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The Impact of Stock, Energy and Foreign Exchange Markets on the Sugar Market

Nikolaos Sariannidis[1]

Abstract

This study examines the effect of financial factors on the sugar market by using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. The results show that changes in capital and energy markets returns have a positive impact on the mean returns of Sugar futures as opposed to changes in volatility returns of the exchange rate of the U.S. Dollar/ Yen that affect it negatively. Finally, the structural analysis of volatility with the GARCH model has shown that current volatility is more influenced by past volatility rather than by the previous day shocks.

Keywords: GARCH model, Sugar futures, Crude oil, Ethanol, Exchange rates

JEL classification: G15, Q13, Q14

1. Introduction

Sugar is widely produced, traded and consumed around the world. Sugar is produced from either sugar cane or sugar beets in more than 120 countries and consumed in every country. Sugar cane is primarily grown in tropical and sub-tropical climates while sugar beets are grown where the climate is more temperate. Some countries (e.g., the United States) produce significant amounts of both crops while others specialize in the production of either cane (e.g., Brazil) or beets (e.g., European Community (EC)).

Sugar is one of the most heavily traded agricultural commodities in the world markets and has long been characterized by volatile prices and widespread intervention. There are many factors that contribute to these unstable and high volatile prices. Specifically, per capita income, population and economic growth greatly influence the demand for sugar and hence the relative price. Besides, a key factor of sugar price variations is weather conditions, as successful crops yields presuppose an annual minimum of around 600 mm. Apart from adverse weather conditions, another factor that can disturb sugar prices is crop infestation by pests (Koo and Taylor, 2009).

Another crucial factor that affects most sectors of economies and hence sugar market, as a basic cost variable, is oil price fluctuations. Baffes (2007) claimed that crude oil prices affect the price of agricultural commodities on the supply side, as it enters in the aggregate production function through the use of various energy inputs (fertilizer and fuel) and in the transportation process of these goods.

1. Technological Education Institute (TEI) of West Macedonia, Department of Financial Applications, Kila 50100, Kozani, Greece - email: sarn@hol.gr

Moreover, the biofuels demand is a new factor that has influenced the food market and hence the sugar market whereas food prices were previously linked to oil prices only on the supply side (Piesse and Thirtle, 2009). Global biofuels production has expanded rapidly in recent years, playing an increasingly important role in the sugar markets and appears set to continue on this growth path. The market is dominated by ethanol, which grew threefold from 2000 to 2007, mainly in the US (world leader with production of 30 billion litres) and Brazil (19 billion litres).

Furthermore, the movements of exchange rates influence the price of all world traded goods and hence the price of sugar, because they are related to the price of imported/ exported goods, substitutes, raw materials and other cost variables (Piesse and Thirtle, 2009). Also, the volatility of exchange rates affects traders and investors as they seek to operate and invest their money in stable economies with stable currency (Kwek and Koay, 2006; Bloningen, 2005).

Finally, there has been a great deal of conversation regarding the effect of alternative trade liberalization policies on sugar prices. Particularly, in most recent years, over 70% of world sugar production is consumed domestically, implying that only a small portion of production is traded internationally. Since only a small proportion of world production is traded freely, small changes in production and government policies tend to have large effects on world sugar markets (Devadoss and Kropf, 1996; Yang et al., 2001; Huan-Niemi and Kerkela, 2005; Koo and Taylor, 2009).

The presented study is limited to capture the effect of financial factors on the price and volatility of sugar, as they concern substantially integrated and mature world markets with available daily data. Specifically, the factors that we have finally used are the crude oil, the ethanol, the exchange rate of the U.S. Dollar/ Yen and the SP500. We have chosen the Dollar/ Yen exchange rate for the following reasons. First of all, the U.S. Dollar is the biggest traded invoice currency, so it is considered as the predominant currency (McKinnon and Schnabl, 2002). Also, the majority reserve of currency is in U.S Dollars and hence the variability of the U.S Dollar could disturb the economic environment. In addition, Yen is one of the currencies of carrying trade (investors borrow low-yielding currencies and lend-invest in high-yielding currencies) and consequently its level relative to dollar plays a crucial role to all world markets. The SP500, the index of the largest economy in the world which augurs the future of other economies, has been used as a proxy for the world economic growth (activity), a fact which agrees with the conclusion of international bibliography (Fama, 1981; Fama, 1990; Schwert, 1990; Barro, 1990; Hassapis and Kalyvitis, 2002; Mauro, 2003; Enisan and Olufisayo 2009)

2. Data

For the empirical analysis, daily observations of the Sugar World No 11 (Sugar)[1], S&P 500 Stock Index (SP)[2], CL Crude Oil Light Sweet (Crude)[3], Denatured Fuel Ethanol

1. The contract size for #11 world raw sugar futures traded at Intercontinental Exchange (ICE, formerly the New York Board of Trade) is 112,000 pounds (50 long tons).
2. The S&P 500 is a stock market index containing the stocks of 500 American Large-Cap corporations.
3. Light Sweet Crude Oil futures are traded on the New York Mercantile Exchange under ticker symbol CL in U.S. dollars and cents per barrel.

