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Market Responses to India's Carbon Credit Trading Scheme: Sectoral Evidence from Carbon Emission Intensive Industries

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ABSTRACT: This study analyses the stock-market reaction to the announcement of India's Carbon Credit Trading Scheme (CCTS) on 28 June 2023. The study covers four carbon intensive sectors under the scheme namely, Aluminium, Chlor-alkali, Pulp and Paper and Textile. A sample of 18 listed companies was taken from these sectors using an event study methodology. The market benchmark used is the BSE 500 Index. The estimation period is 120 trading days and event window is of 21 trading days (from t-10 to t+10). To measure the market reaction around the announcement, we examine Average Abnormal Returns (AARs) and Cumulative Average Abnormal Returns (CAARs). Further evidence is provided by additional paired t-tests, Wilcoxon Signed-Rank tests, Corrado rank tests and modified Corrado tests. The results show that the CCTS announcement was associated with a negative cumulative market reaction. The AAR was negative but statistically insignificant on the announcement day while the CAAR was significantly negative and remained below zero during the post-announcement period. The first trading day after the announcement showed a large negative AAR and the cumulative effect was statistically significant even at the end of the event window. The sector-wise results show that the response was not uniform in the four sectors. Aluminium and Pulp and Paper exhibited significant negative CAARs in selected event windows whereas the results for Chlor-alkali and Textile were negative but weaker in statistical terms. The additional tests provide mixed evidence on the strength of the response. The results indicate that investors responded negatively to the announcement of the CCTS, but the magnitude and statistical significance of the reaction varied across sectors.

1 INTRODUCTION

Environmental regulation is becoming increasingly relevant for financial markets as shifts in environmental policies could impact how firms operate and how they plan for future costs. Policies relating to carbon emissions can influence production decisions, investment requirements and expected profitability for companies operating in energy intensive industries. In this context, carbon pricing is an important policy instrument that puts an economic value on greenhouse gas emissions and incentives firms to lower their emissions (X. Wang et al., 2025). Thus, carbon markets can connect environmental objectives with economic decision making, allowing emission reductions to be registered via market-based mechanisms (Tang et al., 2015). According to Calel (2013), the economic incentives generated through carbon markets can motivate firms to look for relatively cheap ways of reducing emissions while carrying on their productive activities.

The development of such markets has become particularly important for countries trying to reconcile economic development with long-term emission reduction objectives. India too is moving in this direction through the establishment of a national framework for carbon trading. A key part of this process is the Carbon Credit Trading Scheme (CCTS). Rather than relying on traditional regulatory approaches alone, the scheme adopts a market-based approach in which emission performance is gradually associated with economic incentives and compliance obligations. This development is especially pertinent for industries that consume large quantities of energy or encounter technical challenges in lowering their emissions. Typically, these industries are expected to be impacted earlier by regulatory mechanisms related to carbon, as their shift to lower-emission production can imply important technological and financial adjustments (ICAP, 2024).

India's CCTS became operational as a formal policy framework with its notification by the Ministry of Power on 28 June 2023 under the Energy Conservation (Amendment) Act, 2022. The notified framework covers 743 entities across eight sectors, thus bringing a wide range of industrial activities into the emerging carbon-market structure (BEE, 2023). The participating entities are under some emission reduction requirements and their obligations are tied to emission intensity in terms of tons of carbon dioxide equivalent (CO_2e). These requirements are also associated with India's wider climate commitments within the framework of its Nationally Determined Contributions (NDCs) as discussed by Tran et al. (2025). The introduction of the scheme therefore creates a new regulatory environment in which firms need to consider not only their current production costs but also the financial implications of improving their future emission performance.

Within this broader framework the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors provide an important setting to examine the financial implications of the policy. These sectors have different production processes and energy needs, and so their exposure to carbon-related regulation is not equivalent. New emission-related obligations can influence decisions for technology adoption, operational efficiency, investment and resource allocation. In addition, as the carbon market develops, firms face changes in expected costs and competitive conditions (Bansal et al., 2022). Environmental regulatory changes have wider implications for corporate strategy, investment behaviour, production planning and the cost structure of firms (He & Wang, 2025; Del Olmo García et al., 2026). From this perspective, the CCTS is not only an environmental policy, but also has implications for the financial expectations of companies operating in the covered sectors.

Another important issue is how investors respond when such a policy is introduced. A major regulatory announcement provides information about the future operating environment of affected firms. This leads investors to re-assess expected earnings, the costs of compliance, the investment requirements and the possible competitive consequences of the policy. Such reassessment can be seen in the prices of stocks. Zhu et al. (2025) emphasize the significance of investor expectations for capital market responses to major policy developments. Also, the market-efficiency perspective assumes that information available to market participants can be incorporated into security prices, especially when the information has implications for companies' future cash flows. Therefore, changes in environmental regulations can result in observable changes in stock prices as investors reassess the expected costs and benefits associated with the new regulatory environment (Bai & Yang, 2025). This relation is especially worth examining when considering India's emerging carbon market. We can study the expectations of investors about a new environmental policy through an observable channel in the financial market. According to Syed (2025), the firms with a higher exposure to energy-intensive activities are of particular importance when considering the relationship between carbon pricing and financial markets. The movements in share prices around a policy announcement therefore can give evidence of how investors understood the potential economic implications of the regulatory change. The usefulness of stock market movements to investigate the financial toll of environmental and carbon-related developments is also demonstrated by Da Silva et al. (2016).

The CCTS announcement of 28 June 2023 therefore provides an actual event to evaluate the market's reaction to India's nascent carbon-pricing regime. The present study applies an event study methodology to examine the abnormal returns of the listed Indian companies belonging to the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors covered by the CCTS. Instead of treating the market as a homogeneous entity, the sector-wise approach makes it possible to look at the abnormal-return behaviour of individual industrial segments separately. This is important because differences in industrial characteristics can produce different reactions to the same regulatory development. As Park (2004) suggested, the responses in different segments of the industry leads to a more refined insight about the impact of a common event on firms under different economic conditions. The study is therefore concerned with the behaviour of stock prices around the CCTS notification and examines if the announcement was associated with an abnormal market performance for the selected companies. The analysis examines the behaviour of abnormal returns around the event date and uses statistical testing to determine whether the observed changes are significant departures from normal stock-price behaviour. The study therefore seeks to provide evidence on the financial market interpretation of the introduction of India's carbon-trading framework. The findings also contribute to the relatively developing body of research on the links between environmental policy, carbon-market development, and financial-market behaviour in emerging economies.

