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Price Discovery Efficiency of Cotton Futures Market in India

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Abstract

The paper evaluates the efficiency of Indian cotton futures prices in predicting future spot prices during the period January, 2013 to December, 2015 using Vector Auto Regression (VAR) model and Granger causality tests. The Augmented Dickey-Fuller test was initially applied to check stationarity in futures and spot prices. The results shown that both the variables are stationary at level. The VAR model suggests that lag value of futures has more influence on spot price of cotton. The causality test has further indicated that futures markets have negligible ability to predict subsequent spot prices for cotton. The results of this study will be useful for various stakeholders who are actively participating in agricultural commodity markets.

Key words: Cotton futures, spot price, efficiency, India

JEL Classification: G14

Introduction

Agricultural futures markets primarily function as a mechanism for discovering prices and managing market risks associated with price variability and stock holding. The holding commodity over time entails risk, and as a reward for that risk, the future spot price must be higher than the current futures price. In general, the market participants, including farmers, will hold stocks if futures prices are lower than the expected futures spot prices net of storage cost. For markets to be efficient, we expect spot and futures prices to move together over time to avoid arbitrage opportunities. To perform the risk-transfer and informative or price discovery roles efficiently, we expect the futures markets to meet the basic hypothesis of market efficiency, viz. futures price must be an unbiased predictor of spot price.

Since 2003, the year of commencement of national commodity exchanges in India, the volume of contracts traded on Indian futures markets has increased dramatically, but prices have become more volatile and less predictable after the introduction of futures market. Thus, it is important to empirically examine the price and trading behaviour of agri-commodities in order to suggest measures for strengthening these markets. The present paper specially focuses on one commodity, viz. cotton for which India is the second largest producer, consumer and exporter. Moreover, the volume of cotton futures trading has also grown during 2013 to 2015 which can be seen from figure 1. This suggests although market participants are gaining confidence in the cotton futures, still the figures are not satisfactory. To have a satisfactory figure of the volume of cotton futures trading and to attract more participants to trade in futures, the market is required to be efficient. Therefore, the present paper has analyzed the efficiency of cotton futures market in India.

Data and Methodology

Data

The data for testing the market efficiency of cotton futures market in India, the NCDEX is considered as the prime national level commodity exchange for agricultural commodities and hence was selected for

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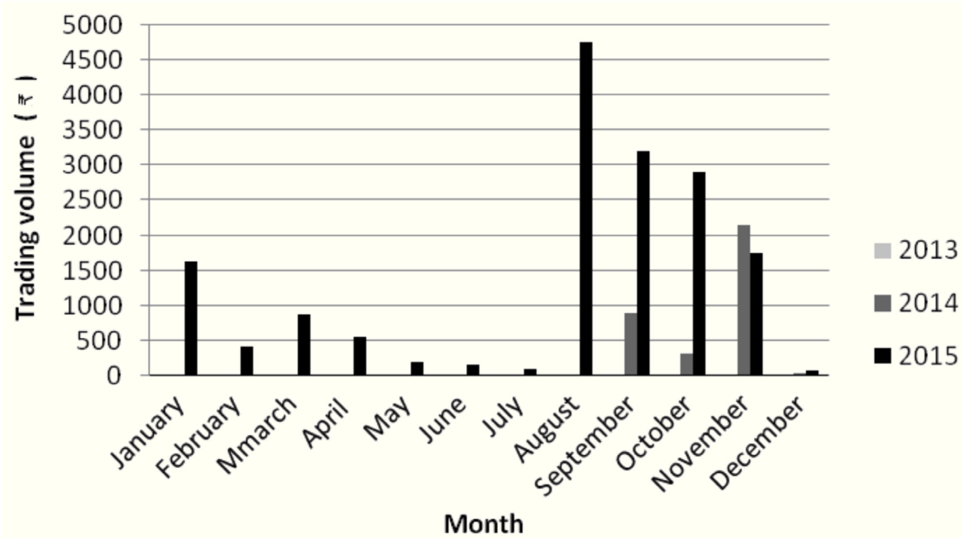

Figure 1. Month wise volume of cotton futures trading in India from 2013 to 2015
Source: www.ncdex.com

Table 1. No. of contracts of cotton during the period 2013-2015

Year	Name of the contract	No. of observations
2013	April	14
	October	154
	November	175
	December	201
2014	October	30
	November	46
	December	67
2015	January	86
	February	107
	March	127
	April	107
	May	113
	June	99
	July	100
	October	103
	November	120

the study. The timeframe chosen for the study was the futures contracts expiring during the period January 2013 to December 2015. The sample used in the study consisted of one agricultural commodity traded on National Commodity Exchange of India, Mumbai, viz. Cotton. The data comprised daily closing spot and futures prices of cotton during the period January, 2013 to December, 2015 as obtained from the home page of NCDEX (www.ncdex.com). Table 1 presents the details of sample contracts.

