Food Grain Policies in India and their Implications for Stocks and Fiscal Costs: A Partial Equilibrium Analysis

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Abstract

This paper analyzes current and possible future reforms of the Indian food policies of the two most important staple grains, wheat and rice, within a two commodity dynamic partial equilibrium model with stochastic shocks. The model is empirically grounded and reproduces past values well. It uses a new reduced-form approach to capture private storage dynamics. We evaluate implementation of the National Food Security Act (NFSA) under several policy measures with the current regime as well as two scenarios with a regime change – implementation of cash transfers and deficiency payments. Implications for market fundamentals and fiscal costs were simulated in the medium term – until 2020/21. The NFSA puts a high pressure on fiscal costs and public stocks. Relying on imports with low MSPs results in a high stock-out risk and the lowest fiscal costs, however with high domestic price levels and volatility and high international prices. A policy strategy to manipulate procurement prices in order to maintain public stocks close to the norms leads to slightly higher fiscal costs with lower and more stable prices and ample stocks. A cash-based regime can bring considerable savings and curb fiscal costs, particularly if targeted to the poor, and would leave ample stocks due to higher private stocks. However, this scenario shows the highest market price levels and variability, which can have negative effects on some producers and consumers as well as political stability.

Keywords: India, grain storage, fiscal costs, food grain policies, NFSA, reforms

JEL classification: I38, O13, Q02, Q18

1. Introduction

India has the world's second largest population with over 15% of it being undernourished (United Nations, 2015), which makes it home to the largest malnourished group of over 190 million people (ibidem). Insuring food availability and stabilizing food prices through large scale interventions in the food grain sector has a long tradition in India. India's government introduced administrative controls, monopoly procurement and public distribution during 1943-47 - after the great Bengal Famine of 1943. Since then, both Indian agriculture and related policy framework have substantially changed – from highly food insecure food importer to often important exporter with large food-grain stocks (see Saini & Kozicka, 2014). The world's largest food support program, the National Food Security Act (NFSA, 2013) is currently implemented and highly debated (Bera, 2015) and there are several voices advocating for reforms, including a radical transformation to a cash-based system (Gulati & Saini, 2014; Kumar, 2015).

Our objective is to quantify and simulate medium term consequences of implementing the National Food Security Act under different policy scenarios. In particular, we examine total stocks, food prices and fiscal costs implications. Further, the alternative policy regime are evaluated such as cash transfers combined with deficiency payments which entail only little market disturbances. Our main finding is that these 'market friendly' reforms are able to achieve the goals of the NFSA at lower fiscal costs but at higher domestic market volatility as well as higher domestic and international prices.

Currently, India's food program encompasses public procurement, storage and distribution of wheat and rice. Within this program, wheat and rice are procured from farmers with guaranteed Minimum Support Price (MSP). Public stock encompasses strategic and operational stock, which define the stock norms. A strategic stock is a buffer for stabilizing grain supply and prices, whereas operational stock feeds Public Distribution System (PDS)[1], which provides grains to the poor at subsidized prices. In practice, these two stocks are combined into one and no distinction is possible. As a result, the entire food subsidy bill is close to 0.8 per cent of the GDP (Economic Survey 2014-15). The open-end character of procurement, trade restrictions and high level of MSP led to a growing share of public procurement – close to 50% of the marketed wheat and rice were procured by the

[1] In our terminology, PDS covers Targeted Public Distribution System and Other Welfare Schemes.

government in the recent years. The absence of clear rules to release surplus stocks resulted in mounting stocks and high food inflation. The combination of high public stocks and limits to private stockholding under the Essential Commodities Act led to a further marginalization of private stocks (Kozicka, Kalkuhl, Saini, & Brockhaus, 2015).

The National Food Security Act, 2013 (NFSA, 2013), which is currently being implemented nationwide, provides a legal right to food at subsidized prices to 67% of India's population (Gulati & Saini, 2014). Major threats to improving food security through this costly system are high wastage and leakage (Dreze & Khera, 2015; Gulati & Saini, 2015). With India being one of the major rice exporters and stockholders, public interventions are not only of domestic importance but do significantly impact global markets and trade.

In order to analyze implications of current policies on market fundamentals and fiscal costs, we use a two commodity (wheat and rice) dynamic partial equilibrium model with stochastic production shocks. Wheat and rice compete through demand. Functional forms and most of the parameters used in the model are derived from the ex post econometric analysis of the data from 1982 to 2012 (based on Kozicka et al., 2015). Major data-sources include FCI, USDA and government reports.

Contrary to econometric analyses, the current study allows considering equilibrium effect on prices, price variability and private grain stocks as endogenous market variables. Such an equilibrium model also allows analyzing counterfactual scenarios. It contributes to the existing research on Indian food-grain policies, for example, by Gouel, Gautam & Martin (2014), Gulati & Jain (2013), Gulati & Saini (2014), Pursell (2014), Shreedhar, Gupta, Pullabhotla, Ganesh-Kumar, & Gulati (2012) and Srinivasan & Jha (2001). Explicit links of policies to the market fundamentals, consideration of both crops simultaneously and estimation of fiscal costs, implementation of endogenous international prices (large country case) as well as a solid empirical grounding in actual processes distinguishes the current setup and makes the study an important contribution to the above mentioned literature. Another extension we provide is a consideration of uncertainty coming from random production shocks, which is reported as variability of endogenous variables. A new reduced-form approach to model private storage based on the competitive storage model is used. It does not require solving a rational expectations equilibrium by numerically estimating the value function. This approach allows to closely re-producing historical (private) storage data.

Finally, we provide, to our best knowledge, the first broad assessment of implications of the NFSA, 2013 in an equilibrium setup. A further important contribution is the simulation of consequences of alternative policy framework in India, namely cash transfers combined with deficiency payments.

2. Conceptual framework

Figure 1 shows a graphical representation of our modelling approach to the Indian wheat and rice sectors. The main variables of interest – prices, stocks and fiscal costs – are influenced by several endogenous and exogenous variables as well as directly and indirectly by policy measures.

