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Impact of price realization on India's tea export: Evidence from Quantile Autoregressive Distributed Lag Model

Debdatta PAL, Subrata Kumar MITRA

Indian Institute of Management Raipur, Raipur, India

Abstract: The quantile autoregressive distributed lag model of Galvao et al. (2013) was employed to assess the impact of price realization on India's tea export. The results of the QADL varied significantly from the conditional mean estimates. It was found that the tea export from India had autoregressive impact, and that production and export price realization had asymmetric relationship with India's tea export that varied over quantiles.

Key words: export price realization, Quantile Autoregressive Distributed Lag model, India

India is the second largest producer of tea, after China, and contributes nearly 25 percent of the world's total production (ONICRA 2014). Nearly 70 percent of this production is consumed domestically while the remaining 30 percent is exported. Though as an exporter, India ranks fourth after Kenya, China, and Srilanka with a 12 percent share in world export, tea is one of the major agricultural commodities exported from India. Export becomes important not only for earning the foreign exchequer but also for the better price recovery in the domestic market as an additional inventory from the previous year would increase the supply in the domestic market and lower its price.

Several econometric investigations have been devoted to unearth the factors affecting export of tea from India (see, Chatterjee 2011 for review). The studies have precisely considered the relative international price, i.e., the price of Indian tea relative to the tea price of the competing countries, the relative domestic price which is the ratio of the Indian tea export price to the domestic price, and the exchange rate, as explanatory variables.

We revisited the determinants of the India's tea export due to the following reason: India has experienced a considerable rise in exchange rate and the US$ has reached as high as INR 63.75 during April, 2013 from an average of INR 40 during 2007. In a free foreign exchange market, a higher exchange rate implies the lower price of domestic goods and thus, conducive for export due to the higher price realization from export. Hence, an empirical modelling to understand the effect of the domestic price realization, linked with exchange rate volatility, on the India's tea export was timely and relevant. The novelty of this work was in the application of the quantile autoregressive distributed lag model (QADL), recently suggested by Xiao (2009) and Galvao et al. (2009, 2013). While the classical time series models, namely the co-integration and autoregressive distributed lag model, capture the mean relationship between the variables through the conditional mean, the QADL examines the long-run relationship over quantiles through the conditional quantile function along time. The QADL approach would allow us to examine the variation in the India's tea export across various quantiles along time in response to the regressors. Also, the QADL results are superior to the results of the standard autoregressive distributed lag model regarding the root mean square error of the fat tail distributions.

To the extent of our knowledge, this is the first work using the QADL to identify the determinants of agricultural export, and more specifically the impact of the price realization on the export of commercial crops like tea.

DATA

In this study, we used the monthly time series data spanning from April, 2005 to May 2014. Table 1 shows the data description and data sources. Table 2 gives the summary statistics. The monthly production and

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Table 1. Data and sources

Variable	Description	Source
Y	Monthly tea production (in million kilogram)	Tea Board, Ministry of Commerce, Government of India
X	Monthly tea export (in million kilogram)	Tea Board, Ministry of Commerce, Government of India
P_E	Export price in Kolkata (in US$ per ton)	Commodity price data, World Bank
E	Exchange rate (INR per US$)	Database of Indian Economy, Reserve Bank of India
P	Realized export price in Kolkata (in INR per kilogram)	Derived by multiplying P_E with E

export, and exchange rate and price realization from export are presented in Figure 1 and Figure 2, respectively.

ECONOMETRIC SPECIFICATION

In our econometric analysis, we wanted to use the quantile co-integration relationship of the India's monthly tea export (X) with the monthly tea production (Y) and the export price realization (P) in the proposed multivariate model as follows,

$$X = f(Y, P) \quad (1)$$

More specifically,

$$X_t = a + \beta_t Y_t + \omega_t P_t + \nu_t \; t = 1, \ldots, n \quad (2)$$

where, X_t represents the India's tea export in the month t, Y_t is the India's tea production in the month t, and P_t captures the India's price realization from the tea export in the month t.

