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Sugar price determination in India: an econometric analysis

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Abstract India's sugar sector faces several price and non-price controls that distort prices and hinder the further development of the sector. This paper assesses the impact of policy interventions and technological change on sugar prices. It employs the autoregressive distributed lag (ARDL) model to estimate the interrelationship between sugar price and its determinants in the long run and finds that, in the long run, sugar price is significantly influenced by the recovery rate, beginning stock, jaggery price and per capita income. Further, 86% of the disturbance in the short run in sugar price is corrected within a year.

Keywords Sugarcane, marketing, subsidies, policy, price, ARDL, cointegration

JEL classification Q11, Q13, Q18

1 Introduction

Understanding the impact of market forces and government interventions on the price of sugar in India is important for the following four reasons. First, the Indian sugar market has undergone a series of policy changes. Second, India is the second biggest producer and bulk consumer of sugar- and sugarcane-based products; any change in sugar production not only influences the Indian sugar market but can potentially influence the global sugar market. Third, sugarcane and its derivatives are extensively used as raw materials in a number of industries (Yadav & Solomon 2006); sugarcane derivatives are heavily used in food, agriculture, energy and transport. A shock at any of these levels can influence the livelihoods of farmers, processors and consumers. Fourth, energy security and environmental concerns have attracted considerable attention in the search for alternative renewable energy sources, and sugarcane serves as an alternative (Yadav & Solomon 2006; Walter et al. 2015; Jaiswal et al. 2017; Manochio et al. 2017).

The fluctuations in sugar price and their consequences for farmers and sugar mills have become a serious concern for policymakers in India. The sugar marketing system in India is complex, and it is characterized by asymmetric information and inefficiency. It is important to know whether the price is responsive to impulses generated by market forces and their transmission along the value chain downstream and upstream. The price of sugar is influenced by factors such as technological change along the value chain and government interventions in terms of price fixation, levies and trade policies. A few studies have analysed the market behaviour and price determination in the sugar sector (Mustafa & Khan 1982; Keerthipala 2002; Ribeiro & Oliveira 2011; Kumawat & Prasad 2012; Hamulczuk & Szajner 2015; Pastpipatkul et al. 2016), but these have not explored the impact of policy variables on sugar price and their inter-relationships. This paper intends to identify the major determinants, including government interventions, of the price of sugar.

1.1 Indian sugar economy

Sugar is one of the essential food commodities as a prime sweetening agent. It is consumed directly at the household level and as a raw material in several food industries (Vikas & Babu 2017). About 70% of the sugar in India is manufactured using sugarcane. Sugarcane contributes around 10% to the total value

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of the agricultural sector output, provides livelihood support to around 5 crore farm households and generates employment for over 5 lakh skilled and semi-skilled workers in manufacturing (Indian Sugar Mills Association 2017). India is the second largest producer of sugar after Brazil, contributing 15% to sugar production and 25% to sugarcane production. The country has 735 operating sugar mills, 328 distilleries and 210 cogeneration plants (pulp, paper and chemical units). The industry produces around 350 million tons of cane, 22 million tons of white sugar and 8 million tons of jaggery. Besides, by-products from sugar manufacturing are utilized to produce 2.7 billion litres of alcohol and 2,300 MW power.

Inelastic demand and increases in supply (surplus) result in lower sugar prices and lower profits to manufacturers. The main consequence is the mounting unpaid arrears to sugarcane suppliers, or farmers, and acts as a disincentive against allocating land area to sugarcane in the following years. Thus, sugar production behaves in a cyclical fashion, which does not allow the sugar sector to operate at its full capacity (Sharma et al. 2015). Numerous jaggery units function in India. The public sector does not intervene in the jaggery industry, and these units utilize sugarcane to manufacture jaggery when prices for sugar are below optimum.

The government has enacted legislation to safeguard the interests of farmers and consumers. These include the Sugar Industry (Protection) Act, 1932; Essential Commodities Act, 1955; Minimum Support Price in the 1960s; Sugar (Control) Order, 1966; State Advisory Price, 1970; Sugar Development Fund, 1982; Sugar Cess Act, 1982; Jute Packaging Material Act, 1987; Delicensing Sugar Sector, 1998; and the Ethanol Blending Programme, 2012. Such interventions distort the market equilibrium and cause crises in the sugar sector (Shroff & Kajale 2014). The levy price, in particular, is distortionary; it is less than the market price and it has no linkage with cane price, sugar price, supply or demand (Babu 2017; Meriot 2015; Sharma et al. 2015; Verma et al. 2012). In view of this, the Rangarajan Committee (2013) recommended partial decontrol of the sugar sector to overcome market imperfections. Subsequently, the Government of India removed the levy quota and levy price in 2013 and allowed sugar mills to sell all their ex-mill sugar in the open market.