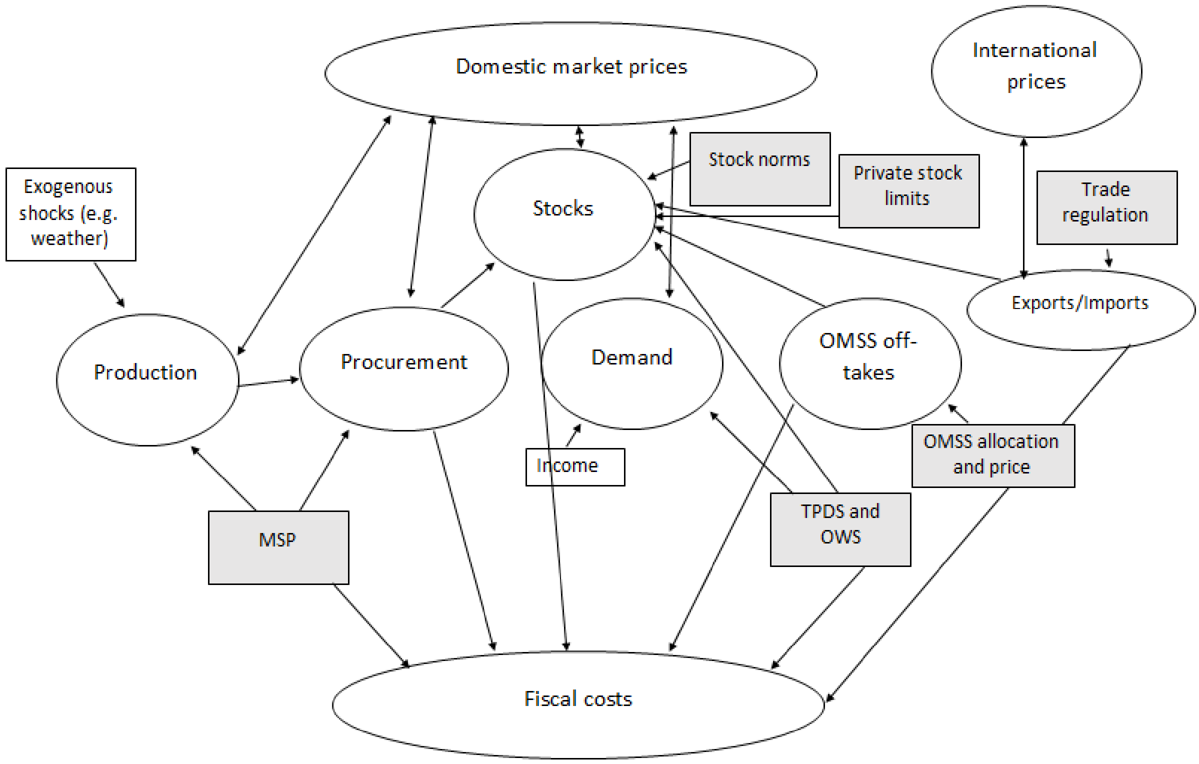

Figure 1 Model Framework

Source: Own illustration
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.

MSP, which is constant throughout a marketing year and is announced before planting, transfers the risk from farmers to the government. It has a strong and significant impact on production and procurement. As a result it affects grain availability, stocks and consequently prices. Expenditures on procurement and stocks contribute to fiscal costs. Stock off-takes for

PDS, Open Market Sale Scheme (OMSS) and exports affect fiscal costs (generate revenues). PDS and OMSS influence domestic market prices and exports affect international prices and consequently private exports.

Caveats of this framework are typical for partial equilibrium models – a bigger picture is neglected, for example there is no link to job market and other sectors.

3. Model description

Our model is a dynamic partial equilibrium model with two commodities, wheat and rice, and stochastic harvest shocks. They are indicated by a subscript $i \in \{w, r\}$. A subscript t denotes a year and $t \in \{2013, \dots, 2020\}$, which is a time span for simulations. All prices are in real terms, deflated by the wholesale price index (WPI).

3.1. Current policy framework

All functional forms, except for equations 5, 6 and 8, are based on the empirical ex-post analysis in Kozicka et al. (2015) and match the current policy framework – open-end procurement with the MSP, distribution through the PDS and corresponding private and public stocks.

The exogenous variables are: PDS – volume and price, MSP, stock norms, population and GDP growth rates, inflation (WPI), trade regime, acquisition, distribution and storage costs. Endogenous variables in the partial equilibrium model are determined with the following equations:

Production

$$\ln \boldsymbol{Q_{t,i}} = \boldsymbol{\alpha^p}_0 + \boldsymbol{\alpha^p}_1 \ln \boldsymbol{p^{MSP}_{t,i}} + \boldsymbol{\alpha^p}_2 \ln \boldsymbol{t} + \boldsymbol{\alpha^p}_3 \boldsymbol{R_t} + \boldsymbol{\varepsilon_{t,i}}, \qquad 1$$

where $Q_{t,i}$ is a yearly production volume of the *i*-th crop, 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 production shock.

Demand

$$\boldsymbol{ln\, D^{net\ cap}_{t,i}} = \boldsymbol{\alpha^d}_0 + \boldsymbol{\alpha^d}_1 \ln \boldsymbol{p_{t,i}} + \boldsymbol{\alpha^d}_2 \ln \boldsymbol{p^{cross}_{t,i}} + \boldsymbol{\alpha^d}_3 \ln \boldsymbol{PDS^{cap}_{t,i}} + \boldsymbol{\alpha^d}_4 \ln \boldsymbol{t}\ , \qquad 2$$

where $D_{t,i}^{net\ cap}$ is per capita yearly consumption of the *i*-th crop net of consumption through the PDS, $p_{t,i}$ 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, t is a time trend. The variable $PDS_{t,i}^{cap}$ is per capita off take under the PDS.

$PDS_{t,i}^{cap} = \frac{PDS_{t,i}}{Pop_t}$, where $PDS_{t,i}$ is a total off-take for PDS of the *i*-th crop in year *t* and Pop_t is a population of India in year *t*.

$D_{t,i}^{net\ cap} = \frac{D_{t,i}}{Pop_t} - \frac{\xi_i PDS_{t,i}}{Pop_t} = D_{t,i}^{cap} - \xi_i PDS_{t,i}^{cap}$ is a relationship between net per capita demand, per capita demand and total demand $D_{t,i}$. ξ_i is an average leakage from PDS.

Procurement

$$\frac{D_{t,i}^{FCI}}{Q_{t,i}} = \alpha^{pr}{}_0 + \alpha^{pr}{}_1 \frac{p_{t,i}}{p_{t,i}^{MSP}} + \alpha^{pr}{}_2 t, \qquad 3$$

where $D_{t,i}^{FCI}$ is the yearly procurement level of the *i*-th 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 a ratio of market price to the MSP and the trend.

Private stocks

Private stocks are modeled using a reduced-form approach that proxies the dynamics of the competitive storage model with rational expectations equilibrium. If domestic supply in terms of harvest and last year's private and public carry-over stock are high, private stocks increase. Hence:

$$\frac{X_{t,i}^{priv}}{D_{t,i}^{trend}} = \alpha^{s}{}_0 + \alpha^{s}{}_1 \frac{S_{t,i}}{D_{t,i}^{trend}} + \alpha^{s}{}_2 \frac{X_{t,i}}{D_{t,i}^{trend}}, \qquad 4$$

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, approximated by a linear trend for simulations, $S_{t,i}$ is a total market supply calculated as $S_{t,i} = Q_{t,i} + X_{t-1,i}^{priv}$ and $X_{t,i}$ is the FCI stock (public stock).

Private exports

Private exports and imports, unless there are government interventions in the form of e.g export bans, are determined by the spatial arbitrage condition[2]:

$$\boldsymbol{Exp_{t,i}} \geq \mathbf{0} \perp -\boldsymbol{p_{t,i}^{int}} + \boldsymbol{p_{t,i}} + \boldsymbol{\theta_{ex}} + \boldsymbol{\omega_i} \geq \mathbf{0}\,, \qquad 5$$

$$\boldsymbol{Imp_{t,i}} \geq \mathbf{0} \perp \boldsymbol{p_{t,i}^{int}} - \boldsymbol{p_{t,i}} + \boldsymbol{\theta_{im}} \geq \mathbf{0}\,, \qquad 6$$

where $Exp_{t,i}$ and $Imp_{t,i}$ are the total volume of private export and import respectively in a financial year, $p_{t,i}^{int}$ is an international price converted to Rupees, in real terms (divided by Indian WPI), $p_{t,i}$ is a domestic price, θ_{ex} and θ_{im} are trade costs and ω_i is an export tariff.

Public exports

Public exports occur in times of an excessive stock (stock above the norm), when a certain share, τ, is released. When the stock is not sufficient to feed the PDS needs with a certain reserve, the required volume is imported. η defines the operational needs, for example $\eta = 0.25$ would mean a 3-month PDS requirement.

$$\boldsymbol{NExp^{pub}}_{\boldsymbol{t,i}} = \mathbf{min}(\boldsymbol{X_{t,i}} - \boldsymbol{\eta PDS_{t,i}}, \boldsymbol{\tau}(\boldsymbol{X_{t,i}} - \boldsymbol{NX_{t,i}})), \qquad 7$$

where $NExp^{pub}{}_{t,i}$ is the total volume of net public export in a financial year, $X_{t,i} - NX_{t,i}$ is a public stock surplus (above the stock norm) and $PDS_{t,i}$ is a PDS off-take.

