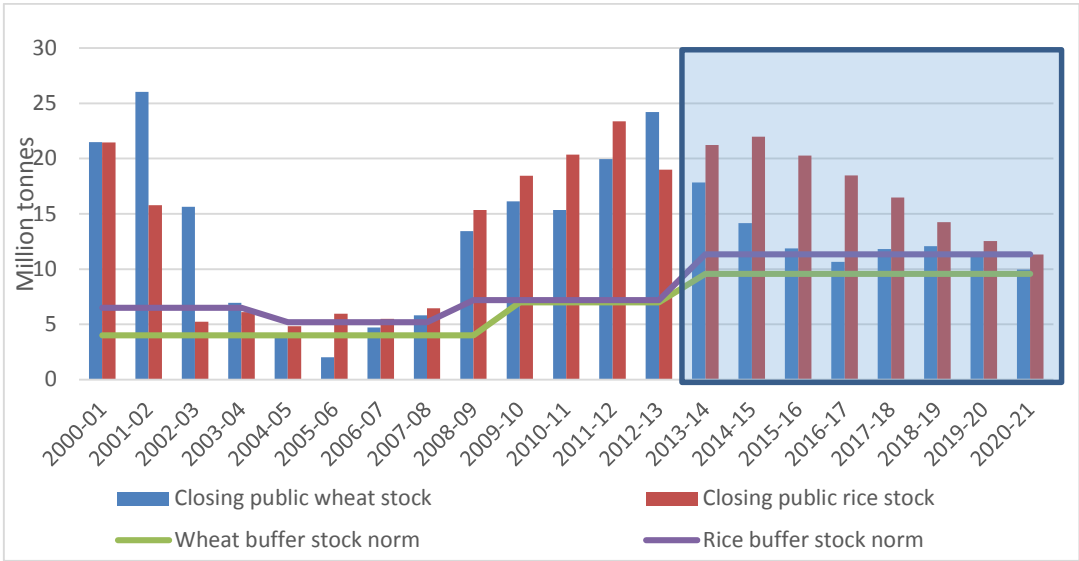
Source: Own calculation

Stock stabilisation within the projection horizon can be achieved by diversifying the growth rate of MSP. With rice stocks remaining ample, there will be no reason for a yearly real increase of 2 per cent in the MSP of rice; however, in the case of wheat, the drawdown of stocks will necessitate an increase in MSP to provide a higher procurement incentive. A scenario with a few strong increases in wheat MSP – by 5 per cent in 2015-16, 4 per cent in 2016-17 and 2 per cent in 2017-18 (later the wheat MSP remains constant till 2020-21, when it rises by 1 per cent) and virtually no changes in rice MSP – only 2 per cent increases in the two last years of the projection period, enables stabilisation of the stock level of the both crops (Figure 34).