The rest of the paper is organized to build the discussion from the conceptual background to the empirical evidence. Section 2 reviews the relevant literature on carbon-market policies, environmental regulation and stock-market reactions and discusses the use of event studies in previous research. Section 3 research objectives, sample selection, data sources, event-study framework and statistical procedures. In Section 4, we present and interpret the empirical results, considering the abnormal-return behaviour of the selected sectors around the CCTS announcement. In Section 5 the main findings are summarized and conclusions drawn from the analysis. The last part of the paper is devoted to limitations of the study.

2 LITERATURE GAP

Financial markets constantly respond to information that change investors' expectations about the future performance of firms. An event study is a useful method of examining such responses by comparing the actual return of a security with the return that would normally be expected in the absence of a particular event. For this reason, event studies have been extensively used to investigate whether a particular announcement or development is associated with an abnormal movement in stock prices. The method has evolved from its early uses in financial markets and is now used to investigate the impact of corporate announcements, economic developments, political decisions, regulatory changes and unforeseen external events.

The growth of event-study research has involved both methodological advances and broader empirical applications. A major issue in the initial development of the method is that stock prices do not always trade continuously. For example, Dimson (1979) addressed the problem of thin trading, and proposed the use of an aggregation coefficient to minimize its impact in the estimation of abnormal returns. Later studies continued to examine the reliability of different approaches for calculating expected returns. The Market Model and the Mean-Adjusted Return Model, for example, have generally produced reasonably comparable estimates under their respective assumptions. As researchers learned more about the problems inherent in traditional event-study methods, more attention was given to improving the statistical tests used to test whether the abnormal returns that are observed are meaningful. The choice of statistical test has also been an important aspect of this methodological development. A major contribution was made by Corrado (1989) who proposed a non-parametric rank test which provided an alternative to standard parametric methods. The application of this approach became more relevant as the financial return data not necessarily satisfy the normality assumptions of traditional tests. Boehmer (1991) further developed the testing framework by considering cases where the variance of returns changes around an event. Corrado and Zivney (1992) also pointed out the usefulness of non-parametric procedures for return distributions which are skewed or characterized by excess kurtosis. These developments illustrate that the reliability of event-study results depends not only on the estimation of abnormal returns, but also on the appropriateness of the statistical tests applied to such returns. Other methodological issues have been addressed subsequently, especially where observations from different firms are correlated with each other. However, problems of inter-firm dependence and distortions that can occur in small samples have remained relevant in event-study research, although an approach to handling cross-correlation was developed by Campbell and Wesley (1993). The discussion on the choice between parametric and non-parametric procedures has therefore kept ongoing. Dutta (2014) compared different testing approaches and concluded that both methods can be used in event studies, but non-parametric procedures tend to produce more consistent results. The continued development of these techniques has helped researchers to make event-study findings more robust in cases where the underlying return data do not fully satisfy conventional statistical assumptions.

Meanwhile, event studies have been applied to a broad range of real-world developments. For example, equity prices have been seen to move noticeably in response to political and macroeconomic events. The evidence of Belgacem et al. (2015) and Seda et al. (2018) demonstrates how political and macroeconomic announcements can lead to fluctuations in stock prices. Another important field of application has been corporate decisions. Kaur and Kaur (2025) looked at dividend announcements and bonus issues to understand their impact on the value of common stocks. Similarly, Liargovas and Repousis (2011) have examined the financial market reactions to such events as demonetization, mergers and acquisitions and currency devaluation. For example, Ghanem and Rosvall (2014) studied the relationship between main national economic events and stock price movements.

Event-study techniques are also applicable to equity markets. Researchers have also used similar methods to study the impact of uncertainty and major external shocks on diverse financial assets. Demir et al. (2018) and Zhou (2024) studied asset returns and volatility that include markets such as bitcoin, crude oil and gold during periods of economic uncertainty. The COVID-19 pandemic was another significant example of a large external shock. Pandey and Kumari (2020) studied the behaviour of global and emerging stock markets during the pandemic and showed that large-scale external disturbances can result in significant changes in financial-market behaviour. These studies demonstrate the usefulness of event-based analysis in studying how investors respond to new information that creates uncertainty about the future state of the economy. Changes in environmental policies can affect firms' expected costs, investment requirements and future earnings, which in turn will affect investor behaviour. Chinese research suggests that changes in carbon-related regulations influences investor behaviour and market performance (Tang et al., 2015). The European Union Emissions Trading System (EU ETS) has also received similar attention, with researchers examining the stock-market implications of changes in carbon-market regulation. These studies are relevant to the present research as they indicate that environmental policy announcements have financial consequences beyond their direct environmental objectives Oberndorfer (2008).

There are also specific studies on market response to carbon-pricing and environmental policy announcements. For example, Han et al. (2018) studied the effect of a carbon-pricing announcement in Australia in an event-study framework. Earlier evidence from the forestry industry provides another example of how environmental policy can affect equity prices. Zhang and Binkley (1995) reported significant stock-price movements by forestry firms in British Columbia in response to changes in forest policy. Policy changes also have financial effects through wider economic channels. Patro et al. (2013) examined currency devaluation and showed that higher import prices and inflationary pressures affect stock markets, which in turn affect corporate profitability, investor decisions and stock prices. Collectively these studies suggest that financial markets respond to policies that directly affect financial activity as well as to regulatory and economic changes that alter the expected operating conditions of firms.

The empirical evidence on carbon-market policy, for the Indian stock market, is sparse, despite the increasing international literature. Some studies have examined past carbon-related developments in India. For example, Kumar and Firoz (2019) investigated whether the issuance of Certified Emission Reductions (CERs) generated abnormal returns for firms. More recently, Lamba and Aggarwal (2024) studied the reaction of the stock market to voluntary carbon-neutral announcements made by Indian firms. These studies provide useful evidence that carbon-related information can be examined from a financial-market perspective, but they do not directly address the market response to India's formal CCTS framework. This leaves a large area for further research, particularly following the official notification by the CCTS on 28 June 2023. The scheme applies to a variety of energy-intensive industries, but firms in different sectors do not face the same economic consequences from carbon related regulation. In the present study, focus is on the listed companies of Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors covered under the scheme. Examining these sectors individually might help to understand whether investors responded differently among industries with different production processes, energy needs and exposure to carbon-related obligations.

The present study investigates the stock market reaction to the CCTS announcement in India using an event-study approach. The analysis uses abnormal returns around the date of the announcement and tests whether the observed movements were statistically different from normal stock-price behaviour. The study aims to contribute to the existing literature by providing sector-specific evidence on the reaction of Indian equity markets to the establishment of the country's carbon-trading system. The four sectors are analysed separately. The study thus contributes to the understanding of the relationship between carbon-market policy, investor response and stock-market behaviour in an emerging economy.

