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ORIGINAL ARTICLE

PRICE VOLATILITY IN FOOD COMMODITIES IN INDIA - AN EMPIRICAL INVESTIGATION

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Abstract : In the recent years, agricultural commodities are characterized by a high degree of price volatility in India. These variations in prices that do not reflect market fundamentals and thus become problematic as they can lead to incorrect decisions. The higher food prices are disastrous especially for the poor where large amount of their total income is being spent on basic foodstuffs. Poor smallholders, who do not have access to credit may have difficulty financing the crucial inputs needed to plant again and stay in business. Thus, both the welfare of the family and the viability of the farm may be threatened by excessive volatility. Uncertainty may also result in sub-optimal investment decisions in the longer term. The study observed that persistent volatility shocks were quite visible in the monthly price volatility in spot price of gram in Delhi, lentil grain (bold) in Indore and rapeseed and mustard oil in Sri Ganganagar market. Empirical results of GARCH Model revealed that the value of first-order autoregressive term ARCH and value of first-order moving average term GARCH were observed to be significant in the price series pertaining to all the years. The quite large value of GARCH term in comparison to ARCH term showed reasonably long persistence of volatility. The persistent volatility was also quite high in selected commodities for most of the years.

Key words : ADF test, LM test, GARCH Model, Stationarity, Volatility

1. Introduction

When prices move along a smooth and well-established trend reflecting market fundamentals or when they exhibit a typical and well known seasonal pattern are not of serious concern. But variations in prices of food commodities in India are large and cannot be anticipated and as a result, create a level of uncertainty, which increases risks for producers, traders, consumers and governments and may lead to sub-optimal decisions. The price policy for agricultural commodities in India generally aims to achieve the objectives of stability in the prices for producers and sustained supply to the consumers at reasonable prices. However, in the recent years agricultural commodity markets are characterized by a high degree of price volatility in India. The consequences of price rise can viewed as the higher food prices are disastrous especially for the poor consumers and smallholders. Also, price risk affects agricultural producers in two ways: directly, increasing or decreasing their profits and indirectly, influencing the whole economy. For developing countries, this indirect impact is much larger as their young economies are very vulnerable to different shocks.

Many economists argued that commodity prices are notoriously volatile creating instability in global commodity markets [Blandford (1983), Heifner and Kinoshita (1994)]. The price volatility behavior in futures and ready markets in India showed that markets are not well integrated and hence not sufficiently matured [Kumar and Sunil (2004)]. In the absence of international trade, with downward sloping demand for agricultural products, negative production shock caused by poor harvest and resulted decreased supply will be compensated by price increase and farmers will not suffer more. On the other hand, increase in supply due to good harvest leads to decrease in prices and drop in profit. In case of internationally traded commodities, price shock going after production shock is exogenous as it is not correlated with their output and producers

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suffer from it because lower prices decrease their profits. However, some country may gain from trade as it compensates drop in price by larger volumes of sales. Rapsomanikis and Sarris (2006) reported that influence of international prices on income of households is small in Ghana, Peru and Vietnam and the main source of income instability is domestic prices. Further, Sagidova (2004) investigated that integration in world and Ukrainian grain prices is insufficient and limited as 87.5% of the potential shock will be absorbed during 8 months in Ukrainian whereas in the world practice time needed for this is about 6 months. On the other hand, Fafchamps (2000) found that in developing countries, households are much less protected from price variation, especially exporters from world price fluctuations.

The autoregressive conditional heteroscedasticity (ARCH) type models are defined in terms of the distribution of errors of a dynamic linear regression model, assuming that a dependent variable of commodity prices is generated by the autoregressive process. The unique strength of ARCH-type models lies in their ability to allow the conditional variance of underlying processes to vary over time. Also, the information that is used in forming conditional expectations is similar to that used to predict the conditional mean (*i.e.* variables observed in previous periods). Bollerslev (1986) proposed an extension to the information set in a simple ARCH model [Engle (1982)] by including a lagged conditional variance to arrive at the Generalized ARCH. Paul *et al*. (2009) employed generalized autoregressive conditional heteroscedasticity (GARCH) models for modelling and forecasting of India's volatile spices export. In view of above facts, the present study was undertaken to address the issue of price volatility in the important food commodities in India using advance econometric tools.