Figure 35 Fiscal costs nominal and real under the converging stocks scenario
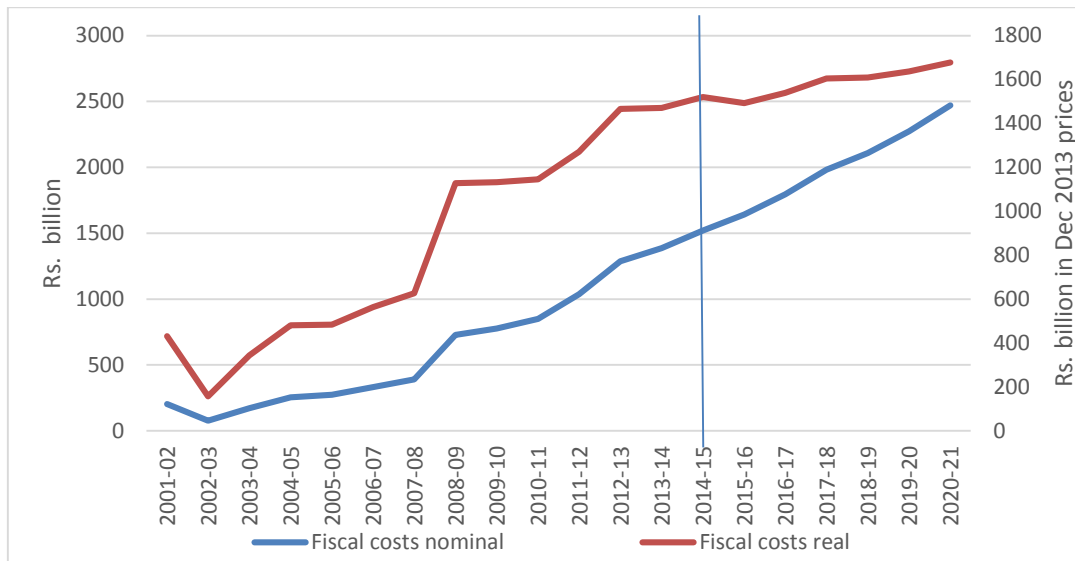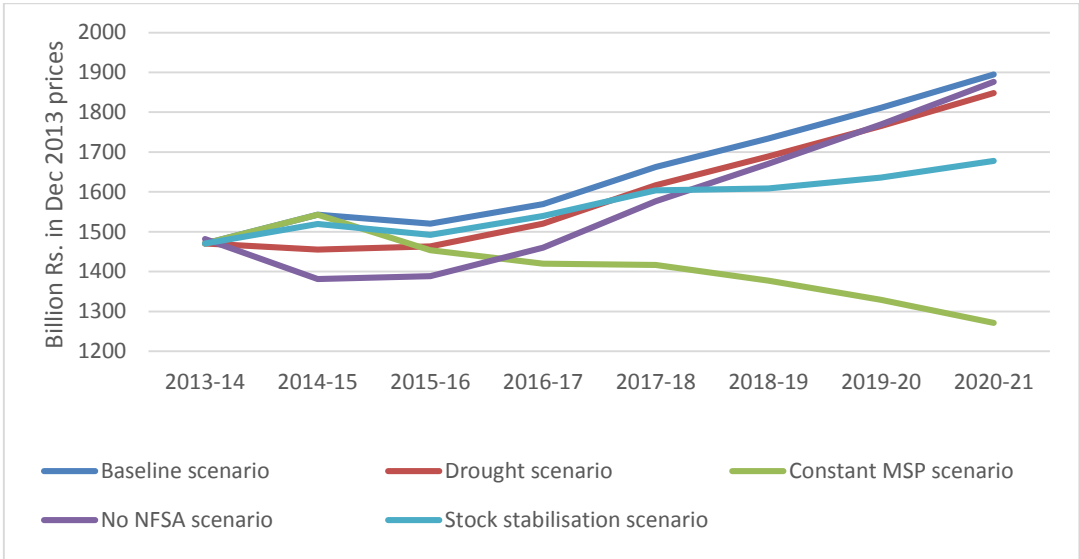

Source: Own calculation

Under the converging stock scenario, fiscal costs grow slower that in the baseline scenario – on average with 1.9 per cent annually in real terms (Figure 35). This is due to rationalising the stock level and minimising the MSP increases.