Of late, energy security and environmental concerns have inspired the use of ethanol in the automobile sector worldwide; to reduce carbon emission, ethanol is being blended with petrol in Europe, Brazil, USA, Australia, Canada and Japan. The Government of India has a yearly target of blending 20% of petrol with ethanol, but it could blend only 3.3% by 2016 (Debnath et al. 2018). It is expected that increased supplies of sugarcane can satisfy the ethanol industry's raw material requirement.

2 Conceptual framework

We develop an econometric framework to identify the factors that can influence sugar price as determined by demand and supply. Let us consider first the demand equation:

$$Q^{s}_{d} = \alpha_0 + \alpha_1 SUGP_t + \alpha_2 SPDS_t + \alpha_3 PCGDP_t + \alpha_4 JP_t + \alpha_5 POP_t + u_d \quad \ldots(1)$$

Where, Q_d is quantity of sugar demanded, SUGP and SPDS are the sugar price and issue price of sugar under the public distribution system, respectively. These variables are assumed to be negatively associated with demand. PCGDP, JP and POP are the per capita gross domestic product, jaggery price and population, respectively, and these are likely to be positively associated with sugar demand, and u_d is error term. Amongst these, SPDS is a policy variable.

The supply equation can be written as:

$$Q^{S}_{s} = \beta_0 + \beta_1 SUGP_t + \beta_2 SCFRP_t + \beta_3 JP_t + \beta_4 MOLP_t + \beta_5 EXP_t + \beta_6 SCAREA_t + \beta_7 RECOV_t + \beta_8 LEVY_t + \beta_9 YIELD_t + \beta_{10} BEGSTOCK_t + u_s \quad \ldots(2)$$

Where, Q_s is quantity of supply of sugar and SUGP is the sugar price. SCAREA and YIELD are area and yield of sugarcane, respectively. RECOV is the sugar recovery rate and BEGSTOCK is the beginning stock of sugar. We expect these variables to positively influence sugar supply. SCFRP is the fair and remunerative price of sugarcane and JP is the price of jaggery. MOLP is the production of molasses. EXP represents sugar export and LEVY represents the levy rate. Sugar supply is expected to be negatively associated with these variables. Amongst the supply-side variables, SCFRP, SPDS and LEVY represent the policy interventions.

The sugar price is then determined at the equilibrium where the quantity demanded is equal to the quantity supplied.

$$Q^{s}_{d} = Q^{s}_{s} \qquad \ldots(3)$$

$$\alpha_0 + \alpha_1 SUGP_t + \alpha_2 SPDS_t + \alpha_3 PCGDP_t + \alpha_4 JP_t + \alpha_5 POP_t + u_d = \beta_0 + \beta_1 SUGP_t + \beta_2 SCFRP_t + \beta_3 JP_t + \beta_4 MOLP_t + \beta_5 EXP_t + \beta_6 SCAREA_t + \beta_7 RECOV_t + \beta_8 LEVY_t + \beta_9 YIELD_t + \beta_{10} BEGSTOCK_t + u_s \qquad \ldots(4)$$

On rearranging we get:

$$SUGP = \gamma_0 + \gamma_1 SCFRP_t + \gamma_2 SPDS_t + \gamma_3 PCGDP_t + \gamma_4 JP_t + \gamma_5 MOLP_t + \gamma_6 POP_t + \gamma_7 EXP_t + \gamma_8 SCAREA_t + \gamma_9 RECOV_t + \gamma_{10} LEVY_t + \gamma_{11} YIELD_t + \gamma_{12} BEGSTOCK_t + v \qquad \ldots(5)$$

Figures 1 and 2 show the trend in the demand-side and supply-side variables used in estimation of the model.

2.1 Empirical strategy

We apply the ARDL model to understand the dynamics of sugar prices. This approach is suitable when the time series variables in an equation represent stationarity I(0) and non-stationarity I(1) processes or are fractionally cointegrated. This model is considered as alternative to the Engel-Granger causality test and Johansen-Juselius (1990) cointegration process as the former is applicable for bivariate analysis, and the latter requires the condition where all the variables included in the model should be non-stationary at level. The ARDL bounds test is robust in case of small samples (Pesaran et al. 1999). The approach is also suitable when explanatory variables are endogenous (Pesaran & Pesaran 1997; Pesaran et al. 2001). In this model, the endogeneity is not much of a problem and is free from residual correlation. Further, the ARDL model can be complemented by the Johansen-Juselius maximum likelihood approach to check its robustness. One of the drawbacks of the model is that it cannot be applied when the order of integration is I (2) or above.

