What Drives India's Rice Stocks? Empirical Evidence

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Abstract
India has a long tradition of maintaining public rice and wheat stocks. Storage and trade policies helped to stabilize prices in the past. However, stock levels and costs are surging while it remains unknown how different factors quantitatively contribute to public stock levels or how private stockholders are affected. This study addresses these issues by empirically quantifying drivers of public carry-over rice stocks at the national level. Furthermore, it applies a recently developed method and combines it with an instrumental variable approach to quantify determinants of private grain stocks. Public storage is found to be inert and driven by the minimum support price (MSP), market supply, and export bans. Private stocks are driven by private supply (production and private stocks) and export opportunities. Each ton of public stocks crowds out half a ton of private stocks but despite huge government interventions, speculative storage activities persist. This is beneficial for consumers as the public stocks currently offer no crisis-responsive consumer protection – only export restrictions do. The 29% increase of the real minimum support price in 2008 contributed 4.9 million tons to public stocks, the export ban another 3.9. These factors, combined with the bumper harvests in 2010 and 2011, led to the recent surges in public stocks. Findings furthermore indicate that policy makers were aiming to implement price stabilizing policies in the wake of the world food crisis but did not anticipate that these policies would result in massive public stock increases. This underlines the need for adjustments in the current system. Different econometric models are applied as robustness checks and yield comparable results.

1. Introduction
Over many years, India's government has tried to tackle two problems with their storage and trade policies: (i) low prices for staple food commodities which may hurt producers, and (ii) high prices which may be problematic for consumers. The rational for public interventions to stabilize prices is provided by the large share of poor people as well as the sensitivity of the population to high prices (compare e.g. Sidhir 2004). The lower boundary for prices is effectively represented by the Minimum Support Price (MSP) which is set by the government every year before planting of the new crop starts. The MSP is designed to cover the costs of production and leave a "reasonable" margin to farmers (Kozicka et al. 2015b). At this price, open-end procurement of rice paddy is guaranteed to farmers. It was claimed, that the MSP follows the international prices in the long run, but even then it remains exogenous for the Indian market actors. Grains are then stored and given to the poor at subsidized rates. However, farmers are free to sell their grains to the open market, i.e. any type of market agent, instead. Trade quotas and bans are used as ad-hoc policies to prevent price surges. While this stabilized domestic prices (Anderson et al. 2013; World Bank 2010), it also amplified world price increases (Anderson et al. 2013; Headey 2010) and led to surging public stocks resulting in large fiscal costs for the government (Kozicka et al. 2015b). Hence, it is questionable whether India's price stabilization policies are cost-effective and can be sustained in the long run. Given the large share of poor households in India, pro-poor food policies are of crucial importance for the country but new policies which achieve the same goals at lower fiscal costs and with lower levels of leakages need to be explored (Kozicka et al. 2015a).

Whether less government involvement and more reliance on the private sector can be part of such a strategy is a question of particular importance.

This study explores the drivers of public and private carry-over rice stocks under the current institutional setting. A new way to analyze the drivers of public storage is applied and a recently developed theoretical method for the analysis of private stock drivers based on the competitive storage model (Brockhaus and Kalkuhl 2015a) is used, adjusted, and applied to Indian data and policies. This allows endogeneity problems to be overcome, which typically plague empirical modeling of supply, demand, and storage. In particular, it is analyzed how the market supply, export opportunities, and policy variables such as buffer norms and the MSP influence the carry-over rice stocks. Public stocks can be analyzed with a simple OLS regression on the levels or first differences while private rice stocks require an instrumental variable approach. To deal with the relatively low number of observations, models are kept as simple as possible and results for different specifications are provided (including levels and first difference specifications). Additionally, different estimators are used in case of the instrumental variable approach to estimate private stocks. Finally, both USDA and FAO-AMIS data is used for separate private stock regressions as an additional robustness check. The Indian government itself does not provide any estimates for private stock data. Overall, this study therefore contributes to the string of literature which analyzes India's market interventions to improve food security policies and possible options for reforms of these policies (Baylis et al. 2013; e.g. Ganesh-Kumar et al. 2012; Gouel et al. 2014; Gulati and Jain 2013; Gulati and Saini 2014; Gupta 2013; Jha et al. 2007; Kozicka et al. 2015b; Pursell 2014; Shreedhar et al. 2012; Srinivasan and Jha 2001, 1999).

A particular focus of this study is the interaction between public and private stocks. In general, knowledge about how public stocks influence private stocks is mostly derived from theoretical models (Brockhaus and Kalkuhl 2015b; Miranda and Glauber 1993; Williams and Wright 1991; Wright and Williams 1982) but quantitative empirical studies on this question are missing. Typically, stock data is not available or is poorly documented (Abbott 2013). India constitutes an exceptional case in the sense that data on both private and public stocks is available and the system underwent no major changes for a time period of about 40 years. Hence, India provides a rare situation that allows analyzing how public stocks influence private stocks. Naturally, results are specific to India. Private stocks are held by farmers, traders, millers, and co-operatives. Private-public partnerships have also been built to extend and modernize the storage capacity (World Bank 2011).

Public rice stockpiling policies are well defined in India by setting the MSP which drives the procurement. In addition, rice millers are indirectly taxed by having to deliver a state-dependent share of their milled rice to government agencies (Saini and Kozicka 2014). This so-called levy has been used since the mid-1960s (Acharya et al. 2012) but it has been announced to be discontinued from October 2015 onward (Dash 2015). The procured grains are stored and (supposedly) given to the poor through the public distribution system (PDS) which offers predefined quantities of rice and wheat at fixed prices. However, leakages are substantial (Drèze and Khera 2015; Gulati and Saini 2015). Up until 1997/98 the distribution was non-targeted and specified quotas of subsidized grains were distributed through so called fair price shops (Jha et al. 2007). From 1997/98 to 2000/01, a transition to a targeted system was made in order to reduce costs and improve targeting the poor (ibid.). Quantities and prices then became specified for three groups, the poorest of the poor (AAY), the below poverty line (BPL) and above poverty line (APL) (for an analysis of the PDS compare e.g. Khera 2011). These quantities and prices are rarely changed. Other Welfare Schemes (OWS) exist, through which the government releases additional quantities such as for mid-day meal schemes (Saini and Kozicka 2014). In this analysis, these are treated together with the PDS offtakes. Additionally, the government can release grains for public exports or through the Open Market Sales Scheme (OMSS) if stock levels are above the predefined stock norm while rarely occurring public imports may be used to ensure stocks do not fall below the norm. Figure 1Figure 1 provides an overview about all processes related to the public carry-over rice stocks, i.e. the inflows and outflows which happen during the marketing year.