3 OBJECTIVE, SCOPE AND METHODOLOGY

3.1 Objective and scope of the study

This study examines the relationship between the announcement of CCTS in India and stock-market performance of listed firms in the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors and are covered under the CCTS Scheme. To analyse the pricing of the CCTS policy information in the market performance of the selected companies, we use daily stock returns of the selected companies around the date of the announcement of the CCTS. The analysis first tests whether the announcement was followed by abnormal stock returns. The first null hypothesis states that the abnormal returns observed around the announcement are not statistically different from zero, i.e., the CCTS announcement did not lead to a significant change in the market valuation of the affected firms. If this hypothesis is rejected, it will provide evidence that investors reacted to the announcement and altered their views on the potential effects of the policy for the firms involved.

The study also examines whether the market reaction was different in the four selected sectors. To this end, Cumulative Average Abnormal Returns (CAARs) are analysed for the relevant event periods. The sectoral analysis allows us to identify whether the magnitude and direction of the cumulative market response differed across the four sectors. Thus, the second null hypothesis is that the CAARs of these four sectors are not statistically significantly different after the announcement of the CCTS. We present a deeper evaluation of how financial markets viewed the introduction of India's carbon-trading framework by looking at the aggregate abnormal-return response as well as sectoral differences. Such sectoral evidence is useful as the transition to a low carbon economy have different financial implications for firms according to their industrial characteristics, production processes and exposure to carbon-related regulatory requirements.

3.2 *Event study framework*

Event studies are based on an event date and generally include some number of days before and after the event date known as a "event window." The event window generally includes five to thirty days surrounding the event date. Moreover, it is also necessary to specify an estimation window and select an appropriate model to calculate normal stock returns in the absence of the event, which allows us to detect abnormal returns related to the event. In this study, the date of the event is considered to be the announcement of the CCTS on 28 June 2023. Event window is of 21 days. t_{-10} to t_{+10} relative to announcement. The estimation window is 120 trading days, from t_{-130} to t_{-11} pre event date. The analysis includes only active trading days.

3.3 *Sample*

The scheme covers 743 firms, including some multiple firms of the same company, with about a tenth being listed firms. The sample for the research is drawn from the population discussed above, which consists of 18 companies listed on the Bombay Stock Exchange (BSE) (Aluminium: 3; Chlor-alkali: 5; Pulp and paper: 5; Textiles: 5). All the listed companies from Aluminium sector are covered under the scheme. Five companies with the largest market share in each industry are selected in the case of Chlor-alkali, Pulp and paper, and Textiles sectors. To avoid duplication, when a firm operates in several sectors, it is represented in the database only once. The sample selection is shown in Table 1. The daily closing stock price data of each company was obtained directly from the official website www.bseindia.com of the Bombay Stock Exchange from 19 December 2022 to 13 July 2023.

Table 1. Sample data overview

	Sector	Name of the company	BSE Security Code	Ticker Symbol
1	Aluminium	Hindalco Industries Limited	500440	HINDALCO
2		Vedanta Limited	500295	VEDL
3		National Aluminium Company Ltd	532234	NATIONALUM
4	Chlor-Alkali	Grasim Industries Limited	500300	GRASIM
5		Gujarat Alkalies and Chemicals Limited	530001	GUJALKALI
6		DCM Shriram Limited	523367	DCMSHRIRAM
7		Chemplast Sanmar Limited	543336	CHEMPLAST
8		Atul Limited	500027	ATUL
9	Pulp & Paper	JK PAPER LIMITED	532162	JKPAPER
10		ITC Limited	500875	ITC
11		Tamil Nadu Newsprint & Papers Ltd	531426	TNPL
12		West Coast Paper Mills Limited	500444	WSTCSTPAPR
13		Seshasayee Paper and Boards Ltd	502450	SESHAPAPER
14	Textile	Vardhman Textiles Limited	502986	VTL
15		Raymond Limited	500330	RAYMOND
16		K.P.R. Mill Limited	532889	KPRMILL
17		Welspun Living Limited	514162	WELSPUNLIV
18		Trident Limited	521064	TRIDENT

Source: Bombay Stock Exchange official website (https://www.bseindia.com)

3.4 Benchmark Index

The performance of selected companies in the stock market is studied against the market benchmark i.e. BSE 500 Index. The index is broad-based covering the Indian equity market with companies from various industries and a large number of companies listed on the Bombay Stock Exchange (BSE). Its broad coverage of sectors makes it useful to separate company-specific or sector-specific movements in stock returns from changes occurring in the broader market. Another important feature of the BSE 500 Index is the coverage of a large part of the total market capitalization of companies listed on the BSE. Therefore, the index movements provides a fairly broad indication of the general market conditions during the period tested. The index is constructed using the free-float market capitalization methodology, where the weight of a constituent is based on the proportion of its shares available for public trading. This approach gives more importance to companies with higher freely tradable market value. The BSE Index Committee also reviews the constituents of BSE 500 Index from time to time. This periodic revision helps to keep the index relevant to reflect the changes in the Indian equity market. Therefore, the present study is undertaken to evaluate the returns of selected companies in the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors. This allows the analysis to focus more specifically on abnormal movements in the stock prices of the selected firms around the event period and not movements in the stock prices that are due to the general market.

3.5 Estimation framework

The event-study analysis requires an estimate of the return that a stock would normally be expected to generate in the absence of the event. For this purpose, the estimation period is used to establish the normal relationship between the return of each sample company and the return of the market benchmark. Since the observations in this period precede the event window, they provide a basis for estimating the expected return under ordinary market conditions. In the present study, expected returns are estimated using the Ordinary Least Squares (OLS) approach. The market model is specified as follows:

$$E(R_{it}) = \alpha_i + \beta_i R_{bt} \tag{1}$$

where α_i is the intercept for company i, β_i indicates the sensitivity of the company's return to movements in the market, and R_{bt} represents the return of the benchmark index on day t. In this study, the BSE 500 Index is employed as the benchmark for estimating the expected returns of companies

3.6 Identification of Abnormal Performance (AR)

Once the expected return has been obtained from the market model, the next step is to determine whether the actual return of a company differs from what would normally be expected. This difference is treated as the abnormal return (AR). It is calculated by subtracting the estimated expected return from the actual return observed for the company on a particular trading day:

$$AR_{it} = R_{it} - E(R_{it}) \tag{2}$$

A positive AR indicates that the actual stock return exceeded the return predicted by the model, whereas a negative AR indicates that the realised return was lower than the expected level. In the context of this study, abnormal returns are particularly important because they provide an indication of whether the CCTS announcement was associated with an unusual movement in the share prices of the selected firms. The individual abnormal returns are subsequently aggregated across companies to obtain the AAR for each day of the event window. The AARs are further accumulated over the selected event period to obtain the CAAR. These measures form the basis for assessing the direction and magnitude of the market response to the CCTS announcement.