International price

International price is determined endogenously as a deviation from a 'base' price, depending on the total net exports from India. The focus on impacts within India justifies the assumption that world market prices are stable apart from the influence of India's exports. Non-stable world prices would add an additional stochastic component which makes the results depended on the specific realization but would not change the expected values. Hence, we are mot modelling the international prices but only the impact of the Indian policies on them.

$$\boldsymbol{p_{t,i}^{int}} = \boldsymbol{p_i^{int}}\left[\mathbf{1} - \boldsymbol{\gamma}(\boldsymbol{NExp^{pub}}_{\boldsymbol{t,i}} + \boldsymbol{NExp_{t,i}})\right], \qquad 8$$

[2] ⊥ is used in the mixed complementarity condition means that the two inequalities on the both sides of the symbol are orthogonal, so if one equation holds as a strict inequality, the other side holds as a strict equality.

where $p_{t,i}^{int}$ is international price in rupees, Indian WPI deflated, p_i^{int} is 'base' international price(international price without trade with India), γ is a sensitivity of international price to Indian net exports.

Open Market Sale Scheme (OMSS)

Similarly to public exports equation, stock off-takes via the OMSS, $OMSS_{t,i}$, are calculated as a share $\boldsymbol{\kappa}$ of excessive public stocks, whenever excess stocks are positive:

$$\boldsymbol{OMSS_{t,i} = \kappa \max(0, X_{t,i} - NX_{t,i})}, \quad 9$$

MIP

The Minimum Issue Price $MIP_{t,i}$, the price at which grains are sold through the OMSS, is determined by

$$\boldsymbol{MIP_{t,i} = (1 + ec_i) MSP_{t,i}}, \quad 10$$

where ec_i is the 'economic cost' markup representing storage and transaction costs borne by the FCI.

Fiscal cost

The fiscal costs for the government are calculated as

$$\boldsymbol{FC_t = \sum_i (ac_{t,i} D_{t,i}^{FCI} + c_{t,i}^{d} PDS_{t,i} + k_t X^{op}{}_{t,i} - p_{t,i}^{PDS} PDS_{t,i} - MIP_{t,i} OMSS_{t,i} - p_{t,i}^{EX} NExp^{pub})}, \quad 11$$

where $FC_t$are yearly fiscal costs, $ac_{t,i}D_{t,i}^{FCI}$ are acquisition costs of the *i*-th crop, $c_{t,i}^{d}PDS_{t,i}$ are distribution costs, $k_t X^{op}{}_{t,i}$is buffer carrying cost (where $X^{op}{}_{t,i}$ is the operational stock, which is buffer stock of wheat and rice in the central pool minus four month off-take for PDS and OMSS) and $p_{t,i}^{PDS}PDS_{t,i} + MIP_{t,i}OMSS_{t,i} + p_{t,i}^{EX}NEX_{t,i}^{pub}$ are sales realizations (revenues) from sales from PDS, OMSS and net export off-take. Detailed specification of the components of the fiscal cost equation can be found in Appendix A.

The dynamic equilibrium model is closed by two identity equations:

Public stocks

$$\boldsymbol{X_{t,i} = (1 - \delta_i) X_{t-1,i} + D_{t,i}^{FCI} - OMSS_{t,i} - PDS_{t,i} - NExp^{pub}{}_{t,i}}, \quad 12$$

where δ_i is the public stock deterioration rate.

Market clearing

$$\boldsymbol{Q_{t,i} + OMSS_{t,i} + PDS_{t,i} = D_{t,i} + NExp_{t,i} + D^{FCI}_{t,i} + X^{priv}_{t,i} - (1 - \delta^p{}_i)X^{priv}_{t-1,i},} \qquad 13$$

where $\delta^p{}_i$ is the private stock deterioration rate.

3.2. Cash transfers and deficiency payments

An alternative to state procurement and food price subsidies are deficiency payments and cash transfers. They are considered to provide in principle similar social benefits by increasing real incomes of producers and consumers while reducing market distortions (Blackorby & Donaldson, 1988; Esmaeili, Karami, & Najafi, 2013).

A change from the PDS to cash transfers is modeled by adding the transfer to the disposable income in the demand equation and, on the government side, to fiscal costs while setting $PDS_{t,i} \equiv 0$.

$$\boldsymbol{ln\, D^{cap}_{t,i} = \alpha^d{}_0 + \alpha^d{}_1 \ln p_{t,i} + \alpha^d{}_2 \ln p^{cross}_{t,i} + \alpha^d{}_3 \ln(Income^{cap}_t + Cash^{cap}_t) + \alpha^d{}_4 \ln t,} \qquad 14$$

where $D^{cap}_{t,i}$ is per capita yearly consumption of the *i*-th crop, and $Cash^{cap}_t$ is a yearly per capita cash transfer.

In case of cash transfers, there is no need for high public stocks. Stock norms are kept low, only to cover the emergency reserve. As a result and contrary to (3), procurement happens only when stocks fall below the norms, which can be presented as $D^{FCI}_{t,i} = \max(0, NX_{t,i} - X_{t,i})$.

For the grain rotation, a fraction of the stock is released through the OMSS and the rest is exported. In order to provide support to the farmers and incentivize production, at times when market price falls below the support price (equal to the former MSP), farmers are offered deficiency payments. This is why the production function still has the MSP instead of the market price as the MSP is shaping the expectations of producers. The amount of payment is added to the fiscal costs.

Because our model is based on the empirics, it is useful mostly for short- and medium- term simulations. It needs to be noted that the introduction of cash based transfers and a significant reduction in public stock levels are a major change to the underlying assumptions of the data generating process that it naturally leads to a higher level of uncertainty attached to these scenarios.

3.3. Scenarios

Seven different scenarios projecting the exogenous variables and policy shifts over the next ten years until 2020-21 were simulated with the model. The baseline scenario assumes the implementation of the NFSA, which regulates the exogenous PDS distribution to 67% of the Indian population with the rations defined by the Act and stock norms set to meet the new needs of the system. Management of the system is similar to the past – with growing MSP, small sales through the OMSS and exports. Other exogenous variables develop in a 'likely' way. Details are shown in table 1:

Table 1 Projection of exogenous variables in baseline scenario

Variable	**Scenario**
MSP	2% yearly real growth
Rainfall (R)	Moving average of past 15 observations
Population (POP)	Growth at 1.3% per year (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, WEO October 2014)
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)
Trade regime	No export bans
Acquisition costs, distribution cost, annual rate of buffer carrying cost	2% real yearly growth
Central issue price	Nominal as stated in the NFSA (2 Rs./kg for wheat and 3 Rs./kg for rice)

Source: Own design

The alternative scenarios 1-4 assume implementation of the NFSA (in terms of distribution and stock norms) and different policy measures to fulfil its requirements. Scenarios 5 and 6 assume alternative policy framework with cash transfers and deficiency payments. They differ with the cash transfer coverage. Details are as follows:

Scenario 1 – varying MSP scenario: In this scenario price dynamics are set to meet the NFSA requirements with minimal procurement and stock levels. The MSPs are used to minimize the excessive stock levels (keep stocks close to the norms) and curb fiscal costs. As a result, the MSPs and acquisition costs change with a varying growth rate between 2013 and 2020: The wheat MSP grows on average by 1 per cent yearly in real terms and the rice MSP declines by 2/3 per cent annually in real terms (which means growth nominally) by 2016 and grows further on. As a result the average annual growth rate is close to 0 per cent. The rest is the same as in the baseline scenario.