The daily price return on cotton, both in spot and futures market, is defined as usual, viz. the first difference in the log of commodity price, such that $R_{S/F,\, t} = \ln(P_{S/F,\, t}) - \ln(P_{S/F,\, t-1})$, where P represents the daily price information of cotton in Spot (S) or Futures (F) market.

The reasons to take log of daily price returns are justified by both theoretically and empirically. Theoretically, logarithmic returns are analytically more tractable. On the other hand, empirically logarithmic returns are more likely to be normally distributed which is a prior condition of many standard statistical tests employed in analysing financial time series.

Methodology

An efficient agricultural commodity market is one in which the spot market 'fully reflects' the available information (Fama,1970); i.e. an efficient futures market should send price signals to the spot market immediately to eliminate supernormal profit from arbitraging on price differences or at maturity, the futures prices become equivalent to spot prices, except for some transaction costs. With cost-of-carry (stochastic convenient yield) and no-arbitrage profit expectation, the efficiency in Indian agricultural futures markets can be represented by Equation (1):

$$F_{t,\, t-k} = S_{t,\, t-k} + d_t \qquad \ldots(1)$$

where, d_t is the cost-of-carry, $F_{t,\,t\text{-}k}$ is the futures price at time t for delivery at time t-k, and $S_{t\text{-}k}$ is the expected spot price at maturity of the contract, i.e. time t-k. If the cost-of-carry is stationary or zero, then the arbitrage model implies that the futures price is co-integrated with the spot price. Two critical criteria must be met to ensure long-term efficiency of Indian cotton futures markets, viz. S and F must be integrated (stationary) to the same order and they must also be co-integrated, otherwise S and F will tend to drift apart over time.

Stationarity Test

Stationarity test is important because regressing one non-stationary series on another may produce some spurious results. Therefore, the variables expected to be used in a regression model should possess stationarity. Even if most of the underlying price series are found to be non-stationary, I (1), their first differences are found to be stationary, i.e. I (0). In the present study, price returns, not the actual prices, were considered to test the interrelationship among the spot and futures market. Because prices usually have a unit root, but returns can be assumed to be stationary. A non-stationary time series means the moments will change over time. For instance, for prices, the mean and variance would both depend on the previous period's price. The moments in historical prices will lead to change in its mean and variances. But the return series, more often than not, removes this effect (Sarkar, 2015). Further, time series that are stationary have a lot of convenient properties for analysis. Therefore, to test the stationarity of the present price return series, Augmented Dickey-Fuller (ADF) test has been carried in this study. The ADF test is specified here as per Equation (2):

$$\Delta Y_t = b_0 + \beta Y_{t-1} + \mu_1 Y_{t-1} + \mu_2 Y_{t-2} + \ldots\ldots.. + \mu_p Y_{t-p} + \varepsilon_t \quad \ldots(2)$$

where, Y_t represents time series to be tested, b_0 is the intercept term, β is the coefficient of interest in the unit root test, μ_i is the parameter of the augmented lagged first difference of Y_t to represent the p^{th} order autoregressive process, and ε_t is the white noise error-term.

If the null hypothesis is rejected, this means that the time series data is stationary. The decision criteria involve comparing the computed values of Augmented Dickey-Fuller 't' statistic with the critical values for the rejection of a hypothesis for a unit root. If the computed ADF statistic is less relative to the critical values, then the null hypothesis of non-stationarity in time series variables can not be rejected.

Vector Autoregressive Model

After testing for stationarity, the second step is to identify the interdependencies among spot prices and futures prices of selected commodities by using VAR model. All variables in a VAR are treated symmetrically in a structural sense and each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables. A VAR model describes the evolution of a set of k variables (called *endogenous variables*) over the same sample period (t = 1, ..., T) as a linear function of only their past values. The variables are collected in a $k \times 1$ vector y_t, which has the i^{th} element, $y_{i,t}$, the time t observation of the i^{th} variable. A *p-th order VAR*, denoted VAR (p), is given by relation (3):

$$y_t = C + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + e_t \quad \ldots(3)$$

where, the l-periods back observation y_{t-l} is called the l-th *lag* of y, c is a $k \times 1$ vector of constants, A_i is a time-invariant $k \times k$ matrix and e_t is a $k \times 1$ vector of error-term.