3.7 Statistical Assessment of AAR and CAAR

The statistical significance of the observed abnormal returns is examined to determine whether the movements in AAR and CAAR are sufficiently different from zero to be considered statistically meaningful. The analysis initially employs parametric t-tests for both measures. The standard deviation of abnormal returns during the estimation period is used in obtaining the test statistics.

For each company, the estimation-period standard deviation is calculated from the deviations of the daily abnormal returns from their corresponding mean. The resulting firm-level measures are then used to obtain the aggregate estimation-period standard deviation for the sample. The relevant calculation is expressed as:

$$SD_{ie} = \sqrt{\frac{\Sigma(AR_{it} - AAR_e)^2}{n}} \tag{3}$$

where, SD_{ie} denotes the standard deviation of abnormal returns for company i during the estimation period; AARe represents the average abnormal return during that period, and n is the number of observations used in the estimation period.

The aggregate standard deviation for the sample, SD_{Ne} is subsequently obtained as follows:

$$SD_{Ne} = \sqrt{\frac{\Sigma(SD_{ie})^2}{N^2}} \tag{4}$$

where, N denotes the total number of companies in the study.

Using the estimated standard deviation, the significance of the daily AAR is tested through the following expression:

$$t(AAR_t) = \frac{AAR_t}{SD_{NE}} \tag{5}$$

A similar procedure is followed for evaluating the statistical significance of CAAR. The corresponding test statistic is calculated using:

$$t(CAAR_t) = \frac{CAAR_t}{SD_{NE}\sqrt{N_{t+1}}} \tag{6}$$

where, $CAAR_t$ denotes the cumulative average abnormal return of shares on day t, N_{t+1} refers to the absolute value of event day t plus one. For example, if the event day is 10, its absolute value remains 10, and adding 1 yields 11 (N_{t+1}).

3.8 Additional Tests for Robustness

To strengthen the reliability of the event-study findings, the analysis is supplemented with both parametric and non-parametric tests. A paired t-test and the Wilcoxon Signed-Rank test are employed as additional checks of the observed differences in returns. The use of these tests provides a broader assessment of the results rather than relying only on the conventional t-test. The study also incorporates the rank-based procedure proposed by Corrado (1989). Unlike a conventional test based directly on the magnitude of abnormal returns, the Corrado approach transforms the abnormal returns into ranks over the estimation and event periods. This makes the test less dependent on assumptions concerning the underlying distribution of returns. The modified version proposed by Ataullah, Song and Tippett (2011) is additionally used to examine CAARs over shorter event windows. The Corrado test statistic can be written in a simplified form as:

$$t_{Corrado} = \sqrt{\frac{3}{N(T^2 - 1)}}\sum_{i=1}^{n}[2K(AR_{it}) - (T - 1)] \tag{7}$$

where, N represents the number of observations in the sample, while T denotes the total number of abnormal-return observations considered. In the present analysis, T corresponds to the number of trading-day observations included in the relevant period (141 days in this study). $K(AR_{it})$ refers to the rank assigned to the abnormal return of index i among all 141 trading days.

For assessing the significance of CAARs over a defined event window, the modified Corrado procedure of Ataullah, Song and Tippett (2011) is applied. The corresponding statistic is expressed as:

$$t_{Cor(modified)} = \sqrt{\frac{3}{M(T+1)(T-M)}} \sum_{i=1}^{n} [2K(CAR_{itM}) - M(T+1)] \qquad (8)$$

where, $K(CAR_{itM})$ represents the sum of the ranks associated with the abnormal returns over event window M; M denotes the length of the event window under consideration.

3.9 Explanation of the findings

The event-study analysis provides statistical evidence to evaluate whether the stock-market performance of the selected firms was affected significantly by the CCTS announcement. The sign of the estimated AAR and CAAR indicates the reaction of investors to information released from the policy announcement. A positive and significant value means the selected firms had returns greater than expected in normal market conditions, whereas a negative and significant result points to a fall from the anticipated return. Comparing abnormal returns at the announcement date also serves to understand how the new policy information was incorporated by the market. The fact that abnormal returns are higher than before the event after the announcement indicates that investors change their expectation after the information is released. In contrast, a decline in abnormal returns after the announcement signals a less favourable market reaction.

For the purpose of hypothesis testing, the calculated t-statistic is compared with the relevant critical value at the selected level of significance. A test result is said to be statistically significant when the absolute value of the t-statistic calculated is greater than that of the corresponding critical t-value. Then the sign of the statistic is separately considered to determine the direction of the market response. Thus, the statistical significance of AAR and CAAR and their positive or negative directions are used to determine whether the stock-market movements around the CCTS announcement provide evidence against the respective null hypotheses. Table 2 shows the results of t-statistics for varying sample sizes.

Table 2. t-statistics corresponding to varying sample sizes

Sector	Number of items (n)	Degree of Freedom (n-1)	t value	
			at 5% level	at 1% level
Total sample	18	17	2.03	2.72
Sector-wise:				
a. Aluminium	3	2	4.30	9.92
b. Chlor-alkali	5	4	2.78	4.60
c. Pulp and Paper				
d. Textile	5	4	2.78	4.60
	5	4	2.78	4.60

Source: Author's calculation

4 EMPIRICAL EVALUATION AND DISCUSSION OF RESULTS

4.1 Assessment of Normality

Table 3 presents the normality tests performed for the abnormal returns of the selected companies. The three tests, Shapiro-Wilk, Lilliefors and Jarque-Bera, offer evidence from different parts of the distribution and facilitate the assessment of whether the abnormal returns can be reasonably considered normally distributed. A p-value greater than 0.05 suggests that there is not enough evidence to reject the null hypothesis of normality at the 5% significance level.