Scenario 2 – aggressive OMSS: In this scenario OMSS is used to meet the NFSA requirements with ample level of procurement and high MSP growth rates. Stocks levels are kept close to the norms with high OMSS sales. MSP growth rates are set in real terms 2 per cent and 3 per cent for rice and wheat accordingly, the rest as in the baseline scenario.

Scenario 3 – export bans: In this scenario trade bans are used to meet the NFSA requirements with moderate MSPs. MSPs are set to grow with 1 per cent for rice and 2 per cent for wheat in real terms annually and in times of insufficient stocks (below the stock norms) export bans are introduced. The rest as in the baseline scenario

Scenario 4 –aggressive imports: In this scenario, farmer’s support and procurement are minimized while imports are used to insure functioning of the NFSA. Therefore, MSPs are kept constant in real terms the Public distribution system supplies are supplemented with public imports. The rest is the same as in the baseline scenario.

Scenario 5 – Cash transfer and deficiency payment: The idea of an alternative way to ensure food security is explored in this scenario. We assume that 67 per cent of the population receives the equivalent of the NFSA ration (5 kg of food-grains per person per month against Rs 3/2 per kg for rice/wheat) in cash. The transfer is linked to the market price in the model (is endogenous). In the model, market price is in the wholesale level, so we add 15% markup to reproduce a consumer price.

The emergency reserve is equal to 2mt of wheat and 3mt of rice. If market prices fall below the MSP, 30 per cent of produced grains receive the difference between the two prices. 30 per cent is close to the recent procurement levels – hence the deficiency payment policy would not create additional fiscal costs MSPs are kept constant in real terms.

Scenario 6 – Cash transfer for 30 per cent and deficiency payment: In this scenario, in order to curb fiscal costs, we assume that only those below poverty line receive these transfers, however the ration is set exogenously and is much higher than in the scenario 5. This means that 30 per cent of the population receive Rs. 200 in 2013 prices, constant in real terms. The rest is the same as in the scenario 5. Rs. 200 was an equivalent of 10.5 kg of wheat in New Delhi and 5.9 kg of rice in Chennai in January 2013 (FAO GIEWS retail price). A randomized control trial in Delhi, India in 2010-2011 offered Rs 1000 in unconditional cash transfer per household (Gangopadhyay, Lensink, & Yadav, 2013).

3.4. Calibration

Most of the functional forms and parameter values were estimated using national aggregates from 1982 till 2012. All parameters are reported in tables 2 and 3.

Wheat demand is much more sensitive to market price changes than rice, whereas rice demand is more dependent on PDS distribution. This is probably because PDS functions much better for rice distribution – more rice is consumed form PDS than wheat, rice leakage is much smaller, and major rice consuming states provide additional subsidy and higher coverage than offered by the center. For example, rice in AP, Karnataka, Kerala and Odisha is priced for the poor at only Rs/kg 1. Tamil Nadu has a unique universal PDS, delivering rice to everyone free of cost (DFPD, 2014, p. 54)

Production strongly responds to MSP, which is probably because this price is high enough to cover the cost of production and there is very low risk attached to it.

Table 2 Estimated parameters - current policy framework

	Demand equation		
		Wheat	**Rice**
${\alpha^d}_1$	Own price elasticity	-1.01	-0.11
${\alpha^d}_2$	Cross price elasticity	0.7	0.02
${\alpha^d}_3$	PDS elasticity	-0.07	-0.33
ξ_i	Average leakage from PDS	0.75	0.38
	Production equation		
${\alpha^p}_1$	MSP elasticity	0.65	0.39
${\alpha^p}_3$	Rainfall elasticity	0.35	0.5
	Procurement equation		
${\alpha^{pr}}_1$	Price ratio parameter	-0.39	-0.26
	Private stocks equation		
${\alpha^s}_1$	Supply parameter	0.34	0.34
${\alpha^s}_2$	Public stock parameter	-0.62	-0.62
	Public exports equation		
η	PDS requirenments parameter	0.3	0.3
τ	Excessive stock release parameter	0.1	0.1
	OMSS equation		
κ	Stock release parameter	0.2	0.2
	Trade spacification		
p_i^{int} (Rs/t/WPI)	Base export price[a]	20	24
γ	India export response [a,b]	0.035	0.035
θ_{ex}, θ_{im}	Export/import costs[a]	2.4	2.4
ω_i	Export tariff[a]	0	2
	MIP equation		
ec_i	MSP markup[a]	0.45	0.45
	Public stock and identity equation		
${\delta^p}_i$	Public stock deterioration rate	0.1	0.02
δ_i	Private stock deterioration rate [a]	0.02	0.02

[a] Calibrated

[b] Jha and Srinivasan (1999) quote IFPRI's IMPACT model, which gives the percentage decrease in world rice price due to 1 million tonnes of additional Indian rice exports as 4.7%. We use calibrated 3% response for both wheat and rice markets.

Source: Own design. Parameters, if not calibrated, are based on Kozicka et al. (2015).

Table 3 Estimated parameters – policy change

		Wheat	Rice
	Demand equation – cash[b]		
$\alpha^d{}_1$	Own price elasticity	-0.7	-0.25
$\alpha^d{}_2$	Cross price elasticity	0.65	0.15
$\alpha^d{}_3$	Income elasticity	0.18	0.02

[b] Wheat elasticities were estimated and rice taken from (Kumar, Kumar, Parappurathu, & Raju, 2011)

4. Simulations

Our system of equations is written in the General Algebraic Modeling System (GAMS) programming language and solved with the Mixed Complementarity Problem (MCP) solver PATH. We further considered 1000 realizations of a random *iid* production shock $\varepsilon_{t,i}$ ~ N(0, 0.05) for each scenario simulation to analyze the role of uncertainty and the impact of policies on price volatility. This number of simulations per scenario produces robust results – in a sample of 10 iterations of the simulations for the MSP scenario, maximum difference of prices (domestic and international) between means for consecutive iterations was less than 1%, for consumption and production was less than 0.5% and for fiscal costs less than 0.7%.

4.1. Model fit and selected baseline scenario results

The model reproduces past values of major endogenous variables quite well. Wheat demand tends to be underestimated, which might be the reason for underestimation of the market price. On the contrary, rice demand is slightly overestimated, the same as rice prices. Supply of the both crops is precisely reproduced, as all the explanatory variables are exogenous for the historical phase, including supply shocks, and were introduced into the model[3].

In the baseline scenario, production grows along with the real MSP growth in the medium term. In 2020, total wheat and rice production reaches 208.8 mt. Total consumption grows due to population growth, higher PDS distribution, as outweighed by slightly rising market prices. In 2020, total wheat and rice consumption reaches 199.8 mt.

There are no export bans assumed in this scenario and, as a result, net private exports are between 0 mt and 0.2 mt for wheat and 4.8 mt and 7 mt for rice. The difference arises

[3] In Appendix B we present figures with means of the simulated values for consumption, production, prices, procurement and stocks along with their standard deviations in the projection period. We further compare them with the original time series – actual levels of the variables.

because Indian rice is more competitive internationally and we do assume no export subsidies. Wheat public net exports vary between -0.7 mt and 0.8 mt, whereas rice is exported at volumes between 0.9 mt and 1.4 mt. Also there are small off-takes for OMSS for both wheat and rice – below 1.6 mt of wheat and between 1.9 mt and 2.9 mt of rice. This is as a result of a rule to release excessive stocks. Prices are rather stable and steadily grow in real terms, by 15 per cent for wheat and 9.1 per cent for rice between 2012 and 2020.