In the paper, we used a Quantile Autoregressive Distributed Lag (QADL) model proposed by Galvao et al. (2009, 2013). Tea being an agricultural product, the production of tea fluctuates from month to month showing a cyclical pattern that is evident from Figure 1. Similarly, the export quantity and price also display a cyclical pattern. The QADL model can capture the asymmetric business cycle dynamics of the India's tea export over different quantiles of the economic variables (Galvao et al. 2009). The QADL model of Koenker and Xiao (2009) and Galvao et al. (2013) corresponds to the stationary series, however, Xiao (2009) extended the model for unit-root series.

To explore the existence of varying co-integrating coefficients over time, Xiao (2009) proposed a quantile co-integration model in which the value of co-integrating coefficients will be affected by the shocks in each period. He used the model on Standard and Poor (S&P) 500 index data and proposed a forward looking solution linking prices with market fundamentals using the non-stationary time series of dividend and interest rate as follows,

$$p_t = \alpha + \beta_t d_t + \lambda_t r_t + \sum_{j=-K}^{K} \pi_{jt} \Delta d_{t-j} + \sum_{j=-K}^{K} \gamma_{jt} \Delta r_{t-j} + \varepsilon_t \quad (3)$$

where, p_t represents the real stock price at the time t, d_t is the dividend at the time t, and r_t is the short term interest rate at the time t.

Although the stock price, dividend, and the interest rate series were non-stationary, he found the existence of a long-run relationship among them.

In order to generalize the conventional co-integration model, Xiao (2009) used the time varying

Table 2. Summary statistics

	Y	X	P_E	E	P
Mean	84.6066	18.3477	2.3698	48.1957	115.3551
Median	88.5000	17.4545	2.3751	46.0898	112.9651
Maximum	167.1000	50.6553	3.4122	63.7521	181.6865
Minimum	13.9000	8.2973	1.2655	39.3737	55.71563
Std. Dev.	42.2452	6.2684	0.5537	6.2266	34.4708
Skewness	–0.1235	1.5143	–0.0267	0.9291	0.1797
Kurtosis	1.8814	8.1225	1.8347	3.0654	1.8665

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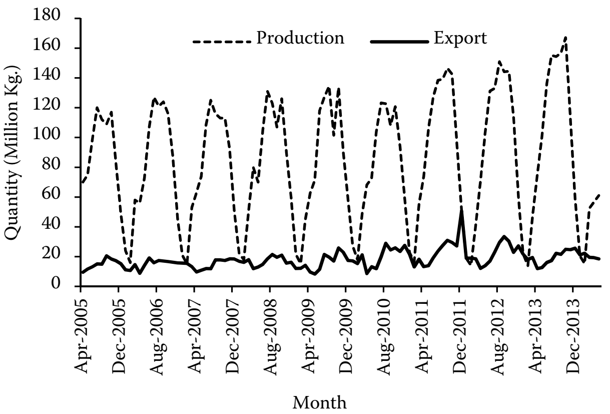

Figure 1. Monthly production and export of tea in India

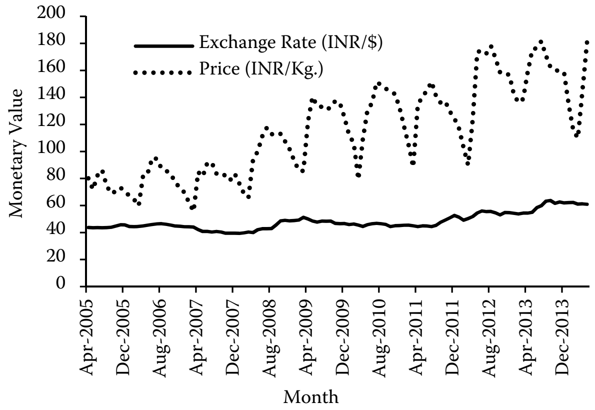

Figure 2. Monthly exchange rate and price of tea in India

coefficients following Barsky and Delong (1993) and Donaldson and Kamstra (1996) and employed the quantile co-integrating regression where the co-integrating coefficients were time varying depending on the new innovation (or shocks) received in each period. To absorb endogeneity, Xiao (2009) also added leads and lags and τ^{th} conditional quantile of stock price p_t was as follows:

$$Q_{pt}(\tau|\mathcal{F}_t) = \alpha(\tau) + \beta(\tau)d_t + \lambda(\tau)r_t + + \sum_{j=-K}^{K} \pi_j(\tau)\Delta d_{t-j} + \sum_{j=-K}^{K} \gamma_j(\tau)\Delta r_{t-j} \quad (4)$$

The evidence suggested that the point estimation of the co-integrating coefficients β and λ vary over time at each quantile and thus, brought asymmetric dynamics over time in the model. We applied the model of Xiao (2009) to examine the tea export from India.

Following Xiao (2009) and Galvao et al. (2013), the autoregressive distributed lag of orders p, q and r (ADL(p, q, r)) model of India's tea export, tea production, and the realized export price can be expressed as follows,

$$X_t = \alpha + \sum_{j=1}^{p} \xi_j X_{t-j} + \sum_{k=0}^{q} \beta_k Y_{t-k} + \sum_{l=0}^{r} \omega_l P_{t-l} + \nu_t \qquad t = 1, \ldots, n \quad (5)$$

Similarly, τ^{th} conditional quantile of India's monthly tea export X_t is as follows,

$$Q_{Xt}(\tau|\mathcal{F}_t) = \alpha(\tau) + \sum_{j=1}^{p} \xi_j(\tau) X_{t-j} + + \sum_{k=0}^{q} \beta_k(\tau) Y_{t-k} + \sum_{l=0}^{r} \omega_l(\tau) P_{t-l} \quad t = 1, \ldots, n \ (6)$$

where ξ(τ) represents the τ dependent autoregressive coefficient of X_t that varies over quantiles and co-integrating coefficients $\beta = \beta_0, \ldots, \beta_k$ and $\omega = \omega_0, \ldots, \omega_l$ may be impacted by the shocks and vary over quantiles.

This model, in this paper, is referred as the quantile autoregressive distributed lag (QADL) of orders p, q and r (QADL(p, q, r)).

In order to apply the Quantile regression on the non-stationary time series, we adopted the method of Xiao (2009), where all economic variables used in that study were non-stationary. As the variables in the proposed model might have unit-roots at the levels, we need to check stationarity of all the variables and thereafter, checked co-integration among the variables.

In a recent empirical investigation, to explore the relationship between the spot and future oil prices, Lee and Zee (2011) employed a quantile co-integration approach using unit-root series. They checked the unit-root using the augmented Dickey-Fuller test (Dickey and Fuller 1979), the Phillips-Perron test (Phillips and Perron 1988), and the Kwiatkowski-Phillips-Schmidt-Shin test (Kwiatkowski et al. 1992), followed by Johansen (1991) test to establish co-integration relationship. Similarly, in our model of tea export, the unit-root among the underlying variables was ascertained using the augmented Dickey-Fuller test, the Phillips-Perron test, and the Kwiatkowski-Phillips-Schmidt-Shin test. It was found that all the variables were integrated of order one $I(1)$, i.e., non-stationary at their levels.

Thereafter, we employed the Trace test and the Maximum Eigenvalue test suggested by Johansen (1991) to examine whether the underlying variables were co-integrated. Table 3 shows the test results against the null hypothesis of no co-integration. As

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Table 3. Unrestricted co-integration rank test

	Trace test	Maximum Eigenvalue test
Test-statistic	99.0318	83.0063
Critical value at 5% level	29.7970	21.1316

the test statistic of both tests exceeded the critical value suggested by MacKinnon et al. (1999) at the level of 5 percent, we reject the null hypothesis of no co-integration.