The results show that the distribution of abnormal returns is not the same for the companies included in the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors. For example, the Shapiro-Wilk test supports normality for 14 of the 18 companies, which is 77.8% of the sample. The companies are HINDALCO, VEDL, NATIONALUM, GUJALKALI, CHEMPLAST, ATUL, JKPAPER, ITC, TNPL, WSTCSTPAPR, SESHAPAPER, VTL, RAYMOND and WELSPUNLIV. Conversely, GRASIM, DCMSHRIRAM, KPRMILL and TRIDENT give p-values below 0.05 in this test; this indicates a statistically significant departure from normality for these four companies. The pattern is somewhat different for the Lilliefors test. In this case, 17 out of 18 companies (94.4% of the sample) have p-values greater than the 5% significance level. Only GRASIM has a p-value below 0.05. This means that the evidence for non-normality is rather weak when using the Lilliefors criterion. It is also seen that most of the companies from the Pulp and Paper and Textile sectors satisfy the normality criterion according to this test, whereas the Aluminium and Chlor-alkali sectors contain the few observations for which some evidence of non-normality is observed. Another view is provided by the Jarque-Bera test which considers the skewness and kurtosis of the distribution. According to the test, 15 companies (83.3%) have p-values above 0.05, while DCMSHRIRAM, KPRMILL and TRIDENT have p-values below the 5% level. Thus, although a few firms exhibit signs of non-normality, the majority of the observations do not provide sufficient statistical evidence for us to reject the normality assumption.

The three tests together indicate that the results support the hypothesis of normality for a significant portion of the sample, but not for all 18 companies equally. The deviations observed for a few firms are not unexpected in stock market data where return distributions can be affected by unusually large price movements, asymmetry and extreme observations. The differences among the three tests also highlight why relying on a single normality test might not provide a complete picture of the distributional characteristics of the data.

Table 3. Results of the normality test

Company	Shapiro-Wilk	Lilliefors	Jarque-Bera
Hindalco Industries Limited	0.4305	0.1370	0.9080
Vedanta Limited	0.4583	0.2391	0.5329
National Aluminium Company Ltd	0.7976	0.2203	0.7515
Grasim Industries Limited	**0.0294**	**0.0453**	0.0710
Gujarat Alkalies and Chemicals Limited	0.1608	0.8664	0.4421
DCM Shriram Limited	**0.0003**	0.0932	**0.0001**
Chemplast Sanmar Limited	0.9768	0.8589	0.9313
Atul Limited	0.2294	0.6901	0.1923
JK PAPER LIMITED	0.8926	0.9676	0.7702
ITC Limited	0.5008	0.2418	0.5587
Tamil Nadu Newsprint & Papers Limited	0.6404	0.2319	0.7805
West Coast Paper Mills Limited	0.2328	0.5790	0.2075
Seshasayee Paper and Boards Ltd	0.5880	0.6019	0.5541
Vardhman Textiles Limited	0.0800	0.0569	0.5669
Raymond Limited	0.8844	0.9370	0.8595
K.P.R. Mill Limited	**0.0061**	0.0956	**0.0252**
Welspun Living Limited	0.6500	0.4337	0.8364
Trident Limited	0.0549	0.3230	**0.0092**

Note: Bold figures indicate results that are statistically significant at the 0.05 level. (Source: Author's calculation)

Therefore, the results taken together provide a basis for continuing the event-study analysis with the statistical methods we planned. However, since some companies exhibit evidence of non-normality in one or more tests, the analysis is not based solely on parametric inference. The inclusion of the Corrado rank test, modified Corrado procedure, paired t-test and Wilcoxon

Signed-Rank test provide further evidence of the robustness of the results. This enables to study the market reaction around the CCTS announcement from both conventional and rank-based perspectives.

4.2 Sample test statistics

Table 4 shows the behaviour of AAR and CAAR over the event window, divided into the pre-event period, the event day and after the event date.

Table 4. Event window AARs, CAARs, and corresponding t-values

Prior to event date					Post event date				
Time	**AAR value**	**AAR t-value**	**CAAR value**	**CAAR t-value**	**Time**	**AAR value**	**AAR t-value**	**CAAR value**	**CAAR t-value**
t_{-10}	0.000	0.001	0.000	0.000	t	-0.726	-1.822	-1.132	-2.842**
t_{-9}	0.166	0.418	0.167	0.132	t_1	-1.302	-3.267**	-2.434*	-4.320**
t_{-8}	-0.435	-1.093	-0.269	-0.225	t_2	-0.351	-0.881	-2.785**	-4.035**
t_{-7}	0.080	0.201	-0.188	-0.167	t_3	-0.559	-1.402	-3.343**	-4.196**
t_{-6}	0.372	0.934	0.184	0.174	t_4	-0.231	-0.579	-3.574**	-4.012**
t_{-5}	-0.644	-1.615	-0.460	-0.471	t_5	-0.356	-0.893	-3.930**	-4.027**
t_{-4}	0.133	0.334	-0.327	-0.367	t_6	0.480	1.205	-3.450**	-3.273**
t_{-3}	-0.011	-0.028	-0.338	-0.424	t_7	0.364	0.915	-3.085**	-2.738**
t_{-2}	0.498	1.249	0.160	0.231	t_8	-0.630	-1.582	-3.715**	-3.109**
t_{-1}	-0.566	-1.421	-0.406	-0.721	t_9	0.724	1.817	-2.991**	-2.374*
t	-0.726	-1.822	-1.132	-2.842	t_{10}	-0.538	-1.352	-3.530**	-2.671**

*Denotes significance at the 5%, **Denotes significance at the 1% (Source: Author's calculation)

Table 4 provides the daily AARs and CAARs along with their t-statistics for the event. The results suggest the behaviour of the stock-market around the CCTS announcement was not homogenous. During the pre-announcement period, AARs of both signs were observed, but no AAR t-value of any report reached the conventional significance levels. For example, the AAR increased from 0.000 at t_{-10} to 0.166 at t_{-9} and decreased to negative at t_{-8} and t_{-5} while higher positive AAR of 0.498 was observed at t_{-2}. But these movements were statistically not significant. It implies that there was no clear evidence of unusual daily stock-price behaviour around the announcement date for the selected companies before the announcement. The overall pattern tells a slightly different story. The first CAAR increased to 0.167 at t_{-9}, but then became negative at t_{-8}, and reached -0.460 at t_{-5}. It bounced back a bit in the following days, but the overall performance deteriorated again as the announcement date drew near. CAAR declined to -0.406 at t_{-1} and fell to -1.132 on the event day. Hence, while the individual pre-event AARs were not statistically significant, the cumulative movement suggests a gradual decline in abnormal performance leading up to the announcement.