Despite the drop in 2013 in the case of wheat, procurement of both crops is in an upward trend, feeding the growing needs of the PDS under NFSA, 2013. The major difference between rice and wheat due to the NFSA is that PDS off-takes for rice remain close to the previous level (close to 33mt), whereas for wheat it grows from 23mt to 27mt (in 2013, further it grows along with the population growth). This is reflected in decreasing wheat stocks (figure 2). Higher pressure on wheat PDS and equal growth of MSPs results in growing rice stocks and declining wheat stocks. Stock norms under NFSA are close to 10mt for wheat and 11mt for rice, as estimated by Gulati and Jain (2013). Figure 2 illustrates how sensitive the public stocks are to policy changes. A growing MSP for rice can lead to abundant stocks and, as it will be discussed further, to high fiscal costs, whereas wheat stocks even fall slightly below the norms. Finally, simulated private stock is less than 1 mt in the baseline scenario – mostly as a result of crowding out by high public stock. In terms of variability, most of the outcomes (production, procurement, prices and stocks) are more stable for wheat.

An alternative within the current policy framework is careful management of the MSP, which can minimize public stock levels and the fiscal cost. This is simulated under scenario 1.

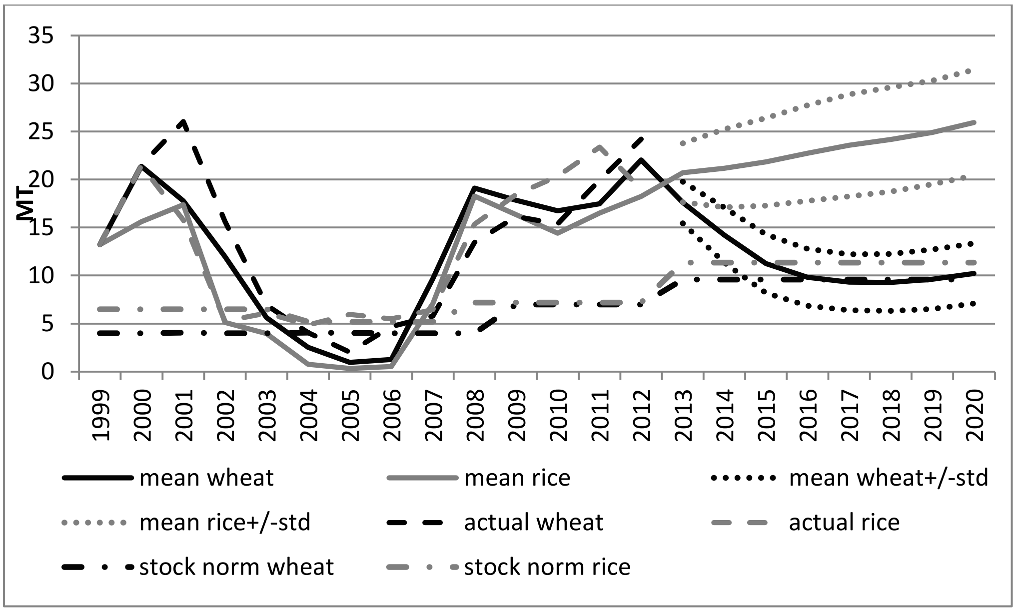

Figure 2 Ex-post and baseline scenario public stock simulation

Source: Own design

4.2. NFSA management policy measures

A comparison of the implications of the NFSA implementation in 2020 under different policies is reported in table 4. Different strategies to deliver the NFSA commitments have sometimes heterogeneous effects on wheat and rice markets, however some common tendencies can be outlined. High subsidies in baseline and OMSS scenarios result in the highest fiscal costs and lowest domestic prices. Fiscal cost related to wheat is 15 per cent higher under the most expensive OMSS scenario, as compared to the cheapest imports scenario. In case of rice, fiscal costs are the highest in the Baseline scenario and consistently the lowest in the Imports scenario with a difference of 21 per cent. MSP and Imports scenarios, on the contrary, lead to the highest domestic market prices and are the cheapest, with the MSP scenario yielding slightly higher fiscal costs among these two. Domestic prices in the Imports scenario are higher by 4 per cent for wheat and equal for rice, as compared to the OMSS scenario. Interestingly, the Trade ban scenario, so managing the system with export bans results in the lowest domestic price variability across simulations. This means that under this scenario, prices are the least affected by the domestic production shocks. The reported standard deviations in the table can be also interpreted as the level of uncertainty related to the realization of the variable. Price volatility over time is discussed in the section 4.4.

High reliance on trade in the Imports scenario results in large public imports and as a result relatively high international price levels and variability, especially in case of wheat. High international prices trigger private exports of 3.1 mt for wheat and 5.5 mt for rice. High private exports (over 6 mt) accompanied by small public exports of rice and no imports of wheat in OMSS scenario lead to the lowest and in the case of wheat, most stable, international prices. The international rice price under OMSS as compared to the MSP and Imports scenarios is lower by 12 per cent. This is a result of high production subsidy payed by the Indian government.

Under the NFSA the majority of consumers are covered with highly subsidized wheat and rice rations, with the poorest consumers receiving the substantial amount of 35 kg per family. As a result, market prices affect the poor only partially. On the other hand, support for the producers varies between the scenarios, so in some variants, high market prices are desirable. Taking these circumstances under consideration, the best policy strategy under implementation of the NFSA is to minimize fiscal costs. This can be achieved through keeping MSPs low and relying more on imports to feed the public distribution system (Imports scenario). However, this strategy can result in very low public stock levels in case of wheat, slightly mitigated by higher private stocks. If insuring sufficient public stocks has a high priority – e.g. for political reasons but also due to the 'right to food' approach of the NFSA, the best strategy is to adjust the MSP to meet the stock norms (MSP scenario). However, setting the 'right' MSP level can be a very difficult task. The solution can be to renew the procurement price institution, i.e. keeping the MSP at the minimum and in case of insufficient procurement levels, introducing additional procurement with a higher price but only until the stock norms are achieved.

Table 4 Simulation results – means and standard deviations in 2020 for the five scenarios

		(1) MSP		(2) OMSS		(3) Trade bans		(4) Imports		Baseline	
		Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
Wheat	**Domestic Price**	20.2	1.2	18.2	1.5	19.6	1.0	21.0	1.1	19.0	1.1
	International price	20.4	0.9	19.6	0.7	20.7	0.9	23.4	1.1	20.3	0.8
	Private net export	0.0	0.0	0.3	0.7	0.0	0.1	3.1	0.8	0.0	0.2
	Private stocks	1.3	1.5	0.3	0.7	1.1	1.1	3.4	1.5	0.6	0.9
	Public stock	10.2	3.6	13.1	2.6	8.6	2.5	1.6	1.6	10.2	3.1
	Public net export	-0.6	1.3	0.3	0.4	-1.0	1.3	-8.0	1.6	-0.5	1.2
	Fiscal cost	85.1	6.9	88.4	5.4	84.3	5.5	76.8	3.5	86.5	6.7
Rice	**Domestic Price**	24.8	2.7	21.2	2.8	23.0	1.9	24.9	2.7	21.7	2.1
	International price	31.5	2.7	27.8	2.8	30.2	2.7	31.5	2.7	28.3	2.1
	Private net export	5.9	1.2	6.2	1.9	4.3	1.6	5.5	1.2	4.8	1.3
	Private stocks	3.7	2.4	0.7	1.0	0.4	0.8	2.0	2.1	0.0	0.2
	Public stock	10.0	4.4	16.5	3.0	17.4	4.9	11.4	4.8	26.1	5.7
	Public net export	-2.1	2.6	0.5	0.4	0.6	0.6	-1.7	2.5	1.5	0.6
	Fiscal cost	137.1	12.2	148.6	11.7	144.1	13.8	131.2	12.6	159.0	15.5