Further, Xiao (2009) observed that the estimated co-integrating coefficients may be influenced by the innovation obtained at each period and the coefficients would vary over quantile. He proposed a bootstrap based formal test to check the varying-coefficient co-integration relationship. To examine whether the co-integrating vector β_t is constant or not, the null hypothesis of H_0: $\beta(\tau) = \bar{\beta}$ over various quantiles (τ) can be tested on the Kolmogoroff-Smirnoff statistic $\sup_\tau|\widehat{V}_n(\tau)|$, where $\widehat{V}_n(\tau) = n(\hat{\beta}(\tau) - \bar{\beta})$ denoting $\hat{\beta}(\tau)$ as the estimator of $\beta(\tau)$, $\hat{\beta}$ as the least square estimator of $\bar{\beta}$.

RESULTS AND DISCUSSION

As we have used monthly data for this empirical analysis, initially we tried with twelve lags of all variables in Equation (5) and Equation (6). However, we found that *p*-values of coefficients of many lagged variables were high. Hence, to reach a parsimonious model, we follow the approach of the general-to-specific modelling by successively dropping the variables carrying high *p*-values. This resulted in a parsimonious model involving of the export, production, and the realized export price. ADL(1,0,0) and QADL(1,0,0) models are as follows,

Table 4. Estimated QADL(1,0,0) coefficients for different quantiles of the tea export

τ	$\xi_1(\tau)$	SE (ξ_1)	$\beta_0(\tau)$	SE(β_0)	$\omega_1(\tau)$	SE(ω_1)	R^2/Pseudo R^2
OLS	0.6184***	0.0654	0.0388***	0.0115	0.0316**	0.0138	0.4744
0.05	0.3535***	0.0473	0.0738***	0.0144	–0.0027	0.0126	0.2486
0.10	0.3847***	0.0587	0.0761***	0.0173	–0.0048	0.0145	0.2144
0.15	0.5588***	0.1049	0.0634***	0.0194	–0.0080	0.0122	0.2310
0.20	0.5629***	0.1002	0.0566***	0.0198	0.0014	0.0126	0.2661
0.25	0.6521***	0.0741	0.0414***	0.0150	0.0063	0.0115	0.2958
0.30	0.7048***	0.0564	0.0295***	0.0085	0.0134	0.0094	0.3177
0.35	0.6892***	0.0614	0.0321***	0.0088	0.0166	0.0104	0.3363
0.40	0.6895***	0.0634	0.0329***	0.0089	0.0174	0.0109	0.3480
0.45	0.7206***	0.0665	0.0354***	0.0094	0.0144	0.0116	0.3537
0.50	0.7042***	0.0720	0.0315***	0.0093	0.0228*	0.0125	0.3586
0.55	0.6598***	0.0861	0.0330***	0.0096	0.0324**	0.0153	0.3655
0.60	0.6564***	0.0976	0.0222**	0.0108	0.0452**	0.0180	0.3741
0.65	0.6821***	0.1005	0.0272**	0.0109	0.0407**	0.0181	0.3851
0.70	0.7342***	0.1090	0.0292**	0.0122	0.0362*	0.0193	0.3990
0.75	0.7519***	0.1078	0.0288**	0.0117	0.0352*	0.0192	0.4031
0.80	0.8107***	0.1189	0.0299**	0.0127	0.0307	0.0219	0.4056
0.85	0.7150***	0.1202	0.0297**	0.0124	0.0511**	0.0222	0.4019
0.90	0.8284***	0.1748	0.0434**	0.0205	0.0356	0.0345	0.3918
0.95	0.8081***	0.1696	0.0520***	0.0194	0.0413	0.0334	0.3594

***,**,* Significant at a level of 1 percent; 5 percent and 10 percent , respectively.

$\xi_1(\tau)$, $\beta_0(\tau)$ and $\omega_1(\tau)$ denote the quantile dependent parameters of export, production, and price realization variables, respectively.