Figure 36 Comparison of stock levels in all five scenarios
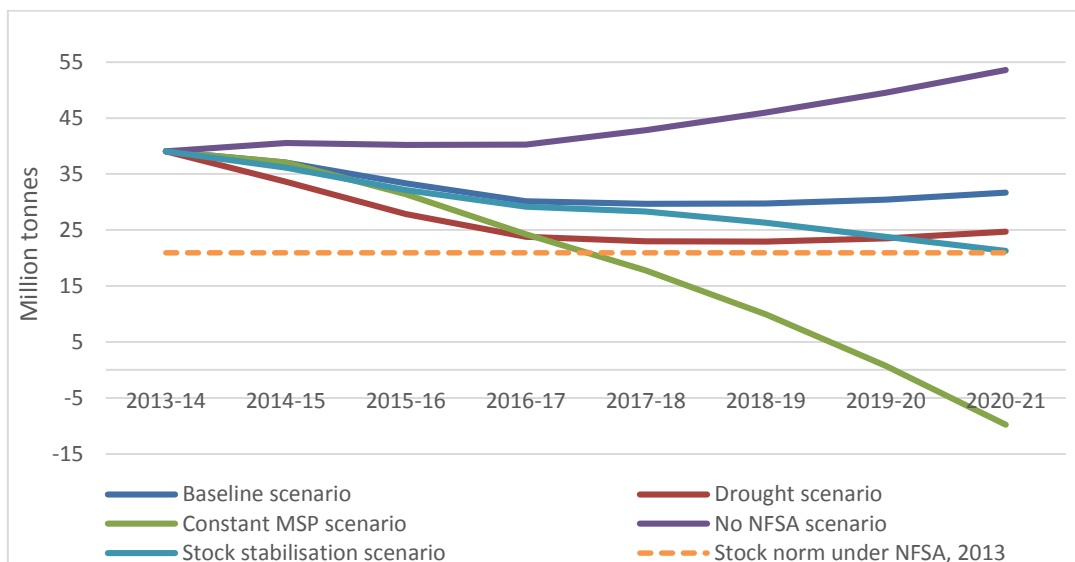
Source: Own calculation

Figure 37 Comparison of fiscal costs in real terms in all five scenarios

Source: Own calculation

A comparison of all five scenarios (Figures 36 and 37) results in a clear message – in the long run, fiscal costs will rise in real terms if MSP growth continues. However, as was shown above, the NFSA commitments require higher procurement, which can be achieved either through trade restrictions or constant increase in MSP. Careful MSP management, not allowing for excessive stocks, can curb the growth in fiscal costs. But this is a difficult task as the stock levels, due to the open-ended character of the procurement, are very sensitive to any even small changes in the MSP to market price ratio.

6. Summary and conclusions

The main findings of this study are as follows. Extensive market interventions resulted in a duality of the wheat and rice sectors with the coexistence of public and private sectors and dual prices, regulated and market prices. The regulated prices strongly influence real processes. Wheat and rice supply strongly and significantly respond to MSP. This result is robust with different specifications. In the case of wheat, price elasticity is higher, which might be due to the more commercial character of the crop. The price elasticities are high compared to acreage and yield elasticities for other countries, which can be explained by the low price risks due to minimum prices. Wholesale prices at planting or lagged harvest time prices are largely irrelevant.

The FCI procurement volume is driven by the production level and the difference between the MSP and the market price. For rice, there is also an upward trend in the proportion of procured grain to total production.

The demand equation estimation turned out to be challenging due to the endogeneity of market price and because of the difficulty in accounting for the consumption from PDS (due do fluctuating and mostly unknown leakages from the PDS). Eventually, the instrumental variable regression was used to assess the impact of the market price on wheat and rice consumption. PDS grain was considered both as a perfect and imperfect substitute for market grain. The signs of the estimated price elasticities for wheat are significant and consistent with theory. For rice, they turned out to be insignificant. Rice consumption turned out to be determined mostly by the time trend and the PDS. The impact of the PDS on wheat consumption is ambiguous. This difference in influence of the PDS on consumption can be explained by the higher rice PDS off-take and lower leakage and high additional subsidy (including universal public distribution) in some big rice consuming states.

Public stock analysis revealed higher storage losses in the case of rice as compared to wheat – 10 per cent and 2 per cent respectively. These numbers are difficult to compare with other studies' estimates due to high variance in results and differences in methodology. OMSS allocations were usually made in case of wheat due to higher seasonality of production and prices. The actual off-take for the OMSS was much below allocations.