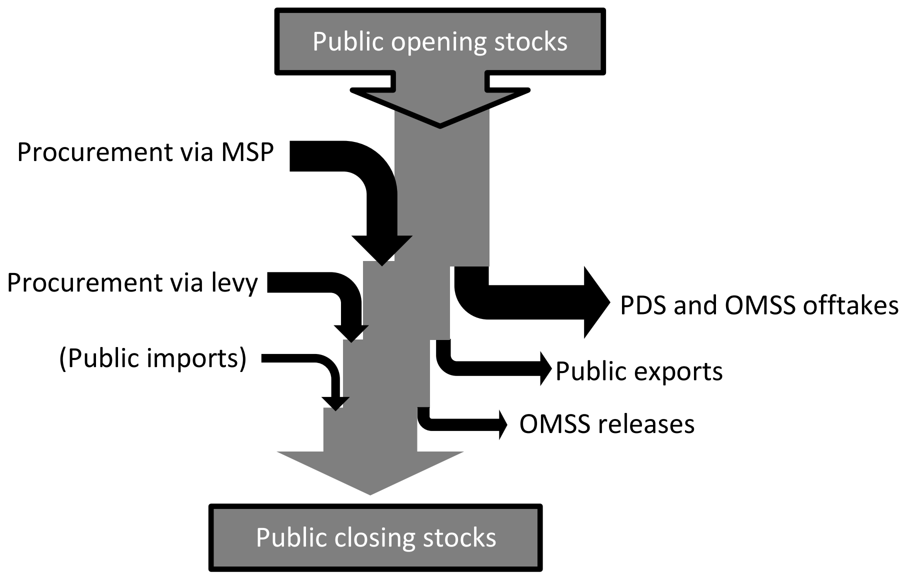

Figure 1: Overview of drivers of public ending stocks (inflows and outflows)

Note: Own illustration. The sizes of the arrows indicate qualitatively the relative importance of the process. Public imports are in brackets because they rarely occurred and if so, they were very small.

Regulatory policies for private storage have been in place in the past and have partly been reenacted such as upper limits on storage volumes for different types of agents. These regulations were introduced by the Essential Commodities Act enacted in 1955. In 2000-2001, rice and other commodities were no longer regulated (Ahluwalia 2002; Landes and Gulati 2004). However, during the world food crisis in 2007-2008, regulations on rice and other food staples were put back in place (Thaindian News 2008). These policies are criticized but still maintained (Cummings et al. 2006; Landes and Gulati 2004; Pursell 2014; Reardon and Minten 2011; Saini and Kozicka 2014). Furthermore, these policies are imposed on the state level, very time-dependent and ad-hoc, poorly documented and difficult if not impossible to aggregate to the national level. Often these policies are not fully implemented or implementation controls suffer from corruption and intransparent and lengthy processes (Mooij 1994). All these factors make it impossible to control for impacts of such policies and as a result they are not considered in the analysis.

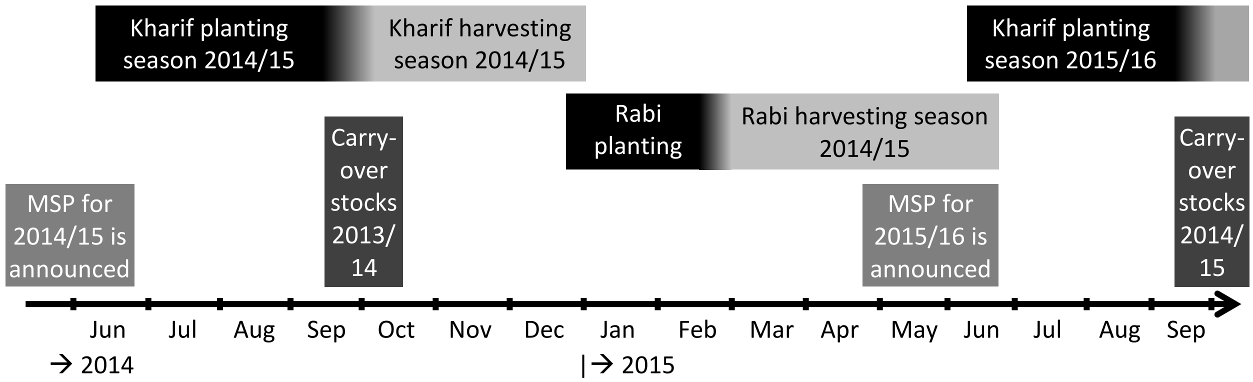

Figure 2: Timeline of events within one marketing year (Own illustration)

There are two rice crop seasons in India, the bigger kharif crop is harvested between October and December and the smaller rabi crop is harvested from March to June (Figure 2). Therefore stocks reach their lowest levels at the beginning of October, right before the new harvest is starting (Figure 3 and Figure 5). Hence, this is considered to be the end of the marketing year where the carry-over stocks are measured. The highest public stock levels are observed between March and April when the second harvest is procured. Overall, some modern silos are available but in most areas there is a lack of modern storage facilities and grains are commonly stored with the cover and plinth method which results in huge losses (Sharon et al. 2014).

The following sections successively describe the data, methodological approach, estimation strategies, results, and conclusions.

2. Data

Data is collected for as many years as possible; however, the data-generating process must not change during the time of the analysis. Before 1975, there were two official prices announced by the government, the Minimum Support Price (MSP) which was a lower boundary of the rice price and the Procurement Price at which the crop was procured by public agencies (Ramachandran 2005). Usually, the procurement price was higher than the MSP but lower than the market price. In 1975, the system was changed to its current version where there is only one price, the MSP, which is announced and guarantees open-end procurement at this price by the government (ibid.). For this reason, no data for the years before 1975 is considered. As a result, a maximum of forty observations can be obtained with data from 1975 to 2014. During this time period, no major reforms were carried out which changed the overall nature of the data-generating process. The most important reform was the National Food Security Act 2013 (NFSA) which extended the existing public distribution system to provide subsidized grains to about two thirds of India’s population. So far, this act has been rolled out only in some states due to several implementation difficulties, including identifying beneficiaries (Das 2015; High Level Committe on Restructuring of the FCI 2015). Therefore, the buffer stock norms were adjusted and accompanied by changes in the public distribution system (Gulati and Saini 2014). However, procurement procedures did not change.

Data on the MSP, public stocks, and buffer norms is obtained from the Food Cooperation of India (FCI), the Ministry of Statistics and Programme Implementation, and the Reserve Bank of India. Production and demand for India as well as for the rest of the world is obtained from the USDA. The MSP is deflated with the World Bank Consumer Price Index. Gulati et al. (2013) provide the times when rice exports were banned.

Empirical data on storage is always scarce and badly documented. The data collection, dissemination and transparency has often been criticized (e.g. Abbott 2013). However, the FCI publishes monthly stock levels for the main staples from 1995 onward. October rice stocks, which are the closing stocks before the new harvest is brought in, are reported from 1990 onward only. However, January (end of the fiscal year) and April stock levels are also reported in the years before and could be obtained from 1972 onward. Data on private storage is usually even harder to obtain. Nevertheless, in India, both the USDA and FAO provide data for the total closing rice stocks, i.e. the sum of private and public stocks in October (FAO-AMIS 2015; Mustard and Singh 2015). It is claimed that no other information is published about privately held rice stocks (Mustard and Singh 2015) and that industry sources are consulted for the USDA estimations. Apart from using industry sources, stock data is often calculated as residual from demand and supply balances (Abbott 2013). The AMIS-website, where the FAO data is obtained, defines the ending stocks as the quantity of the crop held at all levels within the food system before the new crop is harvested (FAO-AMIS 2015). Furthermore, AMIS states that its forecasts are based on official and non-official sources. However, no specific details are provided on how the total stock levels are obtained. FAO STAT only reports stock changes but not stock levels, but a comparison shows that their stock changes do not correspond to the total FAO-AMIS or public FCI stock changes which indicates that other sources or inputs must have been used for the calculation of the total stocks. Often, FAO stock data is computed as a residual from the estimation of the other demand and supply categories such as production, trade, losses, and total demand (Abbott 2013).