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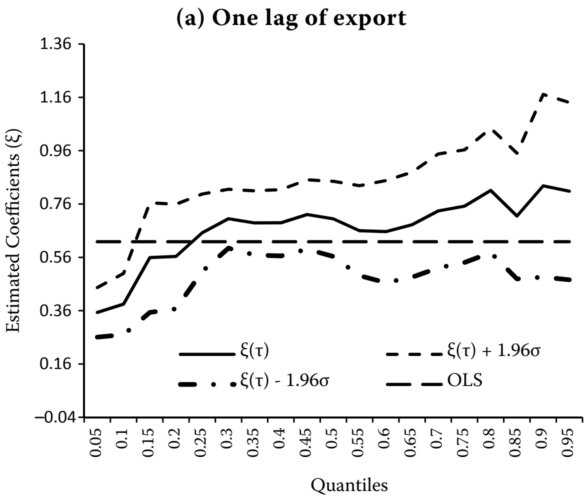
$$X_t = \alpha + \xi_1 X_{t-1} + \beta_0 Y_t + \omega_0 P_t + \nu_t \quad t = 1, \dots, n \qquad (7)$$

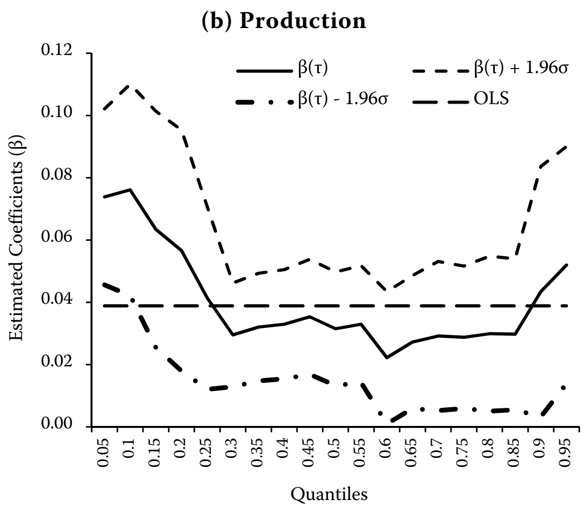
$$Q_{Xt}(\tau|\mathcal{F}_t) = \alpha(\tau) + \xi_1(\tau) X_{t-1} + \beta_0(\tau) Y_t + \omega_0(\tau) P_t \quad t = 1, \dots, n \qquad (8)$$

Setting τ = 0.05, 0.010, 0.015, ..., 0.90, 0.95, Equation (7) and Equation (8) were estimated employing the QADL(1,0,0) model and compared with the Ordinary Least Squares (OLS) results (refer Table 4). For each of the three covariates, 19 different QADL estimates were plotted as the solid curve for τ spanning from 0.05 to 0.95. For each covariate, these point estimates show the impact of one-unit change of the covariate across various quantile on the tea export keeping other covariates constant. Thus, each of the plots in Figure 3(a)–(c) has a horizontal quantile, or τ, scale, while the vertical scale represents the value of the respective coefficients. In each plot, while the OLS estimate of the conditional mean is highlighted by the dashed line, the confidence band of ±1.96 standard error σ for the QADL long-run coefficients were also indicated.

In Table 4, as per the OLS estimate, one lag of export variable was positively related (i.e., ξ = 0.6184) with the export variable. However, according to QADL(1,0,0) the estimated values of $\xi_1(\tau)$ vary over quantiles. The estimated value of $\xi_1(\tau)$ at τ = 0.05 was 0.3535 and continued to increase up to 0.7206 at τ = 0.45. The estimated coefficients of $\xi_1(\tau)$ decreased till it attained 0.6564 at τ = 0.60. The value of $\xi_1(\tau)$ further increased until reaching its peak 0.8284 at τ = 0.90. To be precise, the higher the quantiles were, the larger the estimated coefficients of $\xi_1(\tau)$. This indicates that the tea export displays autoregressive behaviour for the successive months, resulting from the a-priory export contract and the execution of the contract in the successive months, which is an established procedure in the international trade.