The ARDL bounds test analyses cointegration (long-run relationship) amongst variables and also the short-run dynamics. The short-run effects are directly assessed and the long-run relationships are indirectly estimated. The test uses lags of the endogenous variables, and lagged and contemporaneous values of the exogenous variables (Eq.6). The ARDL bounds test can be represented by the following unrestricted error correction model (Ghosh 2010):

$$\Delta SUGP_t = a_{OSP} + \Sigma ni{=}1\ b_{iSP}\, \Delta SUGP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta SCFRP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta SPDS_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta PCGDP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta JP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta MOLP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta POP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta EXP_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta SCAREA_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta RECOV_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta LEVY_{t-i} + \Sigma ni{=}1\ b_{iSP}\, \Delta YIELD_{t-i} + \Sigma ni{=}1\ b_{iSP}$$

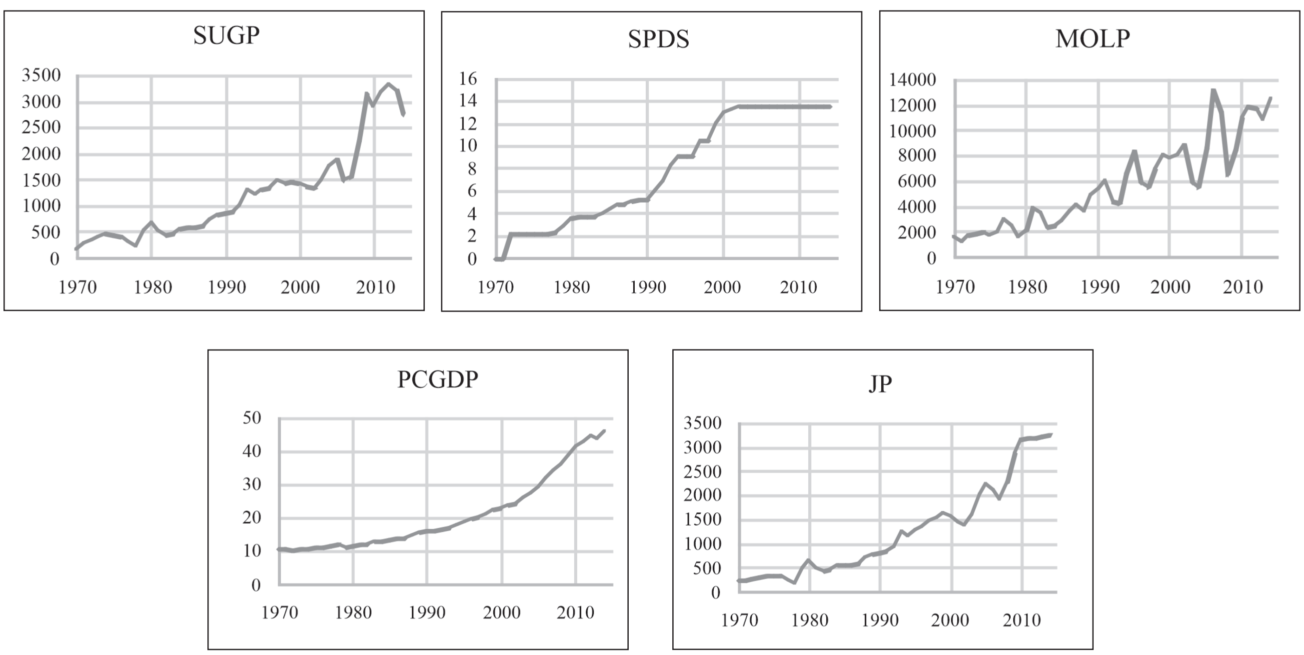

Figure 1. Demand equation variables

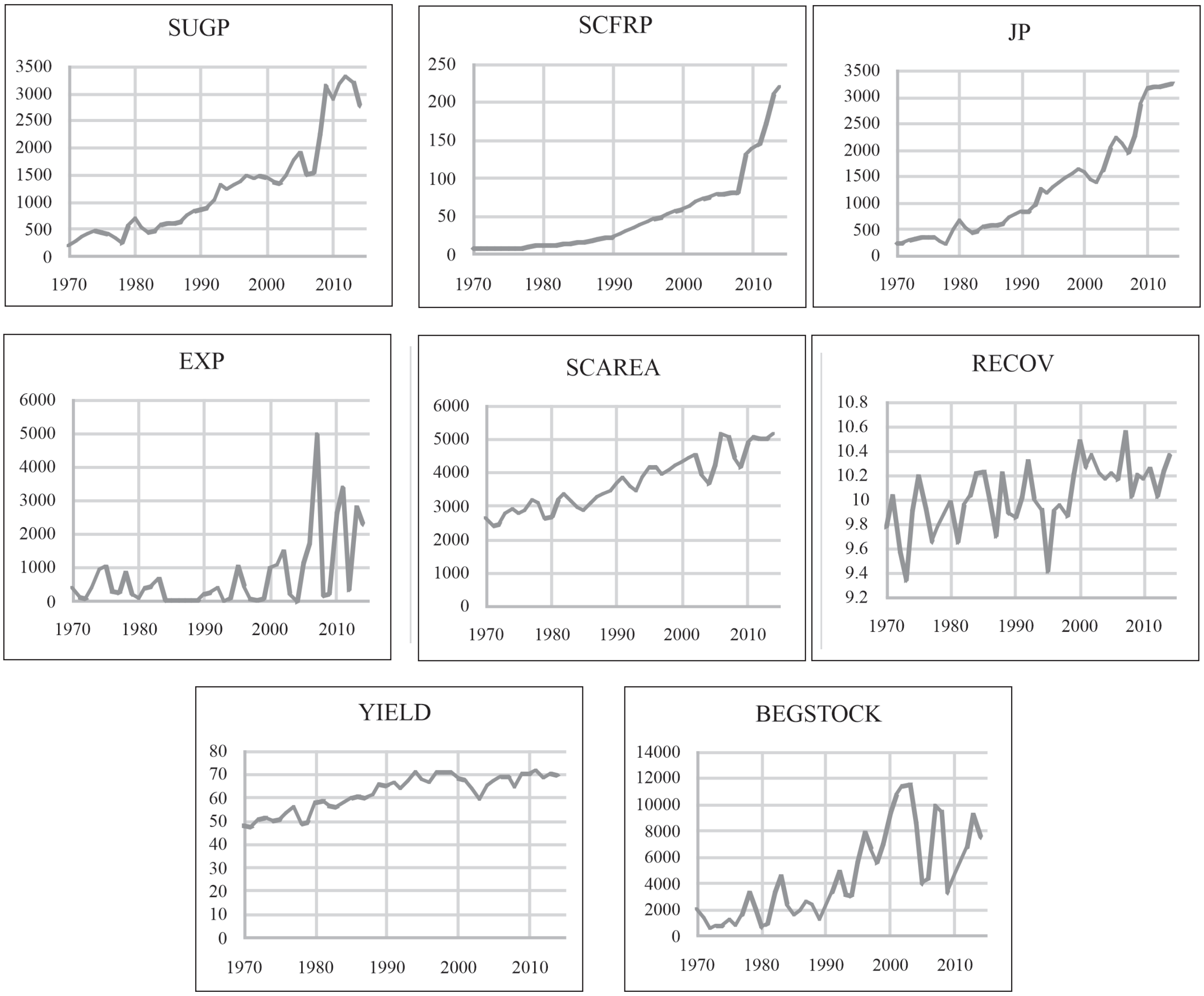

Figure 2. Supply equation variables

$\Delta BEGSTOCK_{t-i} + \Sigma ni=1\ \sigma_{1SP}\ \Delta SUGP_{t-i} + \sigma_{1SP}\ \Delta SCFRP_{t-i} + \sigma_{2SP}\ \Delta SPDS_{t-i} + \sigma_{3SP}\ \Delta PCGDP_{t-i} + \sigma_{4SP}\ \Delta JP_{t-i} + \sigma_{5SP}\ \Delta MOLP_{t-i} + \sigma_{6SP}\ \Delta POP_{t-i} + \sigma_{7SP}\ \Delta EXP_{t-i} + \sigma_{8SP}\ \Delta SCAREA_{t-i} + \sigma_{9SP}\ \Delta RECOV_{t-i} + \sigma_{10SP}\ \Delta LEVY_{t-i} + \sigma_{11SP}\ \Delta YIELD_{t-i} + \sigma_{12SP}\ \Delta BEGSTOCK_{t-i}$ … (6)

Where, Δ is the first difference operator, $á_0$ is drift component, ε_t is white noise, Σ is summation of error correction dynamics and σ denotes long-run relationships amongst variables. The null hypothesis is:

$H_0 = \sigma_{1SP} = \sigma_{2SP} = \sigma_{3SP} = \sigma_{4SP} = \sigma_{5SP} = \sigma_{6SP} = \sigma_{7SP} = \sigma_{8SP} = \sigma_{9SP} = \sigma_{10SP} = \sigma_{11SP} = \sigma_{12SP} = 0$ …(7)

in contradiction of,

$H_1 \neq \sigma_{1SP} \neq \sigma_{2SP} \neq \sigma_{3SP} \neq \sigma_{4SP} \neq \sigma_{5SP} \neq \sigma_{6SP} \neq \sigma_{7SP} \neq \sigma_{8SP} \neq \sigma_{9SP} \neq \sigma_{10SP} \neq \sigma_{11SP} \neq \sigma_{12SP} \neq 0$ …(8)

For order of lag selection, we adopted two sets of asymptotic critical F-test values as provided in Pesaran et al. (2001). One set assumes that all variables are I(1) and the other assumes I(0). If the sample size is large, we use Pesaran et al. (1999); if the sample size is small (Narayan & Smyth 2005), critical F-test values are appropriate. The decision of cointegration-causality exists if the computed F-statistic is higher than upper critical bounds I(1); the decision of no cointegration is reached if the estimated F statistic is less than the lower critical value I(0); and the decision of inconclusiveness is taken if the computed test value lies between lower I(0) and upper critical bounds I(1).

2.2 Data and variables

We compile our data from various issues of the *Cooperative Sugar and Indian Sugar Journal* published by the Indian Sugar Mills Association. We consider the data on sugar price (Rs/100 kg); fair and remunerative price (Rs/100 kg); the price of sugar in the public distribution system (PDS) (Rs/kg); per capita gross domestic product (GDP) (Rs.); price of jaggery (Rs/100 kg); molasses output ('000 tons); population (million); exports of sugar ('000 tons); sugarcane cropped area ('000 hectares); sugarcane yield (tons/ha); beginning stock ('000 tons); sugar recovery rate (%); and sugar levy rate (%). The data pertain to the period from 1970-71 to 2014-15. The time series is long enough for a cointegration analysis. The prices and other economic variables have been deflated by the consumer price index (CPI) at 1986-87 base.

3 Results and discussion

3.1 Unit root test

The ARDL technique can be used without considering whether the time series is of order I(0) or I(1). If it is of order I(2), the F-statistic computed using Pesaran et al. (2001) is not valid, as the bounds test is based on the assumption that the series should be of order I(0) or I(1) (Ouattara 2004). Hence, the application of unit root test for ARDL is necessary to ensure that any variable included in the model is not of order I(2) or more.

First, we conducted the Augmented Dickey Fuller (ADF) and Philip-Perron (PP) tests to find whether the variables are of order I(0) or I(1). The results of the unit root test are presented in table 1. The results of ADF and PP tests – with intercept; with intercept and trend; and without intercept and trend – show that sugar price, jaggery price, molasses production, exports, PDS sugar price, recovery rate, levy percentage, population and sugarcane cropped area are stationary at level, while all other variables are non-stationary. The ADF test show some of the variables are stationary at level I(0) and others are at first difference I(1); none of the variables is stationary at second difference I(2) or more.

3.2 Lag length selection

To avoid any serial correlation bias, it is important to choose an appropriate lag length. For this, we used the Akaike Information Criterion (AIC), as suggested by Pesaran et al. (2001), to select the optimum lag length of the vector autoregressive (VAR) model. The AIC criterion offers dynamic results with exceptional properties compared to the Schwartz Bayesian Criteria. Since the aim is to select the optimum lag order for the VAR, we selected a high enough order, up to 2. Two VAR (p), p=0,1,2 models were estimated for the period from 1970-71 to 2014-15. Accordingly, we choose VAR (2) model as appropriate for our sample size (table 2). For the annual data, the maximum order length should be 2 (Pesaran & Shin 1998; Narayan & Smyth 2005).

3.3 ARDL bounds test

Having the assurance that none of the series is of order I(2) and beyond; and appropriate optimal lag order, the existence of a long-run relationship (cointegration) was examined through the ARDL bounds test. The results of the F-statistic from the bounds test are presented in table 3.

The calculated F-statistic for sugar price falls outside the critical bounds at 1% level of significance, indicating the existence of two cointegrating vectors. This means that there exists a log-run relationship between sugar price with all other independent variables.