Causality Test

The Granger-causality test is used to investigate direction of causation between futures price and spot price. The outcome from the Granger-causality test is utilized to determine whether the variables under study can be used to predict each other or not. Granger proposed that if a causal relationship exists between variables, then these variables can be used to predict each other. The causality test helps to ascertain whether a uni-directional or bi-directional relationship exists between spot price and futures price (Kushankur and Debasish, 2012). To achieve this, the study employed the Granger-causality statistic to test the statistical causality between the spot price and futures price of cotton as well as to determine the predictive content of one variable beyond that inherent in the explanatory variable itself. The study has used the daily returns of spot (RS_t) and futures (RF_t) of cotton in percentage form for the Granger causality test. More specifically, the Granger causality test involved analysing the relationship between RS_t and p lagged values of RS_t

and RF_t by estimating the regression models (4) and (5):

$$RS_t = a_0 + \sum_{k=1}^{p} a_{1k} RS_{t-k} + \sum_{k=1}^{p} a_{2k} RF_{t-k} + e_t \quad \ldots(4)$$

$$RF_t = a_0 + \sum_{k=1}^{p} a_{1k} RF_{t-k} + \sum_{k=1}^{p} a_{2k} RS_{t-k} + e_t \quad \ldots(5)$$

F-test is used to test whether RF_t does not Granger-cause RS_t by examining the null hypothesis that the lagged coefficients of RF_t are equal to zero. A similar F-test is used to test the opposite effect, i.e. whether RS_t does not Granger-cause RF_t.

Results and Discussion

The computed values of Augmented Dickey-Fuller 't' statistic for all the 16 contracts of cotton are presented in Table 2 at 5% level of significance. The results of unit root tests indicate that both the spot and futures prices are stationary at level form. The results are characterized as I (0). This satisfies the first criterion of market efficiency.

The ADF test displays the calculated *tau* figures in Table 2 and it is seen that these are higher in absolute terms than the associated critical values at 5 percent level in all instances, and so it is concluded that the null hypothesis that these series are non-stationary and do contain a unit root can be rejected. As both the variables are stationary, VAR (Vector Auto Regression) equations were taken in level form to test the interdependency of the two variables, i.e. spot price and futures price of cotton. Prior to estimating VAR equations, it is required to know the optimal lag of endogenous variables (here both variables) used as independent variables in order to have the best valid results. Therefore, test for optimal lags are conducted. Table 3 shows the obtained log-likelihood (LL), likelihood ratio (LR), final prediction error (FPE) and

Table 2. Augmented Dickey-Fuller test for stationary

Commodity: Cotton

Year	Contract	No. of observations	Spot 't' statistics (Levels)	Futures 't' statistics (Levels)	Critical 't' at 5%
2013	April	14	-4.26	-4.31	-3.10
	October	154	-11.74	-12.89	-2.88
	November	175	-12.29	-13.50	-2.88
	December	201	-13.31	-14.66	-2.88
2014	October	30	-4.27	-7.30	-2.96
	November	46	-5.39	-9.51	-2.93
	December	67	-6.18	-10.13	-2.91
2015	January	86	-7.05	-7.23	-2.90
	February	107	-7.98	-10.77	-2.89
	March	127	-8.93	-11.80	-2.88
	April	107	-8.72	-12.41	-2.89
	May	113	-9.13	-10.08	-2.89
	June	99	-5.64	-9.33	-2.89
	July	100	-5.64	-9.59	-2.89
	October	103	-9.37	-9.19	-2.89
	November	120	-9.77	-10.18	-2.89