The announcement day itself deserves special attention. The AAR at t was -0.726 with a t-statistic of -1.822 which is not statistically significant at the reported levels. Thus, the daily return on the announcement day alone does not provide sufficient evidence for a statistically significant abnormal reaction. The CAAR on the same day, in contrast, was -1.132 and the t-statistic was -2.842, which is significant at 1% level. The difference between AAR and CAAR suggests that the negative cumulative movement had already been built up through the preceding trading days and was not just created by the return observed on the announcement day. A stronger negative pattern emerges after the announcement. At t_{+1}, the AAR is -1.302 and is statistically significant at the 1% level with a t-value of -3.267. At the same time, CAAR also decreases further to -2.434 with a t-statistic of -4.320, significant at 1%. The cumulative abnormal performance is statistically significant on each subsequent post-event day listed in the table. CAAR is -2.785 at t_{+2}, down to -3.343 at t_{+3} and -3.930 at t_{+5}. There is some improvement at t_{+6} and t_{+7}, with CAAR moving to -3.450 and -3.085 respectively, but it is still well below zero.

The daily AARs following the announcement also fluctuate rather than continuously decline. There are positive AARs at t_{+6} (0.480), t_{+7} (0.364) and t_{+9} (0.724) and negative values on several other days. None of these positive AARs is statistically significant. Similarly, the negative AARs after t_{+1} are also not significant individually in most cases. The one exception is t_{+1} where the negative AAR is statistically significant. This demonstrates that the post announcement market reaction did not have significant negative abnormal returns on each trading day. Instead, the persistent significance of the CAAR implies that the negative cumulative effect was maintained even as individual daily abnormal returns fluctuated in both directions. The AAR at t_{+10} is -0.538 with a t-value of -1.352, which is still statistically insignificant. However, CAAR is -3.530 and t-statistic of -2.671 is significant at 5% level. Thus, the cumulative abnormal performance remains significantly negative at the end of the 21-trading-day event window. Thus, the temporary improvements in the CAAR around t_{+6}, t_{+7} and t_{+9} were not enough to offset the overall negative cumulative movement.

Thus, the overall evidence presented suggests a negative cumulative stock-market reaction to the CCTS announcement for the selected companies from the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors. The lack of significant AARs for much of the pre-event period indicates that there was no strong evidence of abnormal daily returns before the announcement. The AAR on the announcement day itself was statistically insignificant and the CAAR was significantly negative. The most pronounced daily response was on the first trading day after the announcement. AAR was -1.302, significant at the 1% level. More importantly, the CAAR remained significantly negative in the post-event period and closed at -3.530 on t_{+10}. The results therefore indicate that the market response was more distinctly captured in the cumulative performance of the selected firms rather than persistent statistically significant daily abnormal returns.

Table 5. Behaviour of AAR and CAAR in the period surrounding the event date

Period around the event date	AAR value	AAR t value	CAAR value	CAAR t value
-9 to +9	-0.157	-0.395	-2.992**	-2.120*
-7 to +7	-0.188	-0.471	-2.817**	-2.231*
-5 to +5	-0.374	-0.939	-4.113**	-3.762**
-3 to +3	-0.431	-1.082	-3.016**	-3.379**
-1 to +1	-0.864	-2.170*	-2.594**	-4.109**

*Denotes significance at the 5%, **Denotes significance at the 1% (Source: Author's calculation)

Table 5 provides another perspective on the stock-market reaction by examining increasingly tighter event windows around the announcement of CCTS. A key finding of the results is that the AAR is negative for all five windows, but the statistical significance varies. The AAR varies from -0.157 in the (-9, +9) window to -0.864 in the (-1, +1) window. For the wider windows the corresponding t-statistics are below the conventional critical level indicating that the daily AAR is not statistically different from zero. However, the AAR is significant at the 5% level with a t-value of -2.170 and is -0.864 in the narrowest window (-1, +1). This shows that the daily abnormal return is stronger in the event of concentrating the analysis on the trading days immediately before and after the announcement. More consistent pattern is observed in the CAAR results. As compared to the AARs, all the reported values of CAAR are negative and statistically significant. The (-9, +9) window shows the CAAR of -2.992 which is negative also for the (-7, +7) window (-2.817). When the event window is further shortened, the cumulative abnormal performance is -4.113 in (-5, +5) and -3.016 in (-3, +3). The narrowest window was -2.594 CAAR. The CAAR t-statistics are also statistically significant with values of -2.120 and -2.231 for the two wider windows at the 5% level and -3.762, -3.379 and -4.109 for the three narrower windows at the 1% level.

The comparison between AAR and CAAR is particularly relevant to understand the market reaction. Daily abnormal return is not statistically significant for most of the different windows. However, the cumulative measure is significant in all of the windows. This means that the negative market movement did not have to be confined to a single trading day. Instead, the accumulation of abnormal returns over the event period yields a statistically significant negative effect. The stronger t-statistic in the (-1, +1) window also suggests that the evidence is especially strong when the analysis is confined to the time period surrounding the CCTS announcement. Thus, the results suggest that the CCTS announcement was associated with negative cumulative abnormal performance for all the analysed event windows. The evidence is particularly strong for the shorter windows where the CAAR is significantly negative and the AAR is significant itself in the (-1, +1) period. This pattern suggests that the market reaction was more accurately reflected in the cumulative stock price change than in statistically significant daily abnormal returns over the entire event window. The results thus point to a negative market reaction around the announcement for the companies in the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors. The statistical evidence gets stronger when looking more closely at the announcement date.

Table 6. Results of the Paired t-test and Wilcoxon Signed-Rank test

Average		**Paired t test**			**Wilcoxon signed rank test**		
Before	After	t value	t critical	p value	z value	p value	W value
-0.040	-0.240	-1.3	2.262	0.226	-1.172	0.241	16

(Source: Author's calculation)

Table 6 reports the comparison of abnormal returns before and after the event using two complementary statistical approaches. The AAR was -0.040 before the event and declined to -0.240 after the event. Thus, the descriptive values show that abnormal returns were more negative in the post-event period. However, this difference in the averages needs to be assessed statistically before drawing any conclusion about whether the change was associated with the event. The paired t-test does not provide sufficient evidence of a statistically significant difference between the two periods. The calculated t-value is -1.3, whereas the reported critical value is 2.262. Since the absolute calculated value is lower than the critical value, the null hypothesis of no significant difference cannot be rejected. This conclusion is also supported by the p-value of 0.226, which is greater than the 5% significance level. Therefore, although the AAR decreased from -0.040 to -0.240 after the event, the observed difference is not statistically significant according to the paired t-test. A similar conclusion is obtained from the Wilcoxon Signed-Rank test, which provides a non-parametric assessment of the difference between the two periods. The test produces a z-value of -1.172 and a p-value of 0.241. As the p-value exceeds 0.05, there is again insufficient evidence to reject the null hypothesis of no systematic difference between the pre-event and post-event abnormal returns. The reported W-value of 16 is consistent with this result.