Note: Means and standard deviations are calculated for stochastic shocks realization; Rice prices are reported for milled rice (as opposed to paddy); fiscal costs are in Rs Cr/WPI; All the aggregate volumes are reported in million tons (mt), prices are reported in Rs/kg in real terms (divided by WPI)

4.3. Cash transfers and deficiency payment scenarios

The introduction of cash transfers instead of physical food delivery and deficiency payments instead of procurement of wheat and rice has various implications for the food system. In the table 5 we present a comparison of this alternative policy framework under two different coverages with the MSP scenario. Results are slightly different for wheat and rice partly due to different coverage with these crops with the PDS and higher leakage in wheat distribution.

Table 5 Simulation results – means and standard deviations in 2020

		(1) MSP		(5) Cash 67%		(6) Cash 30%	
		Mean	STD	Mean	STD	Mean	STD
Wheat	Production	96.8	4.9	87.9	4.5	87.9	4.4
	Consumption	96.4	2.8	90.2	3.1	90.2	3.2
	Domestic Price	18.2	1.5	23.5	2.4	23.4	2.6
	International price	19.6	0.7	21.6	1.8	21.6	1.9
	Private stocks	1.3	1.5	3.7	1.6	3.6	1.6
	Public stock	10.2	3.6	1.9	0.0	1.9	0.0
	Fiscal cost	85.1	6.9	61.9	6.8	63.8	0.1
Rice	Production	108.9	5.3	107.2	5.3	107.6	5.4
	Consumption	104.6	1.0	105.5	2.1	105.5	2.2
	Domestic Price	24.8	2.7	28.5	3.9	28.4	4.3
	International price	31.5	2.7	34.1	2.3	34.0	2.4
	Private stocks	3.7	2.4	9.4	1.9	9.5	2.0
	Public stock	10.0	4.4	3.0	0.0	3.0	0.0
	Fiscal cost	137.1	12.2	89.7	12.7	65.2	2.3

Note: Means and standard deviations are calculated for stochastic shocks realization; Rice prices are reported for milled rice (as opposed to paddy); fiscal costs are in Rs Cr/WPI; All the aggregate volumes are reported in million tons (mt), prices are reported in real terms (divided by WPI)

In both cash scenarios, production is lower than under the MSP scenario. This is an outcome of lower support prices. However, consumption is affected variously – for wheat it is lower and for rice, higher. Cash scenarios result in significantly higher domestic and international market prices and their variability except for the international rice price variability, which slightly declines under cash scenarios. This implies that international prices would be less affected by the Indian supply. Domestic market prices are higher by 14-29 per cent under cash scenarios. Again, the standard deviation was calculated across the production shock realizations, so it refers both to the uncertainty of the projection and the sensitivity of the price to production shocks. International prices are higher by 7.8 – 10.4 per cent in cash scenarios as compared to the MSP scenario. Public stocks are limited to emergency reserves in cash scenarios and, as a result, public stock levels go down to 1.9 mt for wheat and 3 mt for rice. This results in significantly higher private wheat stocks. In the Cash 67% scenario, fiscal costs for rice are reduced by over 27 per cent and, even more, 35 per cent for wheat.

Significant cost reduction can be achieved through delivering cash only to the poor, specifically to those, living below the poverty line. This is estimated to be 30 per cent of the population (according to the Rangaranjan report (Planning Commission, 2014). In this scenario, the cash transfer is increased to Rs 200 per person per months, however fiscal costs are still dramatically lower - 42 per cent less than is the MSP scenario. However, in the Cash 30% scenario, between 2014 and 2020 market price of wheat grows by 29 per cent and of rice, by 14.4 per cent in real terms, which means a significant drop in wheat and rice quantity which can be bought for the transfer amount. The allowance is constant in real terms. On the other hand, the idea of delivering cash instead of in-kind transfers, assumes that the money can be spent on different goods and the average purchasing power of the transfer remains the same due to indexing it with inflation. Linking the transfer to the inflation of the poor would be a useful improvement of this policy measure. Finally, other problems related to cash transfers should be considered. As it was discussed by Birner and von Braun (2015), cash transfers are recommendable only in certain policy contexts.

4.4. Domestic price volatility

Excessive price volatility can have several negative implications for food security and macroeconomic stability (as discussed e.g. in Kalkuhl, Kornher, Kozicka, Boulanger, & Torero, 2013; von Braun & Tadesse, 2012). Food price instability can also have its political cost (Arezki & Brückner, 2011; Sidhir, 2004), which needs to be taken under consideration. In our simulation results, inter-annual price volatility differs quite significantly across scenarios, as presented in the table 6.

The highest domestic wheat price volatility under the NFSA implementation is in the Imports scenario. In case of rice, the highest volatility is in the MSP scenario. Introduction of cash transfers and deficiency payments results in even higher domestic price volatility. Aggressive price stabilization policies have a significant impact in the model. The lowest domestic price volatilities are in the Baseline and the Trade bans scenarios.

Table 6 Simulation results – inter-annual domestic price volatility

	Wheat	Rice
(1) MSP	1.26 (0.35)	1.67 (0.51)
(2) OMSS	1.15 (0.35)	1.48 (0.45)
(3) Trade bans	0.99 (0.27)	1.24 (0.34)
(4) Imports	1.38 (0.37)	1.52 (0.49)
(5) Cash 67%	2.22 (0.56)	1.94 (0.66)
(6) Cash 30%	3.03 (0.77)	2.35 (0.85)
Baseline	0.97 (0.27)	1.17 (0.32)

Note: Price volatility was calculated as annual log returns standard deviation in the projection horizon, i.e. from 2013 to 2020. The means and standard deviations (in parenthesis) of 1000 simulations of each scenario are presented in the table.

4.5. Stocks and fiscal costs

The baseline scenario puts the highest pressure on the fiscal costs. High procurement, high stocks (37 mt) and large distribution with highly subsidised prices to a growing population causes the fiscal cost in our simulation to grow by 49 per cent in real terms between 2012 and 2020 (table 7). In terms of GDP share the number grows from 1.2 per cent to only 1.8 per cent, thanks to the growing economy. The OMSS scenario with slightly lower stock levels also results in very high fiscal cost. This is due to higher MSP levels and higher procurement, so effectively higher transfers for farmers. Relying on imports yields the lowest total stock level of 18 mt and the lowest fiscal cost of 1.5 per cent of GDP, among the NFSA scenarios. The Imports scenario has low fiscal cost because the MSPs are low, which results in low stocks. Only those grains which are necessary to feed the NFSA are imported if there are too low supplies in the domestic market. The MSP scenario results in total stock of 25 mt and still considerable cost of 1.6 per cent of GDP.

The cash 67% scenario brings significant savings and shrinks fiscal costs to 1.1 per cent of the GDP. In addition, due to higher private stocks, total stock amounts to almost 18 mt. This means that stable food supplies are partially carried out by the private market.

The Cash 30% scenario is the 'cheapest' option causing the fiscal cost to decrease in real terms by 22 per cent. Under this scenario, fiscal costs amount to 0.9 per cent of GDP in 2020. Stock levels are similar to the Cash 67% scenario.