Data on surplus of the rest of the world (RoW) is calculated by subtracting the demand trend from the actual production which is brought in at the beginning of the marketing year. The trend is used because demand is not fully foreseeable during the marketing year. Data on production, private stocks, and public stocks is detrended by a Hodrick-Prescott filtered domestic consumption trend to obtain a stationary time series. For the surplus in RoW, the RoW consumption trend is used. Formal tests for stationarity are not reliable without a large number of observations. Nevertheless, most variables are stationary after detrending, according to the augmented Dicky Fuller test, but supply and public stocks are not. Therefore, and as an additional robustness check, results for first difference estimations are reported additionally in the result tables. First differences are stationary for all variables according to the augmented Dicky Fuller test.

3. Method

3.1 Predicting missing observations for public stocks

As explained in the previous section, closing rice stock data is missing in the years before 1990 and for 2015, but January and April stock levels are available for all years and can be used for predicting the October stock levels. There is a large amount of literature about how to deal with missing data (e.g. Afifi and Elashoff 1966; Jones 1980; Little and Rubin 2002; Little 1992). However, the prevailing situation differs in the sense that data on ending stocks, i.e. October stocks, is missing before 1990 and for 2015 but there is data on January and April stocks for those years. Therefore, instead of using maximum likelihood, imputation, Bayes or non-parametric methods, the knowledge of the January and April stock levels can be used to predict the October stocks. It is hence important to notice how stock levels change from April to October (Figure 3). The smaller rabi harvest takes place in March and April such that stocks reach their highest levels during this time. Procurement still takes place between April and October, but the decrease from April to October indicates that it plays a minor role during this period. Hence, most of the stock changes are a result of releases. This is confirmed by the procurement data because only 23% of the yearly procurement is processed in the six months from beginning of April to the end of September (yearly average calculated from the 1991 to 2009 FCI procurement data). Gulati and Jain (2013) also find that these six months have the lowest levels of procurement during the year. Additionally, the value for the procurement share has been relatively constant over the years as the standard deviation of the yearly share of procurement within these six months is less than 5% despite a slight increase over the years. The relatively stable procurement between April and October therefore indicates that the storage inflow can be approximated relatively well for the missing years by assuming similar patterns as for the years from 1990 onward where data is available. However, stock releases also need to be approximated in the same manner. The main way to release stocks is through offtakes for the PDS. In comparison, the amount released through OMSS and public exports are small. Gulati and Jain (2013) show that there is hardly any seasonality in rice offtakes. Figure 4 presents the monthly rice offtakes from 1999 to 2001 which also show little seasonality and in addition no major differences within these three years. This justifies the assumption that stock releases before 1990 can also approximated by stock releases in later years. This periodic uptake of large stocks and subsequent releases over the marketing year result in large costs for the government and have therefore been criticized (e.g. Shreedhar et al. 2012).

Figure 5 shows the changes of the public stocks in relation to their April values. In most years, the stocks are reduced by 6 to 10 million tons while there are two years with higher and two years with lower releases. For most years with high stock releases between April and October, the January stocks were particularly high compared to the April stocks whereas for the years with low stock releases the January stocks often were low compared to the April stocks. This provides a rationale to use both the April and the January stock levels for regressing the October stock levels because the January stock levels then provide additional information about the time trend which is not included in the April stock levels. The April stocks are then expected to have a positive and January stocks to have a negative influence with the absolute coefficient of the latter being smaller than the one of the former. Hence, the regression equation for the October stocks O_t reads as

$$O_t = \gamma_1 + \gamma_2 J_t + \gamma_3 A_t + e_t \quad (1)$$

with γ_1 being the constant, J_t being the stocks in January and A_t being the stocks in April.

Three regressions are performed with different dependent variables (Table 1), once including both J_t and A_t as well as one specification including only J_t and one with A_t only. As earlier years are more important for the estimation and for testing if the coefficients change over time, specification (4) was added which uses weighted least squares and gives twice the weight to the observations before the year 2000 compared to those afterward. However, this construction is somewhat arbitrary. Specification (5) shows the results for a first difference estimation. All results fully meet the expectations and the high R^2s indicate a very good fit of the model. April stock levels are highly significant and positive in all specifications. The size of the coefficient changes depending on whether January stocks are included. January stocks are always significant and negative unless April stocks are excluded. This is a result of the dynamic discussed above, implying that higher January stocks reduce the October stocks, possibly because of high stock outs if stock levels are ample over a longer time period. If April stocks are not included, higher January stocks just lead to higher October stocks with a coefficient which is statistically not different from the April stocks in specification (2) where no other variables are included. Then, the effect that high stocks over a long time period reduce the ending stocks in October cannot be observed any more. The weighted least squares estimation shows that the coefficients are not statistically different if the years before 2000 receive twice the weight of the observations from 2000 onward.

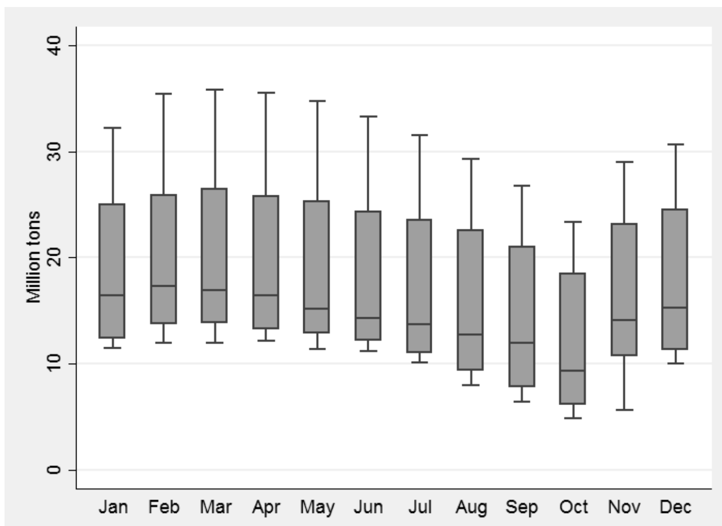

Figure 3: Monthly public rice stock levels

Notes: Own illustration. Markers indicate upper limit and lower limits, 25th and 75th percentile and the median. Raw data from January 1995 to September 2014, obtained from FCI.

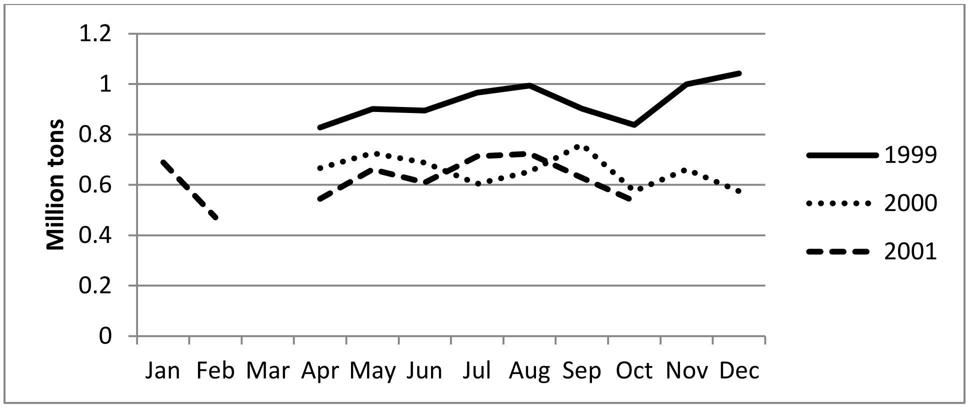

Figure 4: Monthly rice offtakes from the public stocks

Note: Own illustration with raw data from FCI.

Overall, the October stocks can be estimated very well this way as indicated by the high R^2 in all specifications. Specification (1) is used to forecast the October stocks for the years before 1990 where only January and April stock levels are available. This specification has the highest R^2, a high F statistic and low BIC. Furthermore, it makes use of the additional information provided by the January stocks which allows for a short-term time trend.