2. Data and Methodology

Data - Secondary data on daily spot price of gram in Delhi Market, lentil grain (bold) in Indore Market and rapeseed and mustard oil in Sri Ganganagar Market for the period of 1st January 2007 to 31st July 2013 were used in the study to estimate price volatility.

Testing of Stationarity

The unit root or non-stationary test described by Dickey and Fuller (1979) is valid, if the time series y_t is well characterized by an autoregressive (AR(1)) with white noise errors. Many financial time series, however, have a more complicated dynamic structure than is captured by a simple AR(1) model. Said and Dickey (1984) augment the basic autoregressive unit root test to accommodate general autoregressive moving average (ARMA(p, q)) models with unknown orders and their test is referred to as the augmented Dickey-Fuller (ADF) test. The ADF test tests the null hypothesis that a time series y_t is I(1) against the alternative that it is I(0), assuming that the dynamics in the data have an ARMA structure. The ADF test is based on estimating the test regression

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t$$

Where, D_t is a vector of deterministic terms (constant, trend etc.). The p lagged difference terms, Δy_{t-j} are used to approximate the ARMA structure of the errors and the value of p is set so that the error ε_t is serially uncorrelated. The error term is also assumed to be homoscedastic. Under the null hypothesis, Δy_t is I(0), which implies that $\pi = 0$. The ADF t-statistic is then the usual t-statistic for testing $\pi = 0$. This test was applied to the spot price series of gram, lentil grain (bold) rapeseed and mustard oil to test the null hypothesis that the series has unit root or non-stationary.

Price Volatility

The term volatility refers to variations in economic variables over time. In this study, our focus was on variations in agricultural prices over time. Large variations in prices that do not reflect market fundamentals and thus become problematic as they can lead to incorrect decisions. Implied volatility reflects the expectations of market participants on how volatile prices will be and was measured as a percentage of the deviation in the futures price (six months ahead) from underlying expected value for selected commodities.

ARCH-LM Test

For testing the conditional heteroscedasticity, let ε_t be the residual series. The squared series $\{\varepsilon_t^2\}$ is then used to check for conditional heteroscedasticity, which is also known as the autoregressive conditional heteroscedastic (ARCH) effects. Lagrange's Multiplier (LM) test was used for testing conditional heteroscedasticity, which is equivalent to usual *F*-statistic for testing, $H_0 = a_i = 0$, $i = 1, 2, \ldots, q$ in the linear regression

$$\varepsilon_t^2 = a_0 + a_l\varepsilon_{t-1}^2 + \ldots + a_q\varepsilon_{t-q}^2 + e_t, t = q+1, \ldots, T$$

Where, e_t denotes error term, q is pre-specified positive integer and T is sample size. Let $SSR_0 = \sum_{t=q+1}^{T}\left(\varepsilon_t^2 - \overline{\omega}\right)^2$, where $\overline{\omega} = \sum_{t=q+1}^{T}\varepsilon_t^2/T$ is sample mean of $\{\varepsilon_t^2\}$, and $SSR_1 = \sum_{t=q+1}^{T}\hat{e}_t^2$, where $\hat{e}_t$ is least squares residual. Then, under H_0:

$$F = \frac{\left(SSR_0 - SSR_1\right)/q}{SSR_1(T-q-1)}$$

is asymptotically distributed as chi-squared distribution with q degrees of freedom. The decision rule is to reject H_0 if $F > \chi_q^2(\alpha)$, where $\chi_q^2(\alpha)$ is the upper $100(1-\alpha)$th percentile of χ_q^2 or, alternatively, the p-value of F is less than α.