Pit (Ethanol)[4] and U.S Dollar/Yen exchange rate (D/Y) are used. These data have been obtained from the Reuters DataLink database of Thomson Reuters Company. The sample period covers January 1, 2002 to August 31, 2009. It should be noted that the Ethanol variable, as a proxy for the price of biofuels, has available prices from 23/03/2005 and consequently it takes zero values before this period. Moreover, preliminary diagnostic tests have shown that the previous day volatility of the Dollar/Yen exchange rate returns (Var(D/Y)) affect the returns series of sugar.

Daily continuously compounded returns for the selected data are calculated as, $R_t=100*\log(p_t/p_{t-1})$ where R_t and p_t are the daily returns and prices respectively.

3. Methodology and Empirical Findings

Table 1 presents the summary statistics for Sugar, SP, Crude, Ethanol and Var(D/Y) series. The sample mean returns of Sugar, SP, Crude, and Ethanol series are close to zero and we cannot reject the null hypothesis that the mean returns are not statistically different from zero. Also, the coefficients of skewness and kurtosis indicate that the return series have asymmetric and leptokurtic distribution. Moreover, the augmented Dickey - Fuller (ADF) test, allowing for both an intercept and a time trend, showed that the sample series had been produced by stationary series.

Table 2 shows the sample autocorrelation function (ACF) and partial autocorrelation function (PACF) for daily returns and squared daily returns of Sugar series. It can be observed that while there is no significant autocorrelation in simple returns at any lag, on the contrary there is generally a significant autocorrelation in squared daily returns at all lags.

Table 1: Sample statistics

Statistics	Sugar	SP	Crude	Ethanol	VAR(D/Y)
Observations	1883	1883	1883	1883	1883
Mean	0.000811	0.000004	0.000534	0.000087	0.000045
Median	0.000000	0.000600	0.000400	0.000000	0.000014
Std. Dev.	0.020941	0.014089	0.025761	0.017614	0.000112
Skewness	0.126927	0.115439	-0.031454	-0.938708	12.285220
Kurtosis	6.351455	15.840720	7.700961	23.980370	271.398700
Jarque-Bera	886.32	12940.72	1734.16	34812.02	5699337.00

4. Ethanol futures contracts are traded on the Chicago Board of Trade (CBOT)

Augmented Dickey-Fuller (ADF)	-43.255	-35.225	-46.829	-44.512	-45.955

Table 2: Test for serial dependence in First and Second Moments of Sugar variable

Returns				Squared Returns			
Lags	Autocorrelation	Partial Correlation	LB(n)	Lags	Autocorrelation	Partial Correlation	LB(n)
1	0.002	0.002	0.007	1	0.077	0.077	11.066
2	-0.019	-0.019	0.7073	2	0.042	0.036	14.401
3	0.032	0.032	2.5934	3	0.039	0.034	17.332
4	0.013	0.013	2.9324	4	0.077	0.07	28.428
5	0.028	0.029	4.4207	5	0.038	0.025	31.161
6	-0.044	-0.044	8.0166	6	0.008	-0.003	31.287
12	-0.011	-0.014	12.437	12	0.026	0.013	57.8
24	0.01	0.006	34.326	24	0.05	0.026	123.93
36	0.026	0.02	46.523	36	0.022	-0.004	167.12
46	-0.02	-0.018	58.276	46	-0.011	-0.037	186.33
70	0.046	0.041	81.219	70	-0.004	-0.022	276.08

Notes: LB(n) are the n-lag Ljung-Box statistics for $SUGAR_t$ and $SUGAR_t^2$ respectively. LB(n) follows chi-square distribution with n degree of freedom; the sample period contains 1883 daily returns.