Source: Authors' estimations

Table 3. Selection of optimal lag

Year	Contract	lag	Log-Likelihood	Likelihood Ratio	Final Prediction Error	Akaike's Information Criterion	Hannan and Quinn Information Criterion	Schwarz's Bayesian Information Criterion
2013	April	0	1.639482	NA	0.003626	0.055464	0.142380*	0.037599
		1	2.819173	1.814909	0.005688	0.489358	0.750104	0.435763
		2	11.47675	10.65548*	0.002969*	-0.227193*	0.207384	-0.316518*
	October	0	-306.0191	NA	0.226498	4.190736	4.231422*	4.207267
		1	-297.0684	17.53600	0.211747	4.123380	4.245438	4.172973
		2	-289.0812	15.43103*	0.200575*	4.069132*	4.272563	4.151788*
	November	0	-429.6804	NA	0.584674	5.139053	5.176243*	5.154146
		1	-421.3109	16.44010*	0.555042*	5.087035*	5.198605	5.132315*
	December	0	-500.5927	NA	0.609945	5.181368	5.215057*	5.195010*
		1	-494.177	12.63310	0.594945*	5.156463*	5.257531	5.197389
2014	October	0	-81.21122	NA*	1.094053	5.764158	6.047046	5.852755
		1	-77.58029	6.510648	1.065033*	5.738705*	5.833001*	5.768238*
	November	0	-117.8628	NA	0.904184	5.575015	5.656931	5.605223
		1	-106.903	20.39032*	0.654426*	5.251303*	5.497052*	5.341928*
	December	0	-143.1112	NA	0.369818	4.681005	4.749622	4.707946
		1	-132.649	19.91182	0.300276	4.472549	4.678401*	4.553371*
		2	-132.5074	0.260321	0.340262	4.597014	4.940100	4.731718
		3	-131.4125	1.942653	0.374151	4.690725	5.171046	4.879311
		4	-124.986	10.98723	0.346743	4.612451	5.230007	4.854919
		5	-115.0151	16.40369*	0.286986*	4.419843*	5.174632	4.716192
2015	January	0	-187.2152	NA	0.412511	4.790259	4.850245	4.814291
		1	-177.6304	18.44163*	0.358148*	4.648871*	4.828829*	4.720968*
	February	0	-249.0782	NA	0.519863	5.021563	5.073667	5.042650
		1	-239.8583	17.88659*	0.468344*	4.917165*	5.073476*	4.980427*
	March	0	-264.4699	NA	0.290955	4.441165	4.487624	4.460032
		1	-252.2292	23.86939*	0.253621*	4.303820*	4.443195*	4.360421*
	April	0	-222.806	NA	0.307391	4.496119	4.548223	4.517207
		1	-212.8822	19.25209	0.273057*	4.377644*	4.533955*	4.440906*
	May	0	-275.3244	NA	0.641968	5.232536	5.282790*	5.252904*
		1	-271.8742	6.705208	0.648680	5.242909	5.393670	5.304013
		2	-263.5292	15.90261	0.597689*	5.160929*	5.412197	5.262769
	June	0	-196.8825	NA	0.258665	4.323532	4.378353*	4.345658*
		1	-194.1171	5.350309	0.265714	4.350372	4.514837	4.416752
		2	-185.9549	15.43717*	0.242768*	4.259890*	4.533997	4.370522
	July	0	-200.3622	NA	0.266101	4.351875	4.406339*	4.373866*
		1	-198.4839	3.635342	0.278537	4.397503	4.560897	4.463477
		2	-190.9583	14.24202*	0.258241*	4.321684*	4.594006	4.431640
	October	0	-177.29	NA	0.143626	3.735209	3.788633*	3.756804*
		1	-174.0782	6.222849	0.146010	3.751630	3.911902	3.816414
		2	-173.3583	1.364879	0.156359	3.819965	4.087084	3.927939
		3	-165.1674	15.18737*	0.143333	3.732653	4.106621	3.883817
		4	-160.3148	8.795221	0.140893*	3.714892*	4.195707	3.909246
	November	0	-222.3423	NA*	0.186432	3.996041	4.140858	4.054806
		1	-219.7763	4.995851	0.181756*	3.970661*	4.018933*	3.990249*

Source: Authors' estimations.
Note: Lags corresponding to highest number of '* 'marked criterions are considered as optimum lag
NA: Not Available

Table 4. Summary of VAR Model

Year	Contract	Equation of	Cotton lag of spot	Cotton lag of futures
2013	April	Spot	n	n
		Futures	p	p
	October	Spot	0	0
		Futures	0	0
	November	Spot	0	0
		Futures	0	0
	December	Spot	0	p
		Futures	0	n
2014	October	Spot	0	0
		Futures	0	0
	November	Spot	0	0
		Futures	0	0
	December	Spot	0	n
		Futures	p	0
2015	January	Spot	p	p
		Futures	0	p
	February	Spot	p	p
		Futures	0	0
	March	Spot	p	p
		Futures	0	0
	April	Spot	0	p
		Futures	0	n
	May	Spot	0	p
		Futures	0	0
	June	Spot	0	0
		Futures	0	0
	July	Spot	0	p
		Futures	p	0
	October	Spot	0	0
		Futures	p	0
	November	Spot	0	0
		Futures	0	0

n = Explanatory variable significantly influences dependent variable in negative direction, p = Explanatory variable significantly influences dependent variable in positive direction, 0 = Explanatory variable does not significantly influence dependent variable

various information criteria estimates from the models estimated with different lags for all the 16 contracts. Theoretically, a model is better when LL and LR are higher and FPE and ICs are lower. The results show that the optimal lag is 1 for 9 contracts, 2 for 5 contracts, 4 for 1 contract and 5 for 1 contract only.