The analysis of private stocks was challenged by poor data availability and strong time- and state-varying regulations to private stockholding. However, the estimation results for rice are consistent with the theory of competitive storage and the total supply is found to be one of the main drivers of private storage. Furthermore, strong crowding out effects of public stocks on private stocks was found. Nevertheless, as the coefficient is smaller than one, public stocks seem to only partially crowd out private storage, which can economically be interpreted as the behaviour of an "imperfect substitute". Export restrictions are found to increase private closing stocks as well as a surplus in the rest of the world does; both findings are in line with expectations.

Data quality was also a major issue in analysing international trade, particularly due to difficulties in distinguishing between public and private exports. As a result, total exports were analysed. Trade policies, like export bans, seem to react to national and international prices, diluting 'normal' market dynamics (i.e., the higher the international prices, the lower the exports).

The seasonal analysis of intra-year data revealed strong seasonality in prices and procurement, in particular for wheat (less for rice). Off-take from the PDS is non-seasonal. As a result, fluctuations in the stock level are characterised by strong seasonal patterns, which are accounted for in the buffer stock norms.

Starting from 2006-07, there has been a clear upward trend in inflation adjusted fiscal costs associated with procurement, storage and distribution of wheat and rice. There has been a strong rise in expenditures coming mostly from the rising procurement volume and the MSP. On the other hand, revenues have declined in real terms, due to lower real CIP and only marginal revenues from OMSS (D) and exports. As a result, not only have total fiscal costs increased, fiscal costs relative to the amount of grains released through the PDS have also increased.

The implementation of the NFSA will put a lot of pressure on the system – maintenance of ample stock to meet the needs of the public distribution system requires increasing MSP in real terms (especially for wheat) and possibly other market interventions in case of negative production shocks. This will inevitably lead to higher fiscal cost.

The high degree of government involvement in wheat and rice production, trade and storage has resulted in several market distortions and mounting fiscal costs. Further research should

be focused on developing and evaluating alternative policies, like switching from the PDS to food subsidies or from the MSP to deficiency subsidies, which would be less distortive and less costly.

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Appendix 1 Price series constriction

In order to transform the wholesale price index component into a price time series, we need a conversion factor. The monthly price is calculated by assigning a weight to the price in a state by the most recent share of that state in total production and then calculating the weighted average price for all of India. This is done for four consecutive years. Then, the monthly conversion factor is calculated as the ratio of the monthly price and the WPI component. The average over four years is taken to use it as the final conversion factor. The stronger seasonality of production weighted prices goes into the conversion factor. The fluctuations of the conversion factor are the rationale why we cannot use just one month to scale the WPI