Table 7 Simulation results –total stocks and fiscal costs in 2020

	Baseline	(1) MSP	(2) OMSS	(3) Trade bans	(4) Imports	(5) Cash 67%	(6) Cash 30%
Total stock (public+private)	36.9	25.3	30.5	27.6	18.3	17.9	18.0
Total fiscal cost (in % of GDP)	1.8	1.6	1.7	1.6	1.5	1.1	0.9
Total fiscal cost (nominal in Rs Bln)	3002	2717	2898	2793	2543	1854	1577
Fiscal cost growth (% 2020 over 2012, in real terms)	48.5	34.3	43.3	38.1	25.8	-8.3	-22.0

Note: According to our estimates (using the same methodology as in the table), fiscal cost in 2013 was equal to 1.2% of GDP.
GDP data source is OECD, assumed GDP growth rate equal to the baseline scenario.

5. Conclusions

This paper provides an empirically grounded dynamic partial equilibrium model for the Indian rice and wheat sector. Most of the functional forms and their parameters were econometrically estimated using national time series data from 1982. Discretionary policies, like OMSS and public exports, were approximated by simple rules, linking stock levels to PDS requirements and stock norms. The presented model differs from the existing literature in explicitly linking policies to the market fundamentals, including endogenous international prices and domestic private grain stocks, considering wheat and rice simultaneously, as well as estimating fiscal costs. We also provide the first assessment of the implications of the NFSA in a consistent equilibrium framework. Further, for the first time, different strategies to fulfil the requirements of the Act are compared and an alternative policy framework consisting of cash transfers and deficiency payments is evaluated.

The high degree of government involvement results in a high sensitivity of fiscal costs and public stock levels to policy measures. For example, small variations of the MSP strongly influence the production, procurement and stocks. We considered the implementation of the NFSA under several policy measures with the current regime (procurement with MSP and distribution with PDS) as well as two scenarios with a regime change, namely cash transfers and deficiency payments. Implications for market fundamentals and fiscal costs were simulated in the medium term – until 2020/21.

The NFSA puts a high pressure on fiscal costs and public stocks. Careful management of MSPs to keep public stocks close to the norms can reduce the fiscal costs but only to 1.6 per cent of the GDP. This policy measure, however, results in high and volatile domestic prices while international prices are not severely affected. In this scenario, a procurement price should be reintroduced in order to balance stock levels, i.e. the MSP is minimized subject to achieving the stock norms. On the contrary, relying on imports in the NFSA delivery elevates means and volatility of domestic and means of international prices, however this is the cheapest option among the NFSA scenarios. The major advantage would be the farmer's benefits from high prices while poor consumers are protected by PDS.

A policy reform, which introduces cash transfers instead of the PDS and deficiency payments instead of physical grain procurement, could bring considerable savings, decreasing the fiscal costs to 1.1 per cent of GDP in 2020. Even lower cost can be reached with cash transfers being targeted to the poor only. Fiscal cost then decrease to 0.9 per cent of GDP and yet total stocks are ample due to higher private stockholding. However, this scenario shows the highest domestic price variability, which can have negative effects on some producers and consumers. Food price instability can also have its political cost, which needs to be taken under consideration. Additionally, there are several problems, which should be taken care of under cash transfers. For example, payments should be linked to local prices to maintain the purchasing power of the transfers. Leakages can still prevail if people involved in the cash distribution are corrupt but with a very transparent cash transfer system leakages are likely to be reduced, particularly because those occurring at the fair price shops are impeded.

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Appendix A. Fiscal costs components

Table A1 Categories as included in the Fiscal Cost equation

Variable	FCI Category	Source	Unit
$ac_{t,i}$	Acquisition cost	FCI	Rs/quintal, WPI deflated
$D_{t,i}^{FCI}$	Total procurement	FCI	Million tons
$p_{t,i}^{MSP}$	MSP	FCI	Rs/quintal, WPI deflated
$c_{t,i}^{d}$	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
$MIP_{t,i}$	Minimum issue price	Linked to the MSP	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
$NExp_{t,i}^{pub}$	Total net off-take for exports	Endogenous	Million tons