3.4 Long-run and short-run coefficients

The estimated long-run coefficients are presented in table 4. The coefficient of the price of jaggery is positive and significant at 1%, indicating that a 10% increase in jaggery price will raise sugar prices by 5.5%. An increase in the jaggery price diverts the supply of cane from sugar mills to jaggery units, which lowers the supply of cane to sugar mills and raises the price of sugar.

Thus, jaggery production benefits farmers and sugar mills. Jaggery has its own traditional value, and its production can be treated as an instrument to stabilize sugar production, sugar price and lead sugar mills to profit. As expected, sugar stock has a negative and significant effect on sugar price with an elasticity of 0.3; if the current year sugar stock increases by 10%, sugar price would increase by 3%. Any stock coupled with current production increases supply, leading to a decline in sugar price. Similarly, the recovery rate has

Table 1. Unit root test

	Intercept				Intercept and trend				None			
	Level		First difference		Level		First difference		Level		First difference	
	t-stat	p value	t-stat	p value	t-stat	p value	t-stat	p value	t-stat	p value	t-stat	p value
Augmented Dickey Fuller												
LnSUGP	-2.565	0.108	-6.130	0.000***	-5.725	0.000***	-6.063	0.000***	-1.543	0.114	-8.224	0.000***
LnSPDS	-3.781	0.006***	-6.854	0.000***	-4.512	0.004***	-7.521	0.000***	-0.639	0.435	-6.923	0.000***
LnPCGDP	-2.036	0.271	-5.139	0.000***	-2.707	0.239	-5.290	0.001***	-2.764	0.007***	-4.340	0.000***
LnPOP	-7.226	0.000***	-3.594	0.010***	0.600	0.999	-7.055	0.000***	0.460	0.810	-1.415	0.000***
LnJP	-2.286	0.181	-9.402	0.000***	-2.738	0.227	-9.320	0.000***	-1.060	0.257	-9.344	0.000***
LnYIELD	-1.874	0.341	-7.136	0.000***	-2.821	0.198	-7.153	0.000***	1.677	0.976	-6.979	0.000***
LnSCAREA	-0.640	0.851	-11.375	0.000***	-3.363	0.070	-11.230	0.000***	2.883	0.999	-10.100	0.000***
LnBEGSTOCK	-1.457	0.545	-9.450	0.000***	-2.366	0.391	-9.341	0.000***	1.062	0.922	-9.324	0.000***
RECOV	-3.889	0.004***	-8.594	0.000***	-5.252	0.001***	-8.500	0.000***	0.208	0.742	-8.687	0.000***
LnMOLP	-1.046	0.728	-7.969	0.000***	-3.426	0.062	-7.934	0.000***	3.611	1.000	-9.849	0.000***
LEVY	-1.935	0.314	-6.148	0.000***	-5.532	0.000***	-6.363	0.000***	-1.569	0.109	-10.227	0.000***
LnEXP	-4.091	0.003***	-6.246	0.000***	-4.371	0.006***	-6.464	0.000***	0.202	0.740	-7.961	0.000***
LnSCFRP	-1.499	0.525	-6.326	0.000***	-3.105	0.118	-6.532	0.000***	0.249	0.754	-6.383	0.000***
Phillips Perron												
LnSUGP	-2.459	0.132	-12.626	0.000***	-4.709	0.002***	-12.241	0.000***	-2.257	0.025**	-8.687	0.000***
LnSPDS	-3.808	0.006***	-6.883	0.000***	-4.655	0.003***	-7.716	0.000***	-0.573	0.463	-6.982	0.000***
LnPCGDP	-2.101	0.245	-5.036	0.000***	-2.222	0.466	-5.192	0.001***	-3.836	0.000***	-4.333	0.000***
LnPOP	-8.037	0.000***	-3.529	0.010***	1.077	1.000	-7.129	0.000***	15.360	1.000	-1.233	0.000***
LnJP	-2.588	0.103	-7.438	0.000***	-2.595	0.285	-7.545	0.000***	-1.192	0.210	-6.981	0.000***
LnYIELD	-1.856	0.350	-8.680	0.000***	-2.782	0.211	-12.551	0.000***	2.135	0.991	-6.965	0.000***
LnSCAREA	-0.659	0.846	-7.373	0.000***	-4.435	0.005***	-7.265	0.000***	3.502	1.000	-5.336	0.000***
LnBEGSTOCK	-1.716	0.416	-8.322	0.000***	-3.809	0.025**	-8.176	0.000***	0.723	0.868	-7.326	0.000***
RECOV	-3.889	0.004***	-8.594	0.000***	-5.252	0.001***	-8.500	0.000***	0.208	0.742	-8.687	0.000***
LnMOLP	-0.967	0.757	-9.526	0.000***	-4.526	0.004***	-10.022	0.000***	3.328	1.000	-6.362	0.000***
LEVY	-2.837	0.061***	-25.205	0.000***	-5.532	0.000***	-27.505	0.000***	-1.665	0.090	-14.669	0.000***
LnEXP	-4.297	0.001***	-12.163	0.000***	-4.431	0.005***	-13.335	0.000***	-0.449	0.515	-12.063	0.000***
LnSCFRP	-1.499	0.525	-6.515	0.000***	-2.839	0.192	-8.025	0.000***	0.321	0.774	-6.559	0.000***