Figure 38 Paddy WPI and major producing states production weighted price average
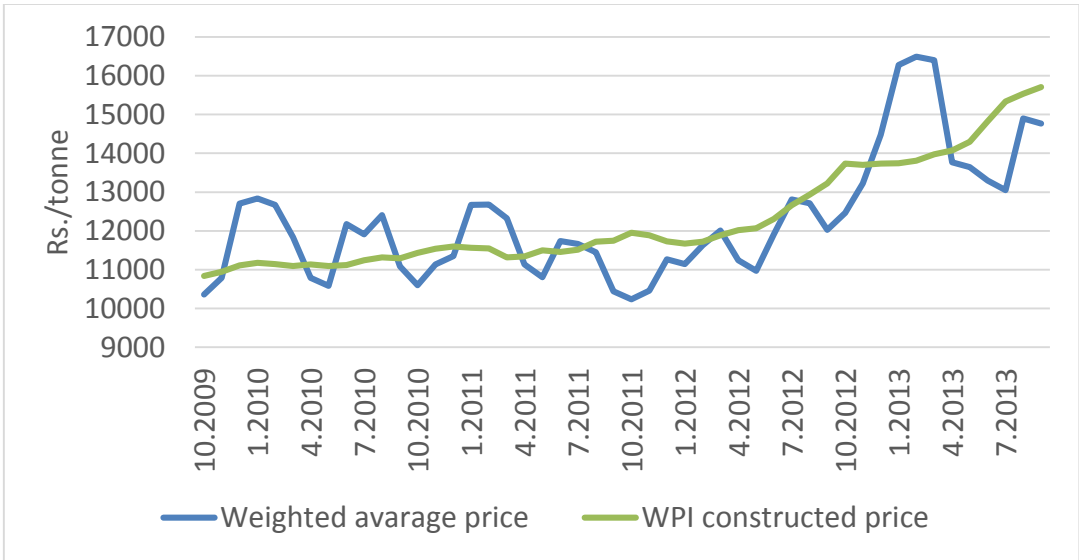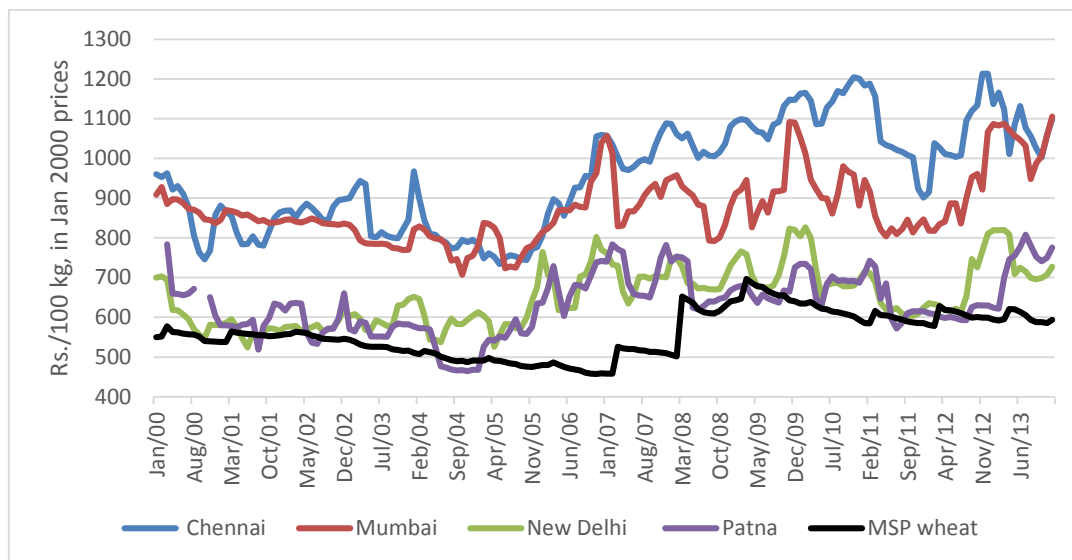