Also, the preliminary results of the linear regression between Sugar and SP, Crude, Ethanol and Var(D/Y) series have shown that the residuals exhibit strong ARCH effect indicating signals of misspecified error variance structure. Particularly, the OLS estimation of the model (equation 1) yields squared residuals that examined with ARCH LM test for 12 lags ($N^*R^2 = 29.65$) and the Ljung –Box test ($Q^2(6)=19.27$ and $Q^2(12)=35.5$) indicate that the hypothesis of no ARCH effects in the standardized residuals cannot be rejected.

$$Sugar_t=b_1+b_2SP_t+b_3Crude_t+b_4 Ethanol_t+b_5Var(Y/D)_{t-1} +u_t \quad (1)$$

In summary, the Sugar return series seems that it is best described by an unconditional leptokurtic distribution and possesses significant conditional heteroskedasticity. This renders the ARCH models a very good choice for modeling the Sugar return series. The autoregressive conditional heteroskedasticity (ARCH) model introduced by Engle (1982), and its extension to the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model (Bollerslev, 1986), allow the fat tails which are often observed in financial distributions and impose an autoregressive structure on the conditional variance and therefore is capable of capturing not only the volatility persistence of return series over time but also the volatility clustering as well. Volatility clustering is an important feature of financial distributions and appears when there is a tendency that large changes in returns prices will follow large changes, and small changes will follow small changes (Kyle, 1985). Moreover, this model is a weighted average of past squared residuals, but it has declining weights that never go completely to zero.

From the large variety of GARCH models, we proposed the GJR-GARCH model, introduced by Glosten, et al. (1993), in order to allow good and bad news to have a different impact on volatility.

The GJR model is a simple extension of the GARGH model accounting for any asymmetries involved. Statistically, this effect occurs when an unexpected drop in price due to bad news volatility increases more than an unexpected increase in price due to good news of similar magnitude. This model expresses the conditional variance of a given variable as a nonlinear function of its own past values of standardized innovations. The estimation of GJR-GARCH model involves the joint estimation of a mean and a conditional variance equation. The GJR-GARCH (1,1) model is stated as follows:

The mean equation

$$Y_t = X_t'\theta + u_t \tag{2}$$

where X_t is a vector of exogenous variables.

The conditional variance equation

$$\sigma_t^2 = a_0 + a_1\sigma_{t-1}^2 + a_2u_{t-1}^2 + a_3S_{t-1}^- u_{t-1}^2 \tag{3}$$

$u_t \sim GED(0, \sigma_t^2)$, i.e. residuals which we assume to follow the GED (generalized error distribution). We employ the GED because of its ability to accommodate fatter tails and peakedness.

$S_{t-1}^- = 1$ if $u_{t-1}<0$

$S_{t-1}^- = 0$ elsewhere

The leverage effect occurs when $\alpha_3>0$. The condition for a non-negative variance requires that $\alpha_0\geq 0$, $\alpha_1\geq 0$, $\alpha_2\geq 0$, $\alpha_2 + \alpha_3 > 0$.

When $R_t - \hat{R}_t < 0$ then $u_t<0$, which means that the observed return is less than the estimated return (in other words, the mean return). Consequently, when S_t^- is 1, the negative change u_{t-1}^2 at time t-1 correlates with the volatility at time t.

In this model, the good news ($u_{t-1}>0$) related to the bad news ($u_{t-1}<0$) has a different effect on the conditional variance. If $u_{t-1}>0$, it implies that at time t-1 we had good news, which had a positive effect on the return (over the mean return), and this is why the residual is positive. Good news reflects on the coefficient α_2 (α_3 absorbs the effect of the bad news). However, bad news has an effect on $\alpha_2+\alpha_3$, because if $S_{t-1}^- = 1$ then equation (3) becomes

$$\sigma_t^2 = a_0 + a_1\sigma_{t-1}^2 + a_2u_{t-1}^2 + (a_3u_{t-1}^2 * 1) = a_0 + a_1\sigma_{t-1}^2 + (a_2 + a_3)u_{t-1}^2 \tag{4}$$

When $\alpha_3 > 0$, we have the leverage effect, i.e. bad news has a greater effect on volatility. When $\alpha \neq 0$, we simply state that the effect of news is asymmetrical.

The preliminary statistical results and the application of the LR test on the GARCH(p,q) model demonstrated the final specification for the estimation of the mean and volatility for the Sugar series. The specification is:

Mean equation

$$Sugar_t = b_1 + b_2 SP_t + b_3 Crude_t + b_4\ Ethanol_t + b_5 Var(Y/D)_{t-1} + u_t \quad (5)$$

Variance equation

$$\sigma_t^2 = a_0 + a_1\sigma_{t-1}^2 + a_2 u_{t-1}^2 + a_3 S_{t-1}^- u_{t-1}^2 \quad (6)$$

$u_t \sim GED(0, \sigma_t^2)$,

Some diagnostic tests were performed to establish goodness of fit and appropriateness of the model. First, it was examined whether the standardized residuals and squared standardized residuals of the estimated model were free from serial correlation. As we can see from Table 3, the LB(n) statistics for standardized residuals are not statistically significant and the LB(n) statistics for standardized squared residuals show no ARCH remaining structure. The ARCH–LM Test concerning four lags in the residuals ($N*R^2 = 4.24$) verifies that we do not need to encompass a higher order ARCH process. Furthermore, the coefficient estimation v=1.21 for tail thickness regulator with 0.045 standard error, confirms the adoption of the GED assumption. Specifically, the assumption of normal distribution is rejected, a fact that verifies the theory for thick tails in the stock returns. A LR test of the restriction v=2 (for v=2 GED distribution is essentially the normal distribution) against the unrestricted models clearly supports this conclusion.