GARCH Model

To measure the extent of price volatility, generalized autoregressive conditional heteroscedasticity (GARCH (1, 1)) model was specified as

$$Y_t = X_t\theta + \varepsilon_t$$

$$\sigma_t^2 = \omega + \alpha \in_{t-1}^2 + \beta\sigma_{t-1}^2$$

The mean equation given in first equation is written as a function of exogenous variables with an error term. Since, σ_t^2 is the one-period ahead forecast variance based on past information, it is called the conditional variance. The conditional variance equation specified in second equation is a function of three terms: a constant term: ω, news about volatility from the previous period, measured as the lag of the squared residual from the mean equation: $\in_{t-1}^2$ (the ARCH term) and last period's forecast variance: σ_{t-1}^2 (the GARCH term). There is an equivalent representation of the variance equation that is useful for interpreting the model. The error in the squared residuals is given by $v_t = \in_t^2 - \sigma_t^2$. Substituting for the variance in the variance equation and rearranging the terms, the model can be written in terms of the errors as:

$$\in_t^2 = \omega + (\alpha + \beta) \in_{t-1}^2 + v_t - \beta v_{t-1}$$

Thus, the squared error follows a heteroscedastic ARMA (1, 1) process. The autoregressive root which governs the persistence of volatility shocks in the price series is the sum of α plus β. The ARCH parameters corresponds to α and GARCH parameters to β. If the sum of ARCH and GARCH coefficients close to 1, indicating that volatility shocks are quite persistent in the spot prices series of gram, lentil grain and rapeseed & mustard oil.

3. Empirical Results

The basic statistics of the three agricultural commodities *i.e.* gram, lentil grain (bold) and rapeseed & mustard oil have been examined in the study as shown in Table 1. The price level of these three commodities has increased over the period. The large value of standard deviation in mean price suggested that there has been wide fluctuation in the commodities price level during the period of 2007 to 2013. The results of historical volatility in prices suggested that there has been persistent volatility of higher magnitude in commodities prices during the period under study (Table 2). The volatility in prices of gram has observed a fluctuating trend. It increased from 17.5% in the year 2007 to 24.4% in 2008 and then declined subsequently to 16.8% in the year 2010, but in the next year it rose to ever high level of 32.5% in 2011, but in the next year 2012 it declined to 26.5%. In case of lentil grain, the price volatility of higher order of 46.6% in 2007, 48.8% in 2008 has decreased in the subsequent years to 24.4% in 2011 and further decreased to 23.3% in the year 2012. The annual price volatility in case of rapeseed and mustard oil has increased from 24.9% in 2007 to 31.6% in the year 2009 and then it declined in the later years. The monthly price volatility in these three commodities has also been shown with the help of graphs as given in Figure 1 to 3, respectively. The persistent volatility shocks are quite visible in these graphs during the period under study.

ADF test was employed to determine the number of times the series needs to be differenced to make it stationary for further analysis. A perusal of Table 3 revealed that the t-statistics obtained for level data for three commodities price series in the year from 2007 to 2013 were found to be non-significant implying that the series has unit roots. The t-Statistics at first difference were found to be significant at 1 per cent level in all the cases. Thus, the data series of prices became stationary at one differencing and ready for further econometric analysis.

Table 1 : Basic statistics of selected commodities.

Particulars	Years						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Gram: Spot Market- Delhi							
Mean Price Rs./100Kgs	2333	2433	2275	2268	2816	4157	3436
Standard Deviation	120.248	169.339	132.995	110.942	430.163	538.180	293.208
Lentil Grain (Bold): Spot Market- Indore							
Mean Price Rs/100Kgs	2596.67	3776.69	4300.75	3471.10	3032.91	3079.66	4069.87
Standard Deviation	319.930	511.792	403.281	259.469	219.819	299.708	337.93
Rapeseed &Mustard oil: Spot Market- Sri Ganganagar							
Mean Price. Rs./10kgs	457.83	610.17	492.85	494.52	611.24	778.80	682.22
Standard Deviation	32.996	48.279	46.863	40.135	48.086	32.530	57.559

Table 2 : Historical annual price volatility (%) in selected commodities.

Commodities	Years						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Gram	17.534	24.365	20.133	16.799	32.552	26.521	30.856
Lentil grain (Bold)	46.652	48.855	33.605	25.969	24.463	23.298	25.654
Rapeseed & mustard oil	24.921	28.122	31.599	27.957	26.813	20.183	22.643

Table 3 : Results of Augmented Dickey-Fuller Unit Root Test for selected commodities.