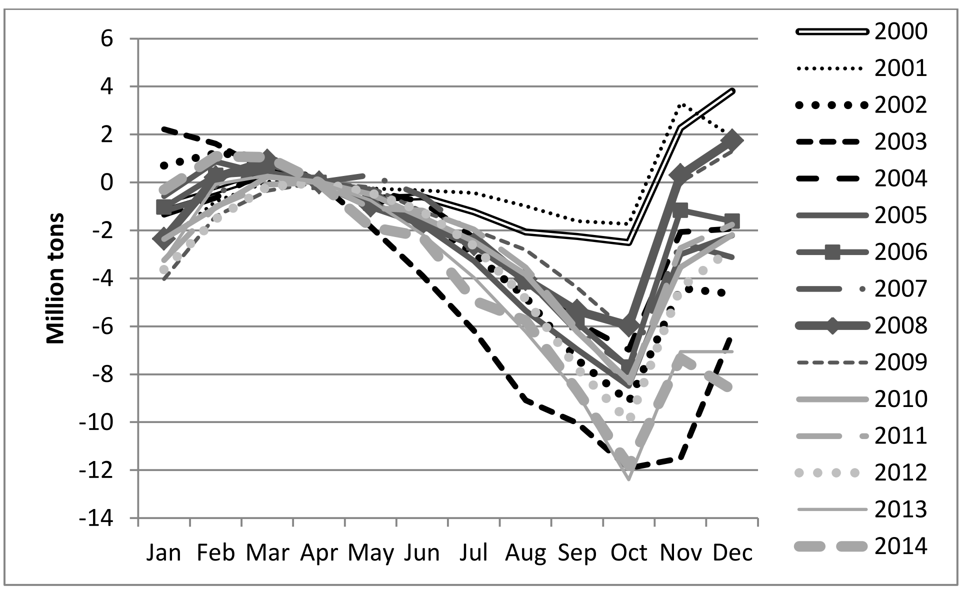

Figure 5: Change of public rice stocks relative to each year's April stocks

Note: Own illustration with raw data from FCI

Table 1: Regression results for the public October rice stocks

	(1)	(2)	(3)	(4)	(5)
Estimation	OLS	OLS	OLS	Weighted LS	FD
January Stocks	-.689*		.749***	-.569*	-.84*
	(.391)		(.081)	(.292)	(.344)
April Stocks	1.39***	.759***		1.25***	1.63***
	(.375)	(.057)		(.275)	(.338)
Constant	-.02	-.023*	-.011	-.012	-1.9e-03
	(.012)	(.013)	(.015)	(.014)	(5.2e-03)
Adj R^2	.835	.808	.686	.833	.784
R^2	.849	.816	.699	.845	.803
F stat	95	175	85.5	60.8	29.7
BIC	-103	-102	-89.3	-107	-106
Observations	25	25	25	25	24

Notes: Own illustration. Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

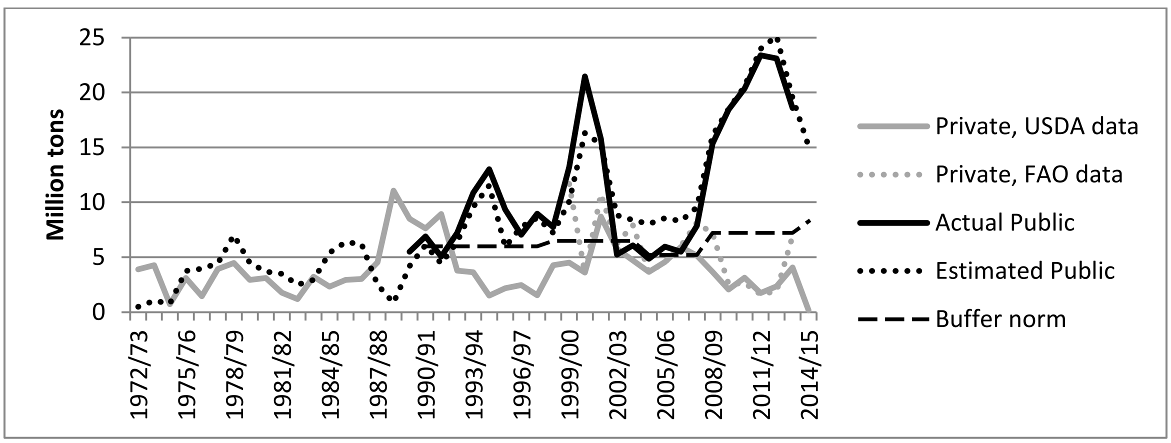

Figure 6: Private (grey) and public (black) closing rice stocks

Notes: Own illustration. Raw data obtained from different sources: public stock data from FCI; total stock data from which private stocks are calculated from USDA and FAO (via AMIS). See text for a description how closing public stocks before 1990 and for 2015 are predicted. While public and private stocks are negatively correlated with a coefficient of -0.36, private stocks can better be described when other control variables are accounted for.

Besides looking at the R^2, it is also possible to compare the estimated public stock levels with the actual ones (Figure 6). The estimated stock levels clearly follow the observed ones, however, for extremely high or low values the estimation performs not as well. For the subsequent analysis, the predicted public stock levels are only used for those years, where actual data is missing. Figure 6 also shows the private stock levels which are calculated by subtracting the public from the USDA or FAO provided total stock levels. Stock levels from both sources show a similar dynamic but differ substantially in individual years.

While the USDA data is available even before 1972/74, the FAO data only starts in 1999/2000. The October buffer norm experienced only minor changes over the years.

3.2 Estimating public storage

In contrast to private storage, public storage is not driven by price expectations of private market actors but by the way the government intervenes in the market. This section presents a new method for the estimation of public closing stocks and how the regression can be performed with exogenous variables only. The processes affecting the public stocks, i.e. the inflows and outflows during the marketing year, are depicted in Figure 1 and the timing in Figure 2.

3.2.1 Overview of determinants

As explained in the introduction, the government procures rice at the pre-defined and therefore exogenous MSP without any limits. Even if the MSP follows international prices in the long-run it still remains exogenous for India which is sufficient here. The open-ended procurement can be described as a mixed complementarity problem (described by the ⊥ symbol),

$$P_t - MSP_t \perp 0 \leq M_t \leq \infty \quad , \tag{2}$$

where P_t is the market price in year t, MSP is the minimum support price and M_t is the amount procured in this year. This complementarity condition sets the MSP as lower limit for the market price. Some rice is additionally procured through the levy on rice traders. The government gets a fixed state-dependent share (Saini and Kozicka 2014) which can be approximated as

$$L_t = \alpha H_t \quad , \tag{3}$$

with L_t being the amount procured, α the average share and H_t the production in year t. The main way to release stocks is through the public distribution system. As explained in the previous paragraph, these stock releases are relatively stable over time. Stock norms are enforced to ensure that stock levels are sufficient to meet the demand of the PDS and other welfare schemes. The Open Market Sales Scheme (OMSS) and public exports are used to release stocks when their levels are significantly above the norm whereas public imports ensure that stocks do not fall below the norms. Decisions about OMSS offtakes, public exports or imports are made ad hoc without clear rules. As public imports hardly ever occurred and were very low (below 100.000 tons) when they occurred, they can safely be ignored. Public exports (PE_t) and OMSS releases ($OMSS_t$) also rarely occurred and were mostly very small when they occurred, but in a few years, public exports were substantial (Figure 7). Altogether, the public ending stock levels in year t can then described by the equation

$$X_t^{public} = (1-\delta)X_{t-1}^{public} + M_t + L_t - PE_t - OMSS_t - PDS_t + e_t \quad , \tag{4}$$

where δ describes the stock losses due to deterioration (the implicit assumption is that they are constant over time and not dependent on the stock levels), PDS_t the offtakes for the PDS and other welfare schemes, and e_t is the error term which may capture leakages or other not-considered factors. The procurement is separated into two parts, M_t which describes the procurement via the MSP and L_t which describes the procurement via the levy.