As the next step, VAR model has been estimated for all the contracts. The results of VAR model are presented in Annexure 1. The outcomes of VAR model can be clearly understood from Table 4. Out of 16 contracts, there are 4 contracts in which the lag of spot influences futures in positive direction. In 12 contracts, there is no influence of lag of spot on futures. But, there are 7 contracts in which the lag of futures influences spot in positive direction and in 2 contracts it influences spot price in negative direction. In 7 contracts it has no influence on spot. Thus, it can be concluded that lag value of futures has more influence on spot.

To reiterate the above results a summary of relationship was examined through Granger causality test and the results presented in Table 5 reflect this inference. The upper and lower rows of the F statistic column report the null hypotheses that spot price does not Granger-cause futures price and futures price does not Granger-cause spot price. Generally, the null hypothesis that the futures market prices do not Granger-cause the prices in spot market is uniformly rejected at 5 percent and 10 percent significance levels for 3 out of 16 contracts. Table 5 also reports that the null hypothesis that the spot prices do not Granger-cause the prices in futures market is uniformly rejected at 1 percent, 5 percent and 10 percent significance levels for 6 out of 16 contracts. It is also observed that bidirectional causality relationship (F↔S) results only for two contracts. Further, in 5 contracts, the test shows no directional relationship between the spot and futures prices. Thus, examination of the F statistics for all the contracts indicates strong evidence that though there is a causal relationship between the spot price and futures price of cotton for some contracts, but they do not influence each other to a great extent. Therefore, it can be concluded that the cotton futures market is inefficient to send price signals to the spot market immediately to eliminate supernormal profit from arbitraging on price differences or at maturity.

Table 5. Granger causality test results for cotton

Year	Contract	Hypothesis	F-statistic	Probability	Direction	Relation
2013	April	S /→ F	37.9353**	0.0258	Bidirectional	F↔S
		F /→ S	31.2417**	0.0313		
	October	S /→ F	1.96407***	0.0877	Unidirectional	S→ F
		F /→ S	1.03391	0.4002		
	November	S /→ F	2.11415***	0.0664	Bidirectional	F↔S
		F /→ S	1.97746***	0.0847		
	December	S /→ F	1.58727	0.1656	Unidirectional	F→ S
		F /→ S	2.50947**	0.0317		
2014	October	S /→ F	1.59297	0.222	Unidirectional	F→ S
		F /→ S	2.35538***	0.0911		
	November	S /→ F	2.16761***	0.0834	Unidirectional	S→ F
		F /→ S	1.24192	0.3136		
	December	S /→ F	1.08598	0.3791	No direction	S—X— F
		F /→ S	1.921	0.1066		F—X— S
2015	January	S /→ F	1.81163	0.1216	No direction	S—X— F
		F /→ S	0.95098	0.4538		F—X— S
	February	S /→ F	1.99563***	0.0866	Unidirectional	S→ F
		F /→ S	0.99969	0.4225		
	March	S /→ F	3.89889*	0.0027	Unidirectional	S→ F
		F /→ S	0.24079	0.9436		
	April	S /→ F	2.90996**	0.0175	Unidirectional	S→ F
		F /→ S	1.20322	0.3139		
	May	S /→ F	4.37905*	0.0012	Unidirectional	S→ F
		F /→ S	0.56507	0.7265		
	June	S /→ F	0.91872	0.473	No direction	S—X— F
		F /→ S	1.40749	0.2299		F—X— S
	July	S /→ F	0.99672	0.4248	No direction	S—X— F
		F /→ S	1.50165	0.1979		F—X— S
	October	S /→ F	0.94449	0.4565	Unidirectional	F→ S
		F /→ S	2.22534***	0.0587		
	November	S /→ F	0.55218	0.7363	No direction	S—X— F
		F /→ S	0.48165	0.7893		F—X— S

Source: Authors' estimations.
Note: *1percent, **5percent significance. F-statistic reported.
In the last column F and S indicate Futures and Spot prices while the symbol → and —X—, respectively indicate Granger cause and does not Granger cause.