Years	t-statistic					
	Gram		**Lentil grain (Bold)**		**Rapeseed & mustard oil**	
	Level data	**At first difference**	**Level data**	**At first difference**	**Level data**	**At first difference**
2007	-2.927	-11.547*	-2.014	-12.081*	-2.851	-12.4*
2008	-2.488	-12.114*	-1.998	-14.400*	-2.488	-12.114*
2009	-3.223	-12.427*	-2.487	-12.612*	-3.223	-12.427*
2010	-2.777	-15.446*	-3.106	-14.242*	-2.777	-15.446*
2011	-0.072	-14.316*	-2.145	-13.803*	-0.072	-14.316*
2012	-2.021	-6.147*	-2.479	-6.896*	-2.021	-6.147*
2013	-1.873	-9.414*	-2.512	-10.031*	-1.501	-7.7367*

Note: Test critical value at 1% level is -4.06829*

Table 4 : ARCH- LM test statistic for selected commodities.

Years	Gram		Lentil grain (Bold)		Rapeseed & mustard oil	
	Annual	**Lag**	**Annual**	**Lag**	**Annual**	**Lag**
2007	2.975*	3	4.7043*	5	5.0820**	4
2008	3.0214*	4	7.2916**	4	5.324**	5
2009	2.6598*	5	5.3445*	6	4.957*	4
2010	4.2564*	4	6.1545**	5	6.254**	4
2011	3.9874*	4	4.5689*	7	6.547**	6
2012	4.2587*	6	6.3259**	5	4.98*	5
2013	5.0214**	5	4.9654*	4	3.254*	5

**and *denote significant at 1% and 5% levels.

The ARCH-LM test was found to be significant for price series of all three commodities confirming the presence of conditional heteroscedasticity in the price volatility (Table 4). Thus, the price volatility has been examined in the daily data of gram spot market (Delhi), lentil grain bold spot market (Indore) and rapeseed and mustard oil spot market (Sri Ganganagar) during the period of January 2007 to April 2013. The univariate GARCH (1, 1) parameters for the variance equations were obtained for all three commodity prices (Table 5). The price volatility was captured through ARCH and GARCH parameters *i.e.* $(\alpha + \beta)$ of spot price series. The observed volatility in the spot price series of gram

Table 5 : Parameter estimates of GARCH (1, 1) Models for selected commodities.

Particulars	Gram		Lentil grain (Bold)		Rapeseed & Mustard Oil	
2007-Variance equation						
Variable	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Constant	12.8573	8.4906	31.3415	10.6988	0.7952	0.3040
ARCH(1)	0.0847**	0.0249	0.1474**	0.0446	0.1023**	0.0319
GARCH(1)	0.9005**	0.0273	0.8100**	0.0431	0.7803**	0.0616
$\alpha+\beta$	0.9852		0.9574		0.8826	
2008-Variance equation						
Constant	26.65273	8.2170	0.8769	0.3336	4.0695	1.1692
ARCH(1)	0.0956**	0.0244	0.1073**	0.0349	0.0891*	0.0354
GARCH(1)	0.8913**	0.0224	0.7665**	0.0664	0.8277**	0.0478
$\alpha+\beta$	0.9869		0.8738		0.9168	
2009-Variance equation						
Constant	222.7185	135.7438	2277.4530	395.5913	1.3737	0.5198
ARCH(1)	0.1456**	0.0493	0.6068**	0.0936	0.2364**	0.0694
GARCH(1)	0.6700**	0.1559	0.1741**	0.1110	0.7217**	0.0669
$\alpha+\beta$	0.8156		0.7809		0.9581	
2010-Variance equation						
Constant	31.3814	24.2043	0.8902	0.3424	5.2545	4.0985
ARCH(1)	0.0797*	0.0375	0.1085**	0.0359	0.1922	0.1613
GARCH(1)	0.8557**	0.0773	0.7654**	0.0677	0.6783*	0.3653
$\alpha+\beta$	0.9354		0.8739		0.8705	
2011-Variance equation						
Constant	28.5112	12.7104	152.5081	60.6510	7.2691	4.3032
ARCH(1)	0.0989**	0.0283	0.2244**	0.0852	0.1548*	0.0725
GARCH(1)	0.8939**	0.0220	0.6713**	0.0949	0.5525*	0.2751
$\alpha+\beta$	0.9928		0.8957		0.7073	
2012-Variance equation						
Constant	32.0266	15.1730	116.5200	200.1249	5.3749	3.3326
ARCH(1)	0.1202*	0.0695	0.0206	0.0262	0.1062*	0.0455
GARCH(1)	0.7803**	0.1402	0.8614**	0.2228	0.7406**	0.1179
$\alpha+\beta$	0.9005		0.8820		0.8468	
2013-Variance equation						
Constant	30.5499	13.5648	31.7770	30.4403	1.2650	1.6948
ARCH(1)	0.0849*	0.0579	0.0959	0.0516	0.1350*	0.0927
GARCH(1)	0.8147**	0.0946	0.8845**	0.0598	0.7150**	0.1914
$\alpha+\beta$	0.8996		0.9804		0.8500	