Table 3: Diagnostics on standardized and squared standardized residuals

Residuals				Squared Residuals			
Lags	Autocorrelation	Partial Correlation	LB(n)	Lags	Autocorrelation	Partial Correlation	LB(n)
1	0.006	0.006	0.07	1	0.035	0.035	2.26
2	-0.02	-0.02	0.81	2	-0.028	-0.029	3.71
3	0.03	0.031	2.56	3	-0.009	-0.007	3.86
4	0.01	0.009	2.76	4	0.013	0.013	4.18
5	0.034	0.035	4.96	5	-0.02	-0.021	4.92
6	-0.037	-0.038	7.60	6	-0.046	-0.044	8.84
12	-0.021	-0.023	10.94	12	-0.006	-0.005	10.84
24	0.006	0.001	26.93	24	0.044	0.042	23.40
36	0.023	0.015	36.09	36	0.001	-0.001	26.19
46	-0.003	0.002	44.31	46	-0.038	-0.043	32.76
70	0.042	0.035	64.12	70	-0.011	-0.005	59.18

Notes: LB(n) are the n-lag Ljung-Box statistics for the residual series. LB(n) follows chi-square variable with n degree of freedom; the series of residual contains 1883 elements.

In Table 4 the results for the mean equations are presented. The statistical significance of the b_2, b_3, b_4 coefficients indicates that the increase of SP500, Crude oil and Ethanol respectively exert positive effect on the conditional mean return of the sugar variable. Regarding the effect of the Dollar/Yen exchange rate returns, the statistical significance of b_5 indicates that the increase of its previous day volatility negatively influences the conditional mean returns of the Sugar variable.

In Table 5 the results for the variance equation are presented. The value of the α_1 coefficient (0.9458), which reflects the influence of σ^2_{t-1}, i.e. the older information (residuals u_{t-2}, u_{t-3}, …), is much higher than the value of the α_2 coefficient (0.038), which correlates the price variation of the present day to the price variation of the previous day. Consequently, the volatility shocks (information) are slowly assimilated to the particular market. Finally, the coefficient a_3, which allows the conditional variance to asymmetrically respond to positive and negative shocks, does not appear statistically significant.

Table 4: Mean equations

$$Sugar_t = b_1 + b_2 SP_t + b_3 Crude_t + b_4 Ethanol_t + b_5 Var(Y/D)_t + u_t$$

b_1	b_2	b_3	b_4	b_5
1.753**	0.0518***	0.105*	0.068*	-0.00087**
(0.826)	(0.0303)	(0.015)	(0.021)	(0.00041)

Notes: Standards errors are shown in parentheses. *indicates statistical significance at the 1% level. **indicates statistical significance at the 5% level.

Table 5: Variance Equations

$$\sigma_t^2 = a_0 + a_1\sigma_{t-1}^2 + a_2 u_{t-1}^2 + a_3 S_{t-1}^- u_{t-1}^2$$

a_0	a_1	a_2	a_3
0.0000057**	0.9458*	0.038*	0.0053
(0.0000025)	(0.0127)	(0.0105)	(0.0151)

Notes: Standards errors are shown in parentheses. *indicates statistical significance at the 1% level. **indicates statistical significance at the 5% level.

4. Conclusion

This study examines the role of financial factors in Sugar market using a GJR-GARCH model. Specifically, we have examined the influence of the SP500, Crude oil, Ethanol and U.S. Dollar/Yen exchange rate variables on Sugar World No 11. The findings show that the stock market, as a proxy variable for economic activity, positively affects the sugar market. Also, higher energy prices, Crude oil and Ethanol, positively influence the sugar market not only because of their connection with intensive inputs such as fertilizers, pesticides and fuels but also because sugar production itself becomes competitive in the energy sector as feedstock for the production of biofuels. Finally, the lag volatility of the U.S. Dollar/Yen exchange rate returns exerts negative influence on the conditional mean returns of the Sugar variable. This can be explained by the fact that the volatility of the U.S. Dollar/Yen weakens the confidence in commodities markets, creating an unstable environment for investments.

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