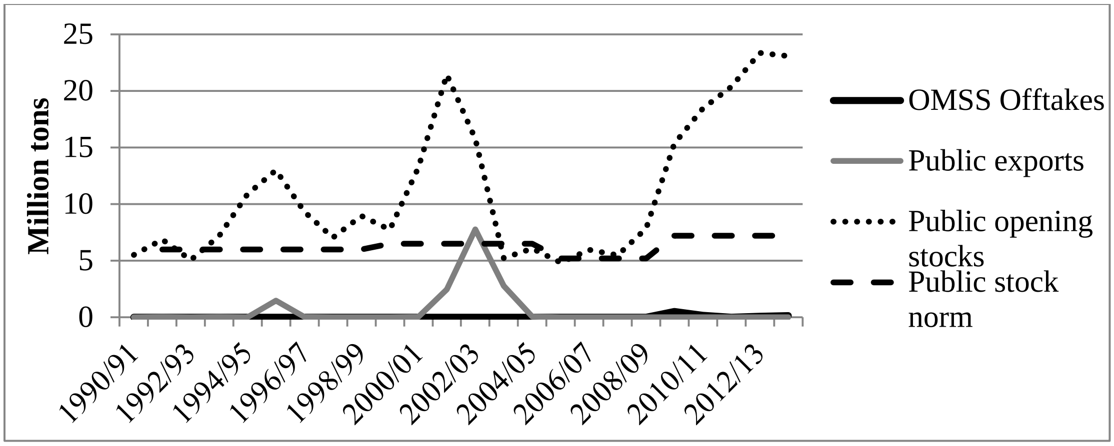

Figure 7: Public exports, OMSS offtakes, opening stocks, and stock norm

Notes: Own illustration with raw data from FCI.

3.2.2 Regression equation with all determinants

Under the assumption of relatively staple consumption-detrended PDS offtakes, three policy variables can be captured in the estimation: the stock norms, the MSP, and the export bans. The proof of the linear influence of these variables on the public stocks is available upon request. From the derivation we obtain the following equation:

$$X_t^{public} = \alpha_0 + \alpha_1 X_{t-1}^{public} + \alpha_2 MSP_t + \alpha_3 S_t + \alpha_4 \mathrm{B_t} + \alpha_5 \left(2\, X_{t-1}^{public} - N_t\right)\theta\left(2\, X_{t-1}^{public} - N_t\right) + e_t \quad (5)$$

As a result, the public stocks are expressed in terms of exclusively exogenous variables. Prices or other exogenous variables are not included, albeit international as well as Indian wholesale prices were tested for both private and public stocks but, as expected, turned out to be insignificant. To ensure stationarity of the time series, non-price data was detrended by the consumption trend as explained in the previous section and price data was deflated by the consumer price index. The general equation describing the public stocks is then given by:

$$\frac{X_t^{public}}{D_t^{trend}} = \alpha_0 + \alpha_1 \frac{X_{t-1}^{public}}{D_t^{trend}} + \alpha_2 MSP_t + \alpha_3 \frac{S_t}{D_t^{trend}} + \alpha_4 B_t + \alpha_5 \frac{2\, X_{t-1}^{public} - N_t}{D_t^{trend}} \theta\left(2\, X_{t-1}^{public} - N_t\right) + e_t \quad (6)$$

where X_t^{public} is the public closing stocks in the marketing year t, D_t^{trend} is the consumption trend, MSP_t is the minimum support price, S_t is the private market supply (i.e. production in the beginning of the marketing year plus beginning private stocks), B_t is an export ban dummy, and N_t is the buffer norm for the public ending stocks. The error term e_t captures leakages and other factors which are not considered.

As a robustness check, the same regressions are performed on the levels (specification 1 and 2 in Table 2) and on the first differences (specification 3 and 4); in both cases, one model including the buffer norm and one without norm is presented as the norm reduces the number of observations and, in particular the degrees of freedom. If the norm is included, the regression uses only the non-extended USDA series of stocks with the exception of the year 2015 where the ending stocks are still predicted.

3.3 Estimating private storage

Estimating private storage requires knowledge about the behavior of private stockholders. Theoretically, private stocks should be driven by price expectations of stockholders. Prices and price expectations themselves are a result of supply and demand expectations of different market agents, including traders, farmers, and consumers. However, unlike current prices, private agents' price expectations or expectations about supply and demand in the future are hard to observe. Even if asked, agents may face incentives to misreport if they could benefit from private knowledge or are not willing to invest time into reporting. Moreover, risk-averse agents such as small-scale farmers may directly use storage for supply and consumption stabilization rather than profit maximization. Therefore, price expectations are included only indirectly, by using the approach presented by Brockhaus and Kalkuhl (2015a). There, a piece-wise linear reduced-form storage equation is derived which is based on the competitive storage model with traders and price responsive producers in a two country setting. Instead of using price expectations, which are a result of supply and demand expectations, supply and demand fundamentals are directly used to find a piece-wise linear approximation of private carry-over stocks. Hence, price expectations are used to describe private stocks but they are not explicitly modelled. This study uses that approach with three simplifications. First, it is limited to the case of one country where the rest of the world (RoW) is only included by the expected surplus within RoW. Second, demand shocks are excluded because demand in India mostly follows production and because the number of observations is low and, hence, requires limiting the number of explanatory variables which are used. Furthermore, GDP shocks, which are used as an approximation of demand, were tested but turned out to be insignificant and were therefore excluded. Third, the storage rule is assumed to be fully linear without a kink which originally occurs when stocks are zero. Assuming full linearity without a kink is justified by the private ending stocks always being clearly above zero, even when estimated operational stocks are subtracted. Explanations of stocks being always strictly positive range from convenience yield approaches postulating an intrinsic possession value (Brennen 1958; Working 1949), mismeasurement and aggregation issues (Benirschka and Binkley 1995; Brennan et al. 1997), and diverse motives of stockholders (Carter and Giha 2007). However, a Tobit model was tested to account for nonlinear storage behavior. This allowed the use of a piece-wise linear function by introducing a cutoff point, i.e. a minimum level of stocks which represents the operational stocks. Yet, the results of this Tobit model were not statistically different from the regular IV regression. In addition, due to the limited number of observations there should be a minimal amount of additional parameters and restrictions on the degrees of freedom imposed on the model. In conclusion, these reasons provide the rationale to test different specifications for robustness but to remain with the simplest applicable version possible.