Conclusions

The study begins with an examination of the importance of cotton in Indian economy, and then proceeds to empirically analyse whether the cotton futures market satisfies market efficiency condition using various statistical tools. The indicate no significant linear dependency between spot and futures price of cotton. The VAR model has clearly indicated that the lag value of futures has little influence on spot. The Granger causality test has provided strong evidence that futures market prices do not lead spot market prices or the spot prices are not discovered in the futures markets. Thus, it can be concluded spot price and futures price of cotton are neither influenced nor caused each other significantly, implying fact that the Indian commodity futures market for cotton is inefficient.

Though numerous factors are responsible for the inefficient functioning of cotton futures market, the exchange-specific problems which can be interpreted from the trading volume of cotton futures contract like low market depth and thin volume, irregular trading, lack of effective participation of trading members, etc. can be considered as the major problems for the market. Apart from this, few more causes of such inefficiency could be lack of awareness about futures market among farmers, undeveloped spot market in the locality of futures market, non-existence of well-developed grading and standardization system, etc. As suggested by Salvadi and Ramasundaram (2008), if these problems can be addressed by proper policy standpoints, the efficiency of cotton futures market can be improved.

Policy Implications

- Policy measures should be taken to increase market depth, regular and efficient participation of trading members, grading and standardization pattern of cotton, etc.
- Appropriate steps should be taken to shift focus from the present system of 'Production-Oriented Extension' to 'Market-Oriented Extension' in cotton to generate awareness on derivatives market among farmers.
- Suitable programmes should be organized on capacity building of farmers' organizations through financial institutions, regulated market committees, NGOs, etc. for their active participation in futures market.
- The lot size of cotton futures contract needs to be adequate enough for small & marginal farmers to take position in the futures market. Moreover, farmers can also take position on commodity exchanges by forming smaller groups and pooling their produces.
- Reliable and reputed warehouse operators backed by government regulations should be brought into picture to make the system effective for the farmers.

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Appendix Table 1. VAR (Vector Auto Regression) Model

Year	Independent Variable									
	Contract	Equation of	One lag of SP	Two lags of SP	Four lags of SP	Five lags of SP	One lag of FP	Two lags of FP	Four lags of FP	Five lags of FP
2013	April	SP		**-16.55** (0.02)				**-15.79** (0.03)		
		FP		**16.70** (0.02)				**16.01** (0.03)		
	October	SP		-0.16 (0.33)				-0.05 (0.77)		
		FP		0.23 (0.11)				0.08 (0.61)		
	November	SP	0.10 (0.37)				0.16 (0.27)			
		FP	-0.03 (0.69)				-0.10 (0.36)			
	December	SP	0.12 (.22)				**0.28** (0.04)			
		FP	-0.07 (0.36)				**-0.20** (0.05)			
2014	October	SP	0.02 (0.91)				0.10 (0.73)			
		FP	0.19 (0.25)				-0.34 (0.12)			
	November	SP	0.13 (0.43)				-0.23 (0.33)			
		FP	0.09 (0.37)				-0.27 (0.09)			
	December	SP				-0.04 (0.73)				**-0.42** 0.03)
		FP				**0.25** (0.01)				0.05 (0.71)
2015	January	SP	**0.25** (0.02)				**0.25** (0.03)			
		FP	-0.02 (0.81)				**0.20** (0.05)			
	February	SP	**0.22** (0.02)				**0.33** (0.01)			
		FP	0.06 (0.44)				-0.11 (0.22)			
	March	SP	**0.22** (0.01)				**0.37** (0.00)			
		FP	-0.02 (0.81)				-0.14 (0.10)			
	April	SP	0.17 (0.22)				**0.49** (0.01)			
		FP	-0.01 (0.85)				**-0.42** (0.00)			
	May	SP		0.05 (0.61)				**0.52** (0.00)		
		FP		0.11 (0.15)				-0.10 (0.32)		
	June	SP		0.01 (0.92)				0.32 (0.06)		
		FP		0.20 (0.06)				-0.09 (0.51)		
	July	SP		0.05 (0.62)				**0.31** (0.03)		
		FP		**0.21** (0.03)				0.01 (0.94)		
	October	SP			0.05 (0.63)				-0.15 (0.22)	
		FP			**0.20** (0.04)				0.20 (0.08)	
	November	SP	0.07 (0.45)				-0.18 (0.20)			
		FP	0.02 (0.74)				0.12 (0.24)			

Source: Authors' estimations
Note: Coefficients in bold are significant at 5% level of significance
p value is given in parentheses