Note: *** and** indicate significance at 1% and 5%, respectively.

Table 2. Selection criteria for lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	155.724	NA	1.24E-19	-6.638	-6.105	-6.441
1	621.528	628.294	1.73E-25	-20.443	-12.988	-17.694
2	991.954	275.665*	1.88e-28*	-29.811*	-15.435*	-24.510*

Note: * indicates the optimal order, that is, the lowest value in the respective criterion.

Table 3. Bounds test for cointegration

Estimated equations	Optimal lag length	F-statistics	R^2	Adjusted R^2
LnSUGP*/ LnSCFRP, LnSPDS, LnPCGDP, LnJP, LnMOLP, LnPOP, LnEXP, LnSCAREA, RECOV, LEVY, LnYIELD, LnBEGSTOCK	2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 2	22.180	0.999	0.992
	I0 Bound	I1 Bound		
10%	4.78	4.94		
5%	5.73	5.77		
2.5%	6.68	6.84		
1%	7.84	5.59		

*refers dependent variable

Table 4. Estimates of long-run coefficients

Variable	Coefficients	Standard Error
LnSPDS	-0.237	0.108
LnPCGDP	-0.423***	0.119
LnPOP	1.453	0.907
LnJP	0.552***	0.128
LnYIELD	-1.207	0.560
LnSCAREA	0.351	0.424
LnBEGSTOCK	-0.301**	0.090
RECOV	-0.208**	0.079
LnMOLP	-0.427	0.260
LEVY	0.001	0.001
LnEXP	0.012	0.010
LnSCFRP	-0.531	0.223
C	5.956***	1.842

Note: *** indicates significance at 1%; ** indicates significance at 5%.

a negative and significant impact on sugar price with an elasticity of 0.21. This is inevitable, as improvements in the recovery rate lead to an increase in sugar production and its supply, and hence a decline in its price. The elasticity of per capita income is 0.42; its effect on sugar price is significant and negative and if the economy grows, the sugar price falls.

The coefficient of ECM (-1) is negative and statistically significant at 5%, indicating the existence of a long-run relationship among the variables and convergence towards equilibrium in the long run. The coefficient of ECM reflects the speed of adjustment. The estimated coefficient of -0.863 suggests that any deviation in price in the short run is corrected fast and the equilibrium is reached in the long run. Thus, 86% of the disequilibrium due to a shock is corrected within a year and the equilibrium is attained. Sugar PDS price, jaggery price, recovery rate, levy percentage, export, sugarcane yield and population have a significant effect on the sugar price in the short run, and any change in these is expected to return the deviation to the equilibrium (table 5).

3.5 Diagnostic and stability tests

The final stage of the ARDL model is to check the stability of the model. The results of the diagnostic tests of functional form, normality, serial correlation and heteroscedasticity are reported in table 6. It is observed that the estimated F statistic of serial correlation and heteroscedasticity tests and Jarque-Bera statistic of normality for ARDL model are insignificant, accepting the null hypotheses of no normality, serial correlation and heteroscedasticity.

Table 5. Estimates of short-run coefficients

Variable	Coefficient	Standard error
D(LnSUGP (-1))	-0.451**	0.155
D(LnSPDS)	-0.035	0.103
D(LnSPDS (-1))	0.196***	0.032
D(LnPCGDP)	0.078	0.140
D(LnPCGDP (-1))	-0.087	0.099
D(LnPOP)	5.289	2.594
D(LnPOP(-1))	14.675***	2.299
D(LnJP)	0.505***	0.081
D(LnJP (-1))	0.687***	0.136
D(LnYIELD)	-0.834**	0.330
D(LnYIELD(-1))	-1.155**	0.326
D(LnSCAREA)	-0.416	0.304
D(LnSCAREA (-1))	-0.413	0.250
D(LnBEGSTOCK)	-0.076	0.032
D(LnBEGSTOCK (-1))	0.027	0.027
D(RECOV)	-0.196***	0.032
D(RECOV (-1))	0.023	0.028
D(LnMOLP)	-0.130	0.105
D(LnMOLP (-1))	0.099	0.098
D(LEVY)	0.001	0.001
D(LEVY(-1))	-0.002***	0.000
D(LnEXP)	0.032***	0.006
D(LnEXP)	-0.300**	0.119
D(LnSCFRP (-1))	-0.053	0.102
ECM(-1)	-0.863**	0.267