in the year 2007 revealed that the value of first-order autoregressive term ARCH (α) has significant term (0.0847) and value of first-order moving average term GARCH (β) was also significant (0.9005). The volatility ($\alpha + \beta$) was quite persistent of the order of 0.985. In the year 2008, both ARCH and GARCH terms were significant and the observed volatility was as high as 0.987. In the year 2009, the persistent volatility was of the order of 0.815, which indicate a decline over the previous year. The extent of persistent volatility has declined in the year 2010, 2011, 2012 and 2013 the value remained 0.935, 0.992, 0.900, and 0.899, respectively.

In case of spot price lentil grain bold at Indore Market, the value of first-order autoregressive term ARCH and moving average term GARCH were observed to be significant in the price series pertaining to all the years except ARCH term for 2012 and 2013. The observed volatility was as high as 0.957 (2007),

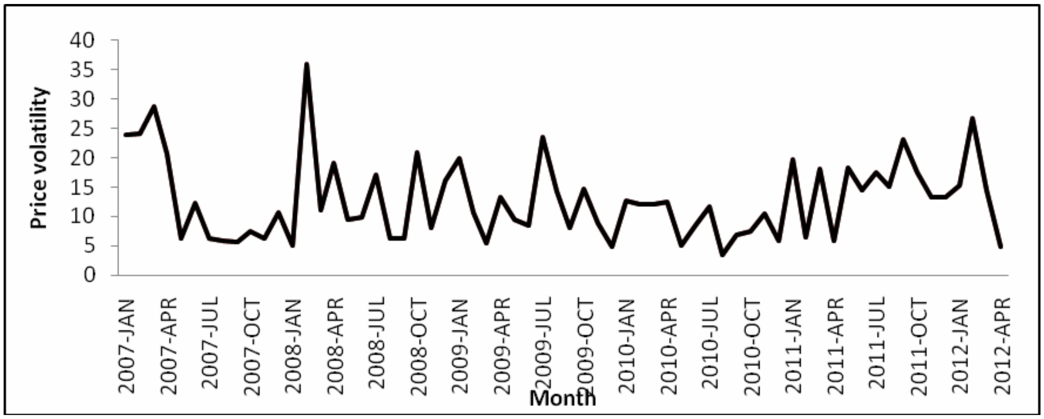

Fig. 1 : Monthly price volatility (%) in gram at Delhi Market.

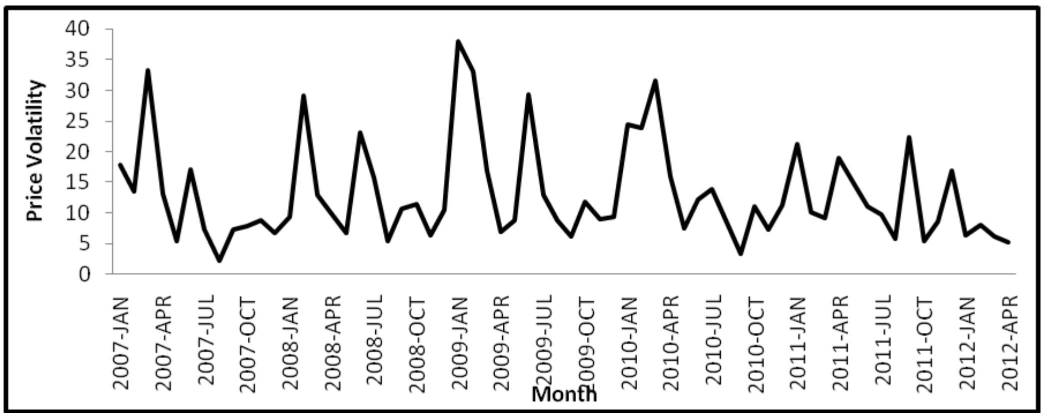

Fig. 2 : Monthly price volatility (%) in Lentil grain (Bold) at Indore Market.