Taken together, both tests lead to the same statistical conclusion. Although the AAR became more negative after the event, the change from the pre-event to the post-event period is not statistically significant. The results therefore do not provide sufficient statistical evidence of a systematic shift in abnormal returns between the two periods. This is important because the negative difference in the average values alone should not be interpreted as evidence of a significant market response. The consistency between the parametric paired t-test and the non-parametric Wilcoxon Signed-Rank test also provides a useful robustness check. Since neither test identifies a significant difference, the observed movement from -0.040 to -0.240 represents variation in abnormal returns during the study period rather than a statistically established change associated with the event. Thus, based on these two tests, the evidence does not support a statistically significant difference in abnormal returns between the periods before and after the event.

Table 7. Event window results based on the Corrado rank test

Before the event date		**After the event date**	
Time	$t_{Corrado}$ value	Time	$t_{Corrado}$ value
t_{-10}	0.261	t_{0}	-2.085*
t_{-9}	0.405	t_{1}	-3.741**
t_{-8}	-1.262	t_{2}	-1.129
t_{-7}	0.510	t_{3}	-1.598
t_{-6}	1.199	t_{4}	-0.347

t_{-5}	-2.102*	t_5	-0.863
t_{-4}	0.845	t_6	1.517
t_{-3}	-0.869	t_7	0.955
t_{-2}	1.482	t_8	-1.517
t_{-1}	-1.795	t_9	1.737
t_{-0}	-2.085*	t_{10}	-1.552

*Denotes significance at the 5%, **Denotes significance at the 1% (Source: Author's calculation)

Table 7 presents the results of the Corrado rank test, a non-parametric test used to determine whether the abnormal returns around the CCTS announcement differ from the normal return pattern. The test is particularly useful because it measures the relative ranking of abnormal returns, not simply their numerical value. The reported results show that evidence of unusual market movements is confined to a few trading days rather than being spread across the entire event window.

Most of the Corrado statistics are not significant statistically before the announcement. The values swing between positive and negative values between 0.261 at (t_{-10}) and -2.102 at (t_{-5}). For the pre-event observations, the Corrado statistic at t_{-5} (-2.102) is significant at the 5% level. The other pre-event values, t_{-8} (-1.262), t_{-3} (-0.869), t_{-2} (1.482) and t_{-1} (-1.795) are not significant at the levels reported. It implies that there is little evidence of statistically anomalous price movements prior to the announcement. The day of the announcement (t) also shows a statistically significant result. The Corrado statistic is -2.085 which is significant at 5% level. The negative sign indicates that the ranked abnormal return on the announcement day was close to the lower end of the distribution under consideration in the test. This is some evidence of a strange market movement coincident with the release of the CCTS information. Post-event results show that the most significant movement happened immediately after the announcement. Finally, the Corrado statistic goes down to -3.741 at (t_{+1}) significant at 1%. This is the biggest Corrado statistic by statistical significance that the post-event period produced. The negative value indicates that the first trading day after the announcement was associated with an abnormally low ranked abnormal return. However, the evidence does not remain statistically significant for the next days. The statistics at t_{+2} (-1.129), t_{+3} (-1.598), t_{+4} (-0.347) and t_{+5} (-0.863) are insignificant. Similarly, the positive values for t_{+6} (1.517), t_{+7} (0.955) and t_{+9} (1.737) do not attain statistical significance. The statistic at (t_{+8}) is also insignificant at -1.517 while at t_{+10} we have -1.552.

The results suggest that statistically significant abnormal movements are clustered around the announcement window, particularly on 't' and (t_{+1}), and do not persist over the post-event window. The large negative statistic at 't' is followed by an even larger negative statistic on (t_{+1}) suggesting that the market experienced a strange downward movement immediately surrounding and after the announcement. However, the Corrado statistics are statistically insignificant after (t_{+1}), meaning that the evidence of abnormal ranked returns becomes weaker as the event window is further away from the announcement. In sum, the Corrado rank test finds evidence of a short term market reaction to the CCTS announcement but the reaction is not statistically significant on most days of the event window. The important observation at (t_{-5}) indicates that an abnormal movement was already present a few days before the announcement whereas the significant results at 't' and (t_{+1}) suggest a stronger evidence around the announcement itself. The results suggest that the post-event significance is mainly concentrated on the first trading day, showing the market adjustment was most evident around the announcement and was not sustained over the post-event period. This result complements the AAR and CAAR results in providing a rank based assessment of abnormal return behaviour of the selected companies.

Table 8. Modified Corrado test findings in the period surrounding the event

Timeframe (M)	$t_{Corrado(modified)}$ value
-9 to +9	-1.020
-7 to +7	-1.016
-5 to +5	-2.014*
-3 to +3	-1.718
-1 to +1	-2.257*

*Denotes significance at the 5%, **Denotes significance at the 1% (Source: Author's calculation)

Table 8 presents the results of the modified Corrado rank test which provides an additional assessment of the CAAR behaviour around the CCTS announcement. Conversely, the test examines alternative event windows and tests whether the CAAR observed around the announcement are statistically significantly different from normal. This serves as a useful complement to the traditional CAAR analysis as the test is based on the ranked abnormal returns rather than their actual values. The results show that modified Corrado statistics are negative for all five event windows, showing a common negative direction of the cumulative market response. The statistical strength of that response, however, changes across the windows selected. The test statistics for the broader periods (-9, +9) and (-7, +7) are -1.020 and -1.016 respectively, neither of which are statistically significant. Likewise, the statistic for the (-3, +3) window is -1.718 which again does not reach the 5% significance level. Therefore, the modified Corrado procedure does not provide sufficient evidence that a CAARis statistically significant for the three windows.

Different results are obtained by considering shorter periods of events. The modified Corrado statistic for the (-5, +5) window is -2.014 which is significant at the 5% level. The best evidence is in the tightest (-1, +1) window where the statistic is -2.257, again significant at the 5 per cent level. These findings imply that the evidence of a cumulative abnormal market response is more severe the closer the analysis is to the CCTS announcement. Therefore, the pattern of the event windows is important. The lack of statistical significance in the wider windows does not imply that there was no abnormal movement around the announcement. Instead, the results suggest that the evidence is statistically detectable in the shorter windows around the event date. This is consistent with the market response being concentrated relatively close to the announcement, and becoming less distinct when observations from a wider period were used in the test. Thus, the modified Corrado results offer some evidence of a significant cumulative market response to the CCTS announcement. For the (-5, +5) and (-1, +1) windows, the significant statistics are negative, indicating that the statistically significant cumulative response found by this test was negative. This evidence is not uniform across all event windows, as seen by the insignificant results for (-9, +9), (-7, +7) and (-3, +3). Thus, the results suggest that the cumulative abnormal movement is more clearly detectable when the analysis is restricted to relatively short periods after the announcement rather than the longer event windows.