Note: *** indicates 1% level significant; ** indicates 5% level significant

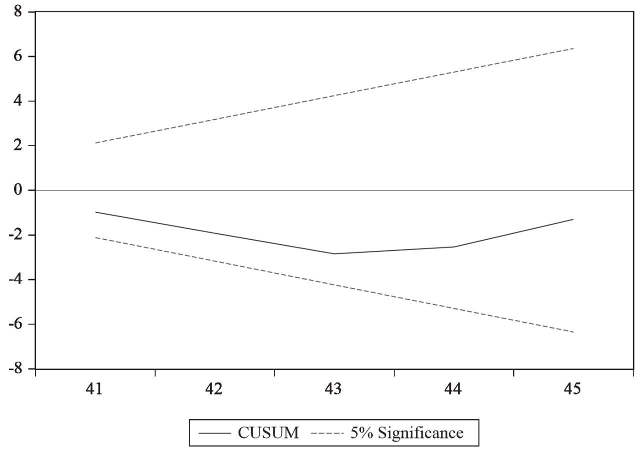

Figure 3. CUSUM stability test

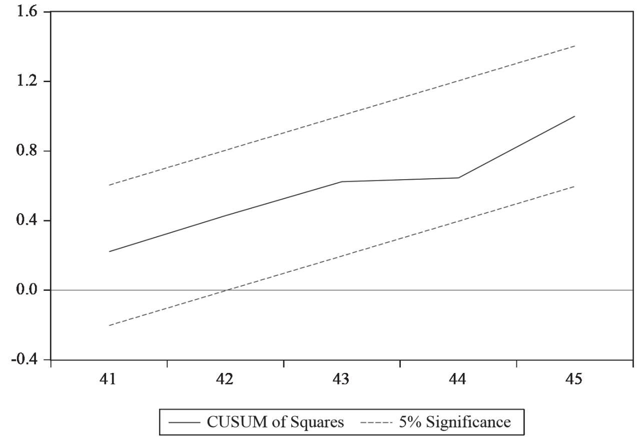

Figure 4. CUSUM of squares stability test

Table 6. Diagnostic test for the ARDL model

S. No.	Diagnostic test statistics	LM test	F – version
1	Serial correlation	Chi-square(2)= 0.0888	F stat (1.189) Prob. F(2,3)= 0.417
2	Heteroscedasticity (Breusch-Pagan-Godfrey)	Chi-square(37)= 0.403	F stat (1.145) Prob. F(37,5)= 0.491
3	Normality (Jarque-Bera)	0.656 Prob. (0.720)	Not applicable
4	Model fit (Ramsey RESET Test)	-	F stat (1.594) Prob. F(1,4)=0.275

Further, we employ CUSUM and CUSUM of squares (CUSUMSQ) tests to evaluate the stability of the estimated parameters (figures 3 and 4). The CUSUM and CUSUMSQ statistics lie within critical bounds, implying that the estimated coefficients are stable. The stability of the estimated model is confirmed by the Ramsey RESET test. The robust results of the diagnostic tests suggest that the ARDL model can be relied for modelling the nexus between sugar price and the variables representing public policies, market forces and technologies.

4 Conclusion

The Indian sugar industry is transforming gradually into a multidimensional industry, and the sugar value chain involves several actors upstream and downstream. A change at any of these stages is expected to influence the efficiency of the entire value chain. The linkage between sugar price and its drivers has not been addressed adequately in the empirical literature in the context of India.

This paper explores the dynamics of sugar price in relation to the changes in other factors. Our results show a long-run cointegrating relationship between the price of sugar and its determinants and a speedy adjustment of short-run price disequilibrium towards equilibrium in the long run. Moreover, the signs of the estimated coefficients on per capita income, price of jaggery, beginning stock of sugar and recovery rate are statistically significant; improvements in the recovery rate and beginning stock raise the supply of sugar and lower its price. A lower recovery rate raises the cost of manufacturing sugar and makes paying for sugarcane a burden for farmers. It also affects farmers, processors and consumers. The impact of jaggery price on sugar price is positive, indicating competition for raw material between sugar mills and jaggery units.

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