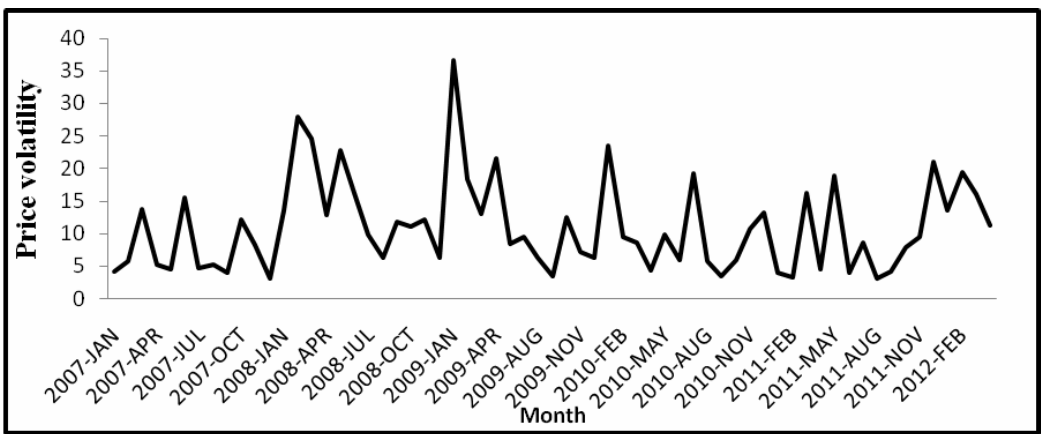

Fig. 3 : Monthly price volatility (%) in rapeseed and mustard oil at Sri Ganganagar Market.

0.864 (2008), 0.781 (2009), 0.874 (2010), 0.896 (2011), 0.882 (2012) and 0.980 in 2013. Empirical results of GARCH model for spot price of rapeseed and mustard oil in Sri Ganganagar Market showed that the ARCH and GARCH terms were significant in the price series pertaining to all the years except ARCH term for 2010. In the year 2011, two terms of moving average GARCH (β) were observed found to be significant. The value of persistent volatility was observed to be as high as 0.883 (2007), 0.917 (2008), 0.958 (2009), 0.871 (2010), 0.707 (2011), 0.847 (2012) and 0.850 in 2013. The quite large value of GARCH term in comparison to ARCH term showed reasonably long persistence of volatility in all three commodities for all the years under consideration.

4. Conclusion

The price levels of these three commodities have increased over the period under study. The large value of standard deviation in mean price suggested that there has been wide fluctuation in the commodity price levels during the period of 2007 to 2013. The annual volatility in lentil grain bold was of high order in initial years and declined in the later years. In gram, it has increased in later years and in rapeseed and mustard oil annual volatility has increased up to 31.59% in 2009 and then decreased upto 20.18% in 2012. The persistent volatility shocks were also quite visible in the monthly price volatility in these three commodities. Empirical results of GARCH model for Spot prices revealed that the value of first-order autoregressive term ARCH and value of first-order moving average term GARCH were found to be significant in the price series pertaining to all the seven years except few cases. The quite large value of GARCH term in comparison to ARCH term showed reasonably long persistence of volatility. The focus of this paper is not to eliminate price volatility, but to reduce/restrict variations by smoothing out the extremes and most importantly, to reflect market fundamentals as accurately as possible through price volatility. Price volatility should not conveyed incorrect signals as a result of missing or wrong information, speculation, panic or other disruptive factors. A reliable market information system and up-to-date information on supply, demand, stocks and export availability may help in reducing price volatility. The recent spurt in prices has revealed the weaknesses in the capacity of the system to produce consistent, accurate and timely information on market and weather shocks. Therefore, government action is needed to increase capacity to undertake systematic monitoring of crops production, improved short-run production forecasts and market analysis. An adequate food stock is a necessary component of a well functioning market, in particular to smooth out seasonal fluctuations and time lags in trade.

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