Overall, three important variables need to be included based on the discussion above: Public closing stocks to control for crowding out of private closing stocks, supply at the beginning of the marketing year to account for future price expectations as well as the influence on public stocks through the levy, and an export ban dummy or the surplus of the rest of the world as alternative measures to control for export opportunities and related expectations of stockholders. Public storage can be important because procurement takes grains from the market and large stocks may also increase the government's PDS distribution quantities, OMSS offtakes, and exports from public stocks. Therefore, public stocks may affect price expectations of private stockholders. While the market supply is fixed to a large extent (opening stocks + kharif production) at the beginning of the marketing year and fully fixed at the time of the rabi harvest (Figure 2), procurement takes place during the whole marketing year. Restrictions on private market actors activities such as restrictions on stock levels through the Essential Commodity Act cannot be considered as they are often badly documented, not enforced, and imposed on the state level and hence hard to aggregate on the national level (see introduction). The general equation describing the private stocks is then given by:

$$\frac{X_t^{priv}}{D_t^{trend}} = \alpha_0 + \alpha_1 \frac{S_t}{D_t^{trend}} + \alpha_2 \frac{X_t^{public}}{D_t^{trend}} + \alpha_3 B_t + \alpha_4 \frac{L_t}{D_t^{trend}} + e_t \qquad (7)$$

where X_t^{priv} and X_t^{public} are the private and public closing stocks in the marketing year t, D_t^{trend} is the consumption trend, S_t is the total market supply, L_t is the expected surplus in RoW calculated as the actual production minus the expected demand (from the demand trend), and B_t is an export ban dummy. This stationary export ban dummy is expected to have a linear influence (discussion available upon request). As closing public sector stocks are considered for the same marketing year as the estimated closing private stocks, endogeneity problems may arise. Hence, the regressions are estimated using the instrumental variables technique.

The public closing stocks are instrumented by the exogenous MSP and the public closing stocks of the previous year which are the public opening stocks of the current year. These two variables are found to be the main driver in the section on public stocks and the other important variables are included as non-excluded instruments in the regression. The public opening stocks are used as an instrument because public stocks only change slowly and are not a perfect substitute of private market supply as they follow different dynamics. In particular, public stock releases react much less flexible than private stock outs. The MSP is used as the second instrument because it is the main driver of the change in public stocks (see sections 3.2 and 4.1) and it is exogenous because it is fixed before the planting season starts (Figure 2). It influences production and public stocks but there is no other channel through which it influences private stocks. The MSP shapes the demand of the government through the open-end procurement which is captured by including (MSP-instrumented) public stocks but apart from that it does not influence market prices or price expectations. In addition, the current MSP does not matter for future demand or price expectations because private stocks occur at the end of the marketing year, i.e. long after the harvest is brought in and the new MSP for the next marketing year is announced (Figure 2). The production is fixed to a large extent already when the bigger kharif season is ending. After the harvest of the rabi season has started, there should be only minor changes to the expected production for a specific marketing year. However, the ending stocks only occur a few months later and hence the production is exogenous to these. As production is controlled for separately, the production effect of the MSP can be neglected and the procurement price only influences expected prices via the procurement which is the desired effect. In addition, because the market supply is used in the regression, i.e. opening stocks plus production, the effect of the MSP on this variable is negligible which also manifests itself in a low correlation coefficient of only 0.21. Overall, these reasons lead to the belief that the MSP is a good instrument for the public stocks but otherwise does not influence the private stocks.

Different test statistics are calculated to ensure the validity of the instruments. As robust standard errors are applied, the Kleibergen-Paap rk LM statistic is used to test for underidentification of instruments (Kleibergen and Paap 2006). Weak identification is tested with the Kleibergen-Paap rk Wald F statistic, overidentification with the Hansen J statistic (Hansen 1982). Contrarily to what is often believed, the latter does not test the validity of instruments but rather their coherency, i.e. whether all instruments identify the same vector of parameters (Hausman 1983; Parente and Santos Silva 2012).

A number of different additional tests are performed. Regressions are performed as IV regressions on the levels (specification 1-3 in Table 3), OLS regressions on the levels (specification 4), IV regression on the first differences (specification 5), and OLS regression on the first differences (specification 6). For the IV regressions, the 2SLS, two-step GMM, limited information maximum likelihood (LIML; Anderson and Rubin 1950; Anderson 2005), and CUE GMM estimators (Hansen et al. 1996) were used and compared. Robust standard errors were applied in all cases. The estimated coefficients for all estimators were statistically not different from one another. Therefore, only the results for the CUE GMM estimator are presented as this as estimator, just as the LIML estimator (Flores-Lagunes 2007), is reported to have better final sample properties than the 2SLS (Hansen et al. 1996). At the same time, in contrast to the LIML estimator, the CUE GMM estimator is also applicable if heteroscedasticity is present (ibid.). The regressions are performed with the user written command ivreg2 (Baum et al. 2007) in Stata 13. As a further robustness check, the included endogenous variables are changed (specifications 1-3) and the same regressions were also repeated on the non-extended USDA data from 1990 onward and on the FAO data (results available upon request).

4. Results

4.1 Determinants of public storage

Both level and first differences regression results for public stocks are in line with prevailing expectations discussed in the previous sections (Table 2). As expected, the MSP turns out to be an important driver of public stocks. It has a very high coefficient which is highly significant in all specifications. As the MSP is deflated (and, as a result, is stationary) the coefficient cannot directly be interpreted by using the MSP in Indian Rupee. Instead the deflated MSP needs to be multiplied by the consumption trend and the respective coefficient, to obtain the total contribution of the MSP to stocks in a specific year. Examples are provided in the discussion of Figure 8.

The private supply is another important factor which always has a positive coefficient. However, it is only significant in the specifications which do not include the buffer norm and therefore have more observations. The coefficient of 0.299 in the first specification implies that 1 million tons of additional production leads to a 0.3 million ton increase in ending stocks. The lagged public closing stocks which are the public opening stocks are significant in all specifications. Their coefficient of 0.767 in the first specification means that every ton of opening stocks leads to 0.767 tons of closing stocks. This is a result of the slow changes which public stocks experience, i.e. a large fraction of the closing stocks is already determined by the opening stocks. The stocks above the buffer norm are insignificant in both specifications and hence no conclusion about how the buffer norms influence public stocks can be drawn. The overall low level of public exports, OMSS releases and in particular public imports (Figure 7) however support the finding that there is no major impact on public stocks. Finally, the export ban is, as expected, positive and significant in all specifications implying that export bans lead to higher public stocks. The very high R² indicate a good model fit. The similarity of the results between the first differences and the level specification support the robustness of the model.

Table 2: Regression results for the public closing stocks

	(1)	(2)	(3)	(4)
Estimation	Levels	Levels	FD	FD
Public Opening	.767***	1.09**	.423*	.901**
Stocks	(.113)	(.402)	(.209)	(.385)
MSP	.82***	1.05**	1.28***	1.26***
	(.299)	(.476)	(.26)	(.386)
Private Supply	.299***	.421***	.186**	.341**
	(.05)	(.147)	(.074)	(.137)
Export Ban	.033**	.035**	.041**	.042**
	(.013)	(.014)	(.019)	(.018)
Above Buffer		.811		.773
Norm		(.648)		(.558)
Constant	-.522***	-.735***	3.8e-04	6.2e-04
	(.084)	(.196)	(5.3e-03)	(7.9e-03)
BIC	-150	-90.4	-138	-75.1
R²	.772	.823	.458	.531
Observations	40	25	39	24

Notes: Own illustration. Robust standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01. The private supply does include the production and the private opening stocks, but not the public opening stocks are they are included separately.