According to the OLS results, the production was positively boosting the tea export. The QADL estimation, however, portrayed a different picture. At the lower quantiles, the production was associated with a higher export. Tea export gradually decreased over higher quantiles and continued to fall up to τ = 0.60. Export then increased and crossed the conditional mean value beyond τ = 0.90. For low quantiles, this result is interpreted as the fact that the tea production reactivates its promotion for export when exports are low as otherwise production with low export would create pressure on the domestic market, resulting in domestic price to fall. For high quantiles, when the export was high, the Indian tea planters would opt





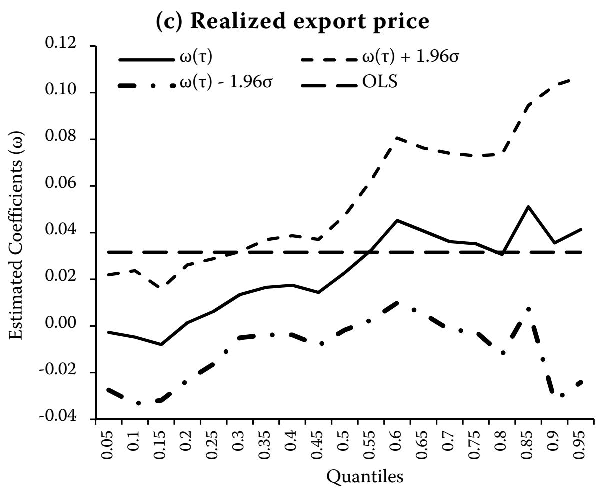


Figure 3(a–c). The OLS and QADL model estimates for the tea export model

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for an aggressive plucking and more production of tea to meet the export targets.

The study had shown an interesting feature on the impact of export on the account of the price realization from exports. The price realization from export is a multiple of the tea auction price and the exchange rate. An increase in the exchange rate makes the domestic goods relatively cheaper and increases the demand for the domestic goods from foreign countries. This also increases the price realization in the domestic country. Thus, the coefficient associated with the price realization from tea export was expected to be positive and it is indeed positive at 0.03 as per the OLS. However, the QADL estimates had shown that it can even be negative in the lower quantiles, though it entered in the positive territory at the upper quantiles. A low price realization from export is detrimental to export and the QADL model aptly portrayed this phenomenon quite well. However, the conventional OLS did a poor job in portraying this range of variations in tea export.

We captured the time varying behaviour of co-integration coefficients used in Equation (8) using the resampling method proposed by Xiao (2009) by bootstrapping 1000 times. The value of the Kolmogoroff-Smirnoff statistic $\sup_\tau|\widehat{V}_n(\tau)|$ was found significant at the level of 1 percent. Thus, the null hypothesis of constant co-integrating coefficients was rejected and the varying coefficient behaviour across various quantiles was evidenced.

Thus, the QADL model could bring important insights related to the asymmetric business cycle dynamics of various economic parameters that influence the tea export from India.

CONCLUSION

Here, we employed the quantile autoregressive distributed lag model of Xiao (2009) and Galvao et al. (2009, 2013) to identify the determinants of the tea export from India. Both the production and the price realization from export were found to be affecting the India's tea export. We observed significant differences between the QADL estimates and the OLS results. The QADL model used in the study could capture the asymmetric business dynamics of the tea export from India over different quantiles of production and the export price realization in addition to the lagged value of these variables. As the coefficients of the QADL model significantly varied over the quantiles compared to the OLS estimates, the findings of this asymmetry make the time series analysis more meaningful as compared to the studies that make use of the time invariant structures.

Finally, the results can be interpreted that the export volume of tea have an asymmetric autoregressive behaviour and that the production and the price realization show an asymmetric influence on the tea export volume along the quantiles. These new findings were credited to the novelty of the QADL model that has provided us a quantile dependent autoregressive dynamic framework.

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Contact address:

Debdatta Pal, Indian Institute of Management Raipur, Raipur 492 015, India
e-mail: debdatta@iimraipur.ac.in