Source: Own calculation based on http://www.dacnet.nic.in/

Figure 39 Wheat WPI and major producing states production weighted price average
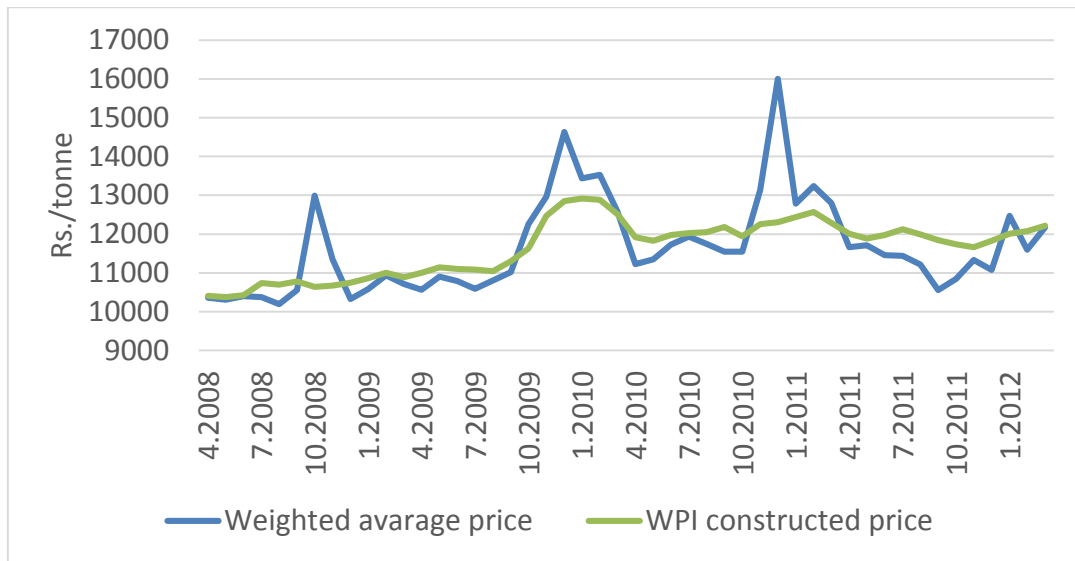
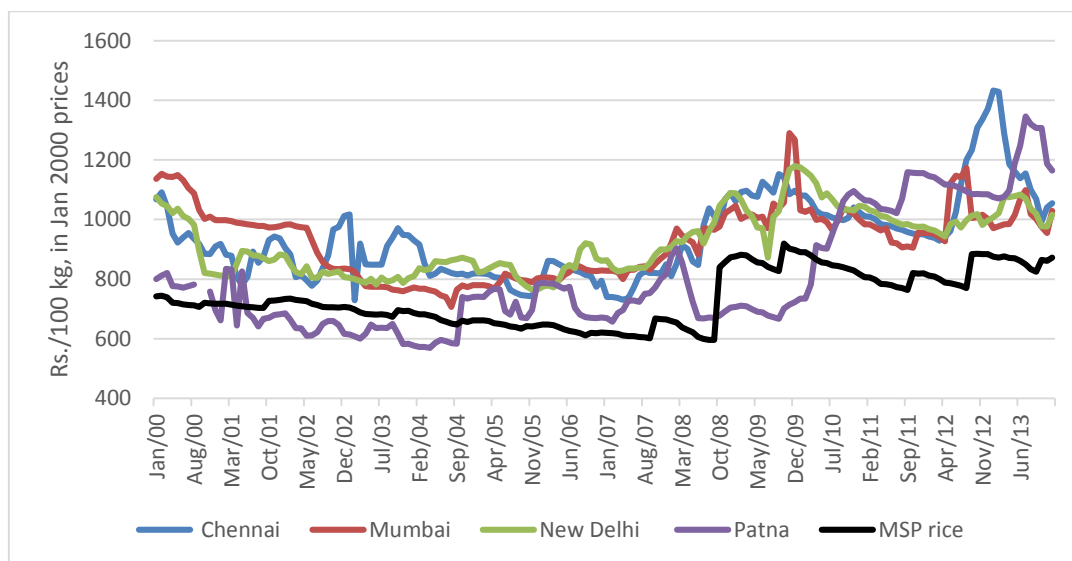*Source: Own calculation based on http://www.dacnet.nic.in/*

Appendix 2 – Regional heterogeneity of prices

Figure 40 Wheat wholesale prices in selected markets

Source: Own design based on the GIEWS, FAO data

Figure 41 Rice wholesale prices in selected markets

Source: Own design based on the GIEWS, FAO data

Appendix 3 – Data sources

Variable	Source
Production	USDA
Consumption	USDA
Marketed surplus	Ministry of Agriculture, Government of India
Procurement	Food Corporation of India (FCI)
TPDS, OWS off-takes	FCI
MSP	FCI
WPI	Ministry of Statistics and Programme Implementation, Government of India
Stocks	FCI
Rainfall	India Meteorological Department, Government of India
Personal disposable income	Reserve Bank of India
Food subsidy	Ministry of Finance, Government of India