Figure 8 illustrates the predicted and actual changes of public stocks as well as the driving factors of these changes according to specification 1 for the years from 2002 to 2015. This sheds some light on the determinants of some observed stock changes in the past. The biggest ever stock decline in India from October 2002 to October 2003 is mostly attributable to the low level of supplies, the reduction of public stocks in the previous year and the reduction of the MSP in real terms – even though it was constant in nominal terms. When the world food crises started in 2007, the government of India introduced an export ban which led to public stocks rising by 2.9 million tons in addition to a 1 million ton increase due to high supply levels. In total, this yielded a substantial increase in stocks despite exceptionally high prices on the world market. In the subsequent year, public stocks soared. The MSP was raised from 6450 INR in 2007/08 to 9000 INR in 2008/09 which is a 40% increase in nominal terms and a 29% increase in real values. According to specification 1 of the results, this change in the support price resulted in 4.9 million tons higher public stock levels in October 2009 (Figure 8). Other factors such as supply levels and the lagged public stocks had a comparably small contribution to the stock increase. In general, the production also responds to the MSP (Kozicka et al. 2015b) and this can be observed in 2008/09 where a record harvest of almost 100 million tons was achieved. This increased public stocks by another 0.5 million tons. It seems that the Indian government was not fully aware of the expected increase in public stocks due to such a massive increase of the MSP. Clearly, this exceptional raise of the support price would have required comprehensive OMSS offtakes; however, these offtakes did not take place and thus public stocks skyrocketed. Had there not been a large negative production shock in the marketing year 2009/10, stocks would have soared even further. Despite this major shortfall, stocks still increased. In recent years, stock levels were brought down by allowing exports, by a low production in 2014/15 and by low procurement prices (except in 2012/13). However, stock levels mostly fall relatively to the consumption levels as can be seen by the contribution of the constant. In absolute levels, their decrease is still rather limited.

This study does not attempt to calculate an optimal rule for public stocks as that would require defining objective functions and welfare functions and is therefore far beyond the scope of this study. It would also involve judgments about how to distribute welfare between consumers and producers. However, any reasonable objective function would require large stock releases in times of production shortfalls and high prices. As these did not happen and stock levels even increased during the world food crisis in 2007/08, it is clear that from the ex-post perspective, the stockholding policies from the Indian government were far from optimal. Indeed, as discussed above, it seems that the problematic interactions of conflicting policies which resulted in stock increases were not anticipated by policy makers.

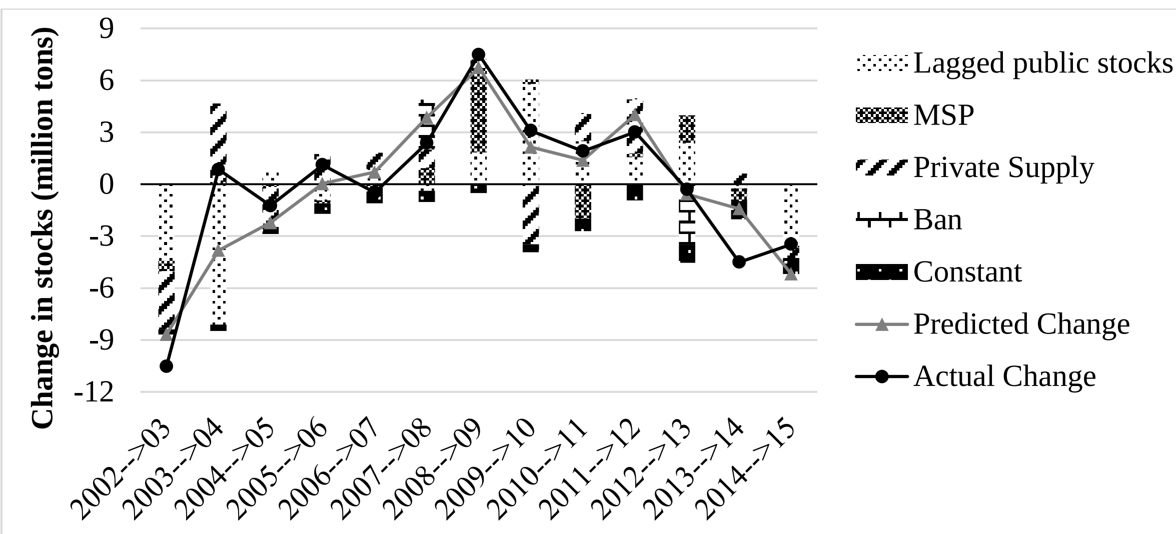

Figure 8: Actual and predicted changes of public closing stocks

Notes: Own illustration. The changes (lines) and the driving factors behind these (bars) according to model specification (1) in Table 2. As the closing stocks are the stocks at the beginning of October, the “2002-->03” stock change refers to the change from October 2002 to October 2003.

4.2 Determinants of private storage

Private stocks are estimated following equation (7) with IV and direct OLS techniques for the levels as well as first differences (Table 3). The supply now contains the private supply and the public opening stocks because these are not included separately as in the public stock regression. Overall, the different specifications provide fully consistent results, i.e. coefficients have a similar magnitude and are statistically significant in all cases. Total (market) supply is found to be one of the main drivers of private storage, which is in line with the theory of competitive storage (Gustafson 1958; Williams and Wright 1991) and the expectation from the theoretical approach (Brockhaus and Kalkuhl 2015a). More grain is stored in years of excess supply and this result is consistent in all specifications. If public stocks did not exist, the response of private storage to production could be even greater. Government stocks consistently 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 substantially; each ton of public stocks reduces private stocks by about half a ton. Again, this finding is in line with the expectations as detailed above and with results obtained by other authors (e.g. Gouel 2013). However, public storage is no perfect substitute, i.e. it only partly crowds out private storage as its coefficient is statistically smaller than one. A possible explanation is the inertia of decisions on public stock releases. While government interventions are substantial, they are far from following optimal storage rules.

Table 3: Regression for the private rice stocks

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation	IV-Levels	IV-Levels	IV-Levels	OLS-Levels	IV-FD	OLS-FD
Public Stocks	-.557***	-.648***	-.651***	-.447***	-.494***	-.3***
	(.13)	(.138)	(.152)	(.142)	(.139)	(.097)
Supply	.323***	.349***	.337***	.261***	.256***	.255***
	(.077)	(.075)	(.08)	(.081)	(.048)	(.049)
Export Ban	.026***					
	(8.5e-03)					
Surplus RoW		.097***				
		(.035)				
Constant	-.295***	-.296***	-.279***	-.21**	-1.7e-03	-2.2e-03
	(.084)	(.076)	(.081)	(.084)	(3.7e-03)	(4.0e-03)
UI: LM / stat	13.3	12.9	11.8		5.38	
UI: LM/ p	1.3e-03	1.5e-03	2.7e-03		.02	
WI: F stat	28	26.9	31.3		25.6	
BIC	-168	-165	-161	-174	-173	-177
R^2	.447	.405	.274	.362	.447	.471
OI: Hansen J/ stat	4.24	2.1	.579		0	
OI: Hansen J/ p	.04	.147	.447			
First-stage R^2	.663	.669	.654		.349	
First-stage F	34.9	37.4	50.2		13.8	
Observations	40	40	40	42	39	41

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Statistics used: Underidentification (UI): Kleibergen-Paap rk LM statistic, Weak identification (WI): Kleibergen-Paap rk Wald F, Overidentification (OI): Hansen J

The export ban coefficient is positive and significant as well as the surplus in the rest of the world variable, so banned exports or a worldwide surplus both lead to higher stocks. Speculative private storage in hope of a future harvest failure may become more attractive when current profit margins from trade decrease. The negative constant in the levels estimation indicates evidence for the private storage threshold which is expected from theory. Private stocks seem to respond more strongly to the market supply than public stocks as the coefficients are higher. However, not for all pairs of specifications which one could compare, they are statistically different from one another.