Appendix B. Model fit graphs

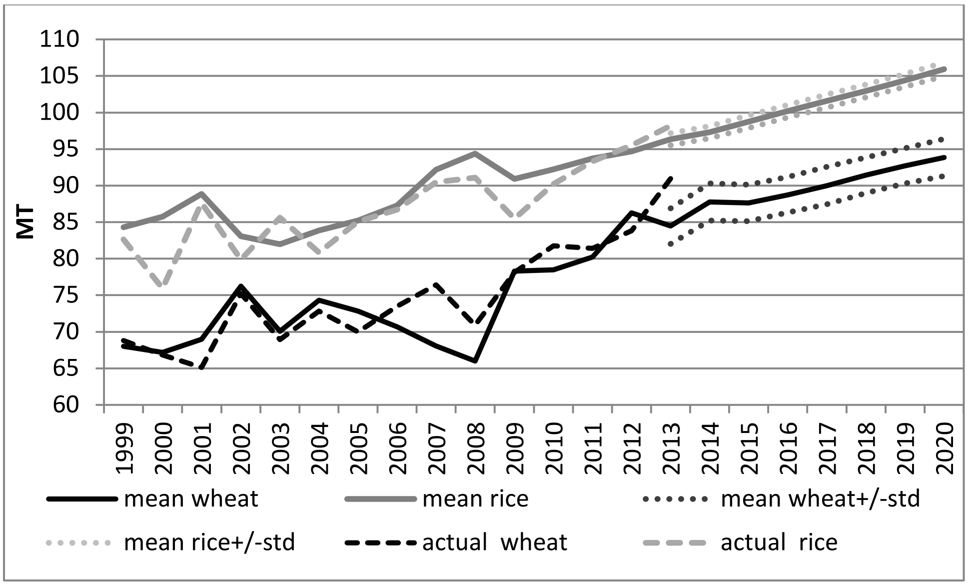

Figure B1 Ex-post and baseline scenario total consumption simulation

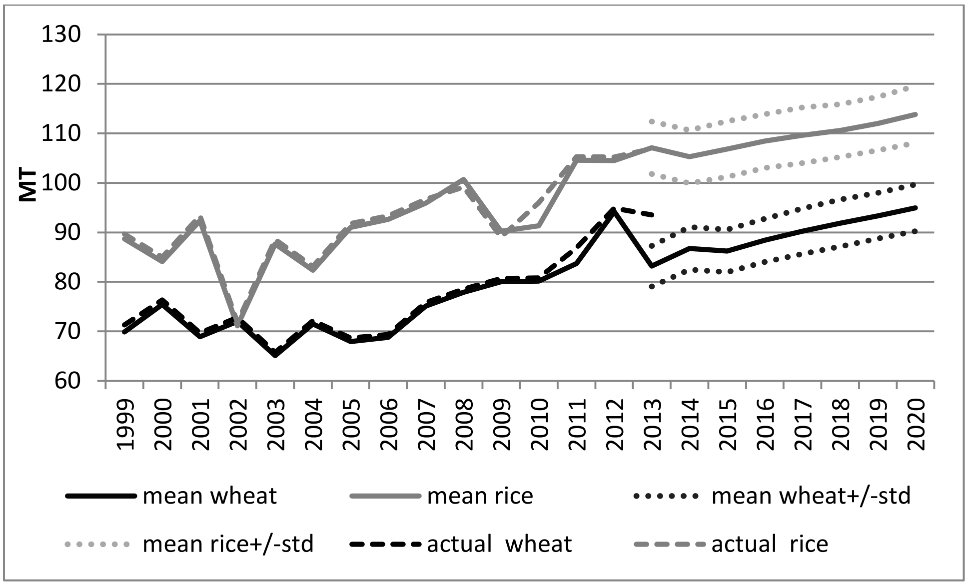

Figure B2 Ex-post and baseline scenario production simulation

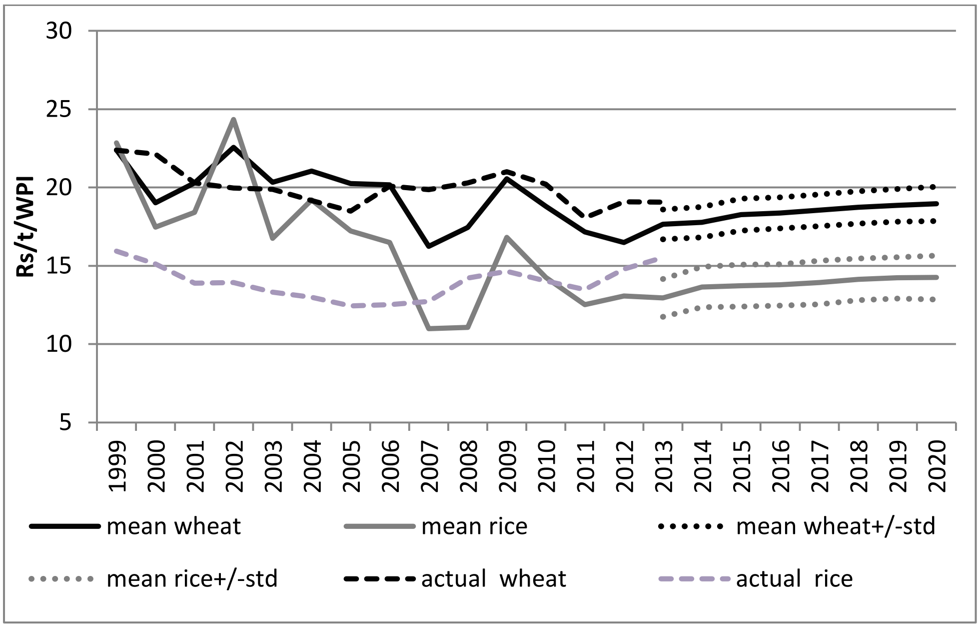

Figure B3 Ex-post and baseline scenario price simulation

Note: Rice price in this graph is for paddy. In the study we use 0.66 as a conversion factor from paddy to rice.

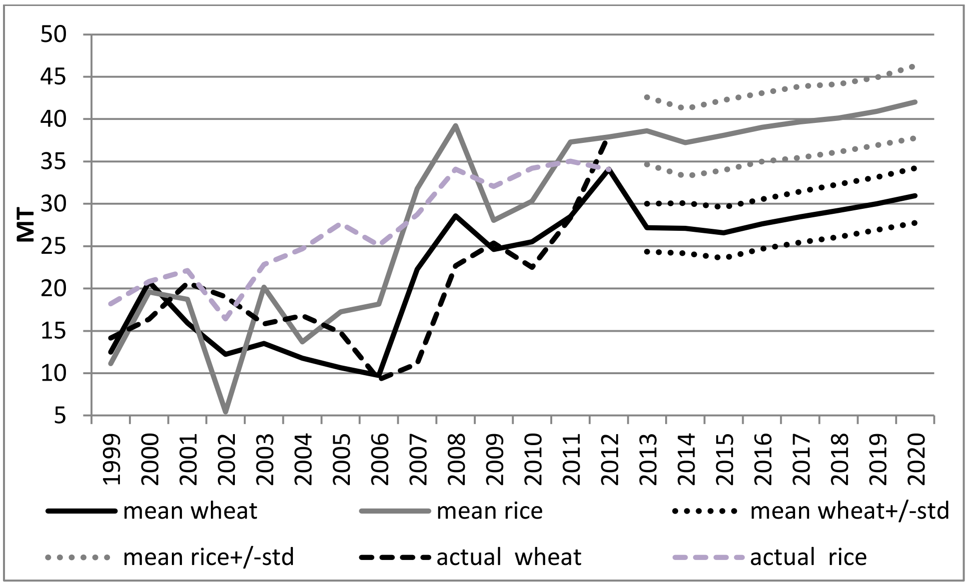

Figure B4 Ex-post and baseline scenario procurement simulation

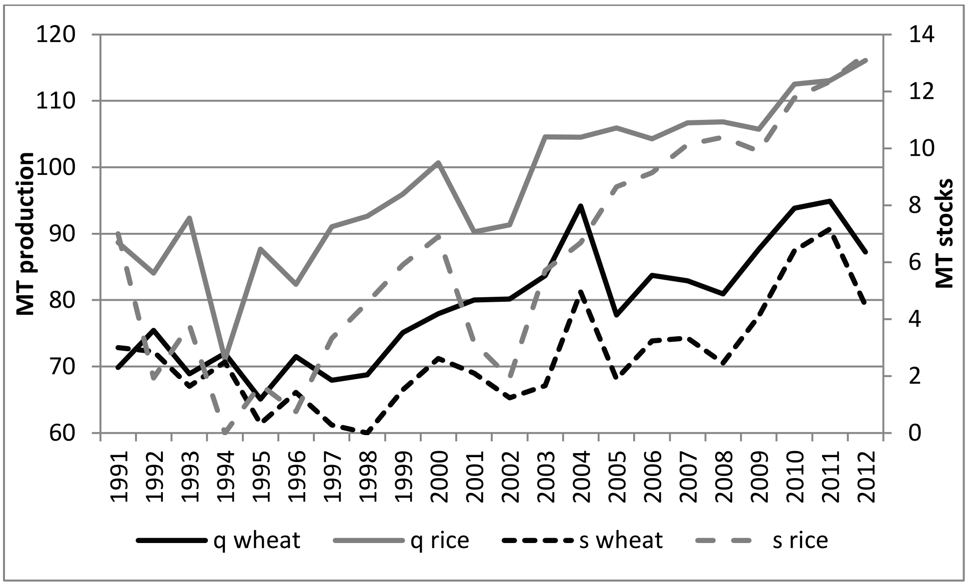

Figure B5 One realisation of private stocks (s) and production (q) in cash scenario

FOODSECURE
FOR POLICIES THAT MATTER

The FOODSECURE project in a nutshell

Title	FOODSECURE – Exploring the future of global food and nutrition security
Funding scheme	7th framework program, theme Socioeconomic sciences and the humanities
Type of project	Large-scale collaborative research project
Project Coordinator	Hans van Meijl (LEI Wageningen UR)
Scientific Coordinator	Joachim von Braun (ZEF, Center for Development Research, University of Bonn)
Duration	2012 - 2017 (60 months)
Short description	In the future, excessively high food prices may frequently reoccur, with severe impact on the poor and vulnerable. Given the long lead time of the social and technological solutions for a more stable food system, a long-term policy framework on global food and nutrition security is urgently needed. The general objective of the FOODSECURE project is to design effective and sustainable strategies for assessing and addressing the challenges of food and nutrition security. FOODSECURE provides a set of analytical instruments to experiment, analyse, and coordinate the effects of short and long term policies related to achieving food security. FOODSECURE impact lies in the knowledge base to support EU policy makers and other stakeholders in the design of consistent, coherent, long-term policy strategies for improving food and nutrition security.
EU Contribution	€ 8 million
Research team	19 partners from 13 countries

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