The different test statistics support the validity of the regressions: no evidence is found for underidentification, weak identification, or the non-validity of the instruments with exception of specification (1) where the overidentification test yields a value just below the threshold of 0.05. The high R^2 indicate a very good model fit and the first stage R^2 support the instrument choice. Overall, only closing private stocks are analyzed and no conclusions about intra-annual effects can be drawn due to lack of data on intra-annual private stocks.

5. Discussion and Conclusion

This study uses a novel approach for the estimation of determinants of public stocks for the Indian context. Furthermore, it uses the method developed by Brockhaus and Kalkuhl (2015a) and combines it with an instrumental variable approach to quantify determinants of private rice stocks in India. The method for private stocks is based on insights from the competitive storage model and numerical approximation techniques and hence has a solid theoretical foundation. The approach for estimating the public stocks is derived from the specific policy interventions in India and standard supply and demand theory (derivation available upon request). These methods allow empirically estimating the determinants of private and public stock levels, including the role of actual policies. Instrumental variables are used to address endogeneity issues that are immanent in the analysis of prices, expectations and speculative storage. Levels and first difference specifications are used together with different sub-specifications to deal with methodological issues such as the low number of observations and a remaining uncertainty about the stationarity of some variables. Various test statistics underlined the robustness of the results and the validity of the instruments in the private stock regression where public closing stocks are instrumented by public opening stocks and the minimum support price.

Public stocks are found to be slowly changing and driven by the MSP, private market supply, and export bans. Together, these factors can explain most of the variation in public stocks. Buffer norms are found to be insignificant but that result needs to be interpreted with great caution as very little data on buffer norms could be obtained and buffer norms were rarely altered leading to little variation in the data. Qualitatively, the non-relevance of buffer norms can be explained by the rare use of public imports, exports, or OMSS releases which are designed to prevent deviations from these norms. Hence, norms are set up but rarely enforced. Clearly, from the ex-post perspective, the FCI did not even approximately follow an optimal strategy in their stockholding policies. Calculating optimal rules goes beyond the scope of this study but any reasonable objective function for public stockholders would require stock releases in times of production shortfalls and high prices. As these did not happen in 2007/08 and in other years with supply shortfalls, the FCI seems to be far away from an optimal policy. This claim is further supported by the lack of well-defined stock release policies for time of crisis. Instead, stocks are only supposed to be released when they are abundant (via OMSS releases) but this does not depend on the current supply situation. In contrast, stock policies in China seem to be closer to an optimal policies as substantial amounts were released during 2007 and 2008 (Yang et al. 2008).

The biggest changes in public stocks in recent years seem to be driven by the amount of rice harvested, the export ban policies and in some years by huge increases in the MSP. During the world food crisis in 2007-2008, India's stocks soared due to the MSP increases and the export ban. For example, the mere introduction of the export ban led to a public stock increase of around 2.9 million tons while the 29% increase of the real MSP contributed another 4.8 million tons to the public stocks. It seems, policy makers wanted to protect Indian consumers with the help of these polices but they neglected the impacts on public stocks which led to dramatic stock increases and thereby huge management costs as well as unnecessary high prices on domestic markets between 2008 and 2012 (even though prices were well below global levels).

Hence, India's buffer stock policy is prone to fail at least one of its objectives, the protection of consumers by preventing high prices. This is a result of the way the stock releases and acquisitions are managed. Stock releases for the PDS are pre-defined and not crisis-responsive. The other channel for stock releases, the OMSS releases, depend on the current stock levels, i.e. stock out happen only when stocks are (substantially) above the norm. Additionally, OMSS releases currently depend on the ability to cover economic costs for the FCI, a policy which urgently needs to be overcome to offer consumer protection. Thus, both channels for stock releases do not respond to high prices, supply shortages, and a crisis in general. Furthermore, the processes for stockpiling as well as stock releases are too slow to be used for quick interventions. Stockpiling reacts to the MSP and the private supply both of which are determined long before the end of the marketing year. Stock outs are mainly carried out through the stable provision of rice for the PDS. However, in times of need, quick and substantial domestic stock releases would be required, in particular, if measures are taken which might increase the ending stocks such as MSP increases or banned exports. Such factors need to be taken into account for future market interventions, for example, a significant raise of the MSP must be accompanied by additional stock releases. Similar stock releases are required if export bans, which may help to stabilize prices via decoupling Indian markets from world markets, are introduced. As noted by Gouel, Gautam, and Martin (2014) a storage policy without clear stock out rules apart from the PDS results in a buy-and-hold strategy. Hence, India's stockholding policy needs to be adjusted to offer crisis-responsive consumer protection.

Unsurprisingly, private stocks are found to be largely crowded out by public storage. However, crowding out is partial as for each ton of public stocks, private stocks are reduced by about half a million ton. These findings indicate that despite the high degree of government interventions, there are still speculative storage activities ongoing in India. These activities contribute to stabilizing prices because the dynamics of the competitive storage model imply a price stabilizing behavior of the stockholders and this behavior was found in the estimation. As crowding out is only partial, the government can increase the total stock levels by holding public stocks. This would allow the Indian government also to use theirs stocks more as an emergency reserve and rely more on private stockholders in "normal" times when supplies are sufficient. However, such an approach would require a fundamental change of the current institutional system. The other main driver of private stocks is the market supply as expected from the theory of competitive storage. Furthermore, private storage reacts to export opportunities, i.e. banned exports or a large surplus in the rest of the world increase the private carry-over stocks.

In general, combining trade and storage policies to stabilize prices may work but the current stockholding system fails to provide the required speed for interventions, the automated channel to releases stocks as response to a crisis, and the means to protect consumers in the short run. Adjustments need to be quicker and more responsive to the market situation, in particular for stock releases. Currently, stock policies cannot protect consumers from fast-onset crises; instead, this was achieved by implementing export bans in the past. Those bans, however, come at huge costs for countries relying in imports. Therefore, storage policies should be adjusted to provide short-term consumer protection and keep fiscal costs in check such that trade can remain unrestricted. Even if incentives to restrict exports in times of a crisis may prevail, better stock releases policies would allow more time for evaluating alternative measures and negotiating with the international community. Furthermore, producers and traders are likely to benefit from the unlimited trade (Shreedhar et al. 2012).

Limitations of this study arise from the quality of the underlying data and statistical limitations. The latter are a result of the limited number of observations and the remaining uncertainty about the stationarity of some variables. However, different approaches including estimations on levels and first-differences were used to account for these. If policy changes are made ad-hoc and not based on the usual rules, such effects also cannot be considered. Furthermore, it is assumed that there are no announcement effects.

With clear rules and possibly more reliance on the private sector, India can reduce the fiscal costs of the policies while maintaining a similar level of price stability or food security (compare Basu 2011; Gouel et al. 2014; Saini and Kozicka 2014). Future research should explore more flexible public storage policies, the effects of trade liberalization policies (Anderson and Martin 2005; "Edward" Yu et al. 2011; Hoda and Gulati 2013; Laborde and Martin 2012), and how the private sector could further contribute to stabilize food prices and supplies. As an alternative to the public stockholding program, future research also needs to explore the potential of cash transfer or food coupon scenarios (as in Basu 2011; Ecker and Qaim 2011 (for Malawi, not India); Kozicka et al. 2015a). Finally, interactions between domestic and international markets need to be studied, in particular if uncoordinated policy responses are implemented in times of crisis (von Braun et al. 2014). A way needs to be found to align domestic price stabilization policies and international efforts to reduce trade restrictions. Increased support from the international community may be the only way to provide the right incentives for India to keep exports flowing when international supply levels fall short.

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