4.3 *Sector-wise impact of announcement of the CCTS*

Table 9. Significant AARs and CAARs of different sectors during the event window

Sectors	AAR values		CAAR values	
	Before event	**After event**	**Before event**	**After event**
Aluminium	0	0	0	10*
Chlor-alkali	0	0	0	6
Pulp and Paper	0	1	0	10
Textile	0	1	0	9

*indicates significant returns during the event day (Source: Author's calculation)

Table 9 compares the frequency of significant AAR and CAAR observations between the Aluminium, Chlor-alkali, Pulp and Paper and Textile sectors during the event window. The results show that the four sectors did not respond to the CCTS announcement in exactly the same way. In the pre-event period, none of the four sectors showed significant AAR or CAAR. It implies that there was no significant evidence of abnormal performance statistically significant before the announcement across the sectors considered. Following the event another pattern is visible. Aluminium and Chlor-alkali sectors do not report significant AARs. Pulp and Paper and Textile sectors report one significant AAR each in the post-event period. It implies that the daily stock-market response was fairly moderate when the sectors are analysed separately. At the same time, results based on CAARs are more pronounced.

The CAAR results show a stronger post-event response across all four sectors. Aluminium records 10 significant CAAR observations, followed by 10 for Pulp and Paper, 9 for Textile, and 6 for Chlor-alkali. Thus, the cumulative abnormal performance is more evidence of market movements than individual daily AARs. The notably high number of significant CAAR observations for Aluminium and Pulp and Paper suggests that abnormal movements were built up over a number of trading days after the announcement, although the corresponding daily AARs are not consistently significant. The results also show that the market reaction was more visible after the CCTS announcement than before. Since none of the sectors has significant CAARs in the pre-event period, the cluster of significant post-event CAARs indicates that the information related to the announcement was absorbed into stock prices in the following trading days. The presence of significant CAARs across all four sectors also suggests that the effect was not confined to one group of industries, though the occurrence of significant cumulative returns differed across sectors.

The sectors with the least number of significant post-event CAAR observations are Chlor-alkali (6), while the sectors with the most observations are both Aluminium and Pulp and Paper (10). Textile is in the middle with (9) significant CAAR observations. The difference in these frequencies suggests that the intensity or persistence of cumulative abnormal performance was not uniform across the sectors covered in the analysis.

Table 10. Test results of sectoral CAARs during short event windows

Sectors	Period around event date				
	-9 to +9	**-7 to +7**	**-5 to +5**	**-3 to +3**	**-1 to +1**
Aluminium	-1.522	-1.011	-1.974*	-1.714*	-2.167*
Chlor-alkali	-1.379	-0.750	-0.968	-1.226	-0.859
Pulp and Paper	-1.357	-1.973*	-2.751**	-1.645	-2.349
Textile	-0.349	-0.787	-1.918	-2.190	-2.819

*Denotes significance at the 5%, **Denotes significance at the 1% (Source: Author's calculation)

Table 10 presents the sector CAAR test statistics of the Aluminium, Chlor-alkali, Pulp and Paper, and Textile sectors across five event windows. The results indicate that the estimated CAAR direction is negative for all four sectors over all event windows. However, the statistical significance varies across sectors and is more apparent in some of the shorter windows. This means that although the four sectors had negative cumulative abnormal movements around the CCTS announcement in general, the strength of evidence was not the same for all the sectors.

The CAAR test statistics of the Aluminium sector are negative in all the five windows. The values range from -1.522 in the (-9, +9) window to -2.167 in the (-1, +1) window. The results are statistically significant in the three smaller windows. The statistics are -1.974, -1.714 and -2.167 for (-5, +5), (-3, +3) and (-1, +1) respectively all significant at 5 % level. Thus, the evidence of a negative cumulative market response is stronger when the analysis focuses on the announcement period. The Chlor-alkali sector is of a different pattern. All five test statistics for CAAR are negative, but none of them are statistically significant at the reported level. Values vary from -1.379 in the (-9, +9) window to -0.859 in the (-1, +1) window. The results, therefore, do not provide sufficient statistical evidence for a significant cumulative abnormal response for this sector for any of the event windows considered. The Pulp and Paper industry also shows negative CAAR test statistics in all windows, but the significant results are concentrated in the two intermediate windows. The statistic is -1.973 for the (-7, +7) window, significant at the 5% level, and more negative at -2.751 for the (-5, +5) window, significant at the 1% level. But the statistics for (-9, +9), (-3, +3) and (-1, +1) not statistically significant. Thus, the evidence for this sector is strongest around the (-5, +5) period rather than the widest or the narrowest window. For the Textile sector, all the reported CAAR test statistics are negative but none is statistically significant. The values range from -0.349 for the widest window (-9, +9) to -2.819 for the narrowest window (-1, +1). As the window narrows, the magnitude is increasing but the movements are not statistically significant and therefore, based on the test results, these cannot be treated as statistically established cumulative abnormal responses.

When comparing the four sectors, Aluminium and Pulp and Paper show the clearest statistical evidence of negative cumulative abnormal performance, whereas Chlor-alkali and Textile do not have statistically significant results in any of the examined windows. It is also worth noting that the important results are not only in the narrowest event window. Significance is found for Aluminium in the (-5, +5), (-3, +3) and (-1, +1) windows and for Pulp and Paper in the (-7, +7) and (-5, +5) windows. The findings thus show that the market reaction to the CCTS announcement was not consistent but varied across sectors. The uniform negative direction of the CAAR test statistics implies a common downward tendency of cumulative abnormal performance, however statistical evidence of this response is available mostly for Aluminium and Pulp and Paper. However, the results for Chlor-alkali and Textile are still not statistically significant considering that they have negative coefficient. These sectoral differences suggest that the stock-market response to the carbon-pricing announcement has been heterogeneous depending on the firm characteristics and exposure in each sector.

Table 11. Paired t-test results for different sectors

Sectors	Pre mean (t_{-10})	Post mean (t_{+10})	t-value	p-value
Aluminium	-0.157	-0.040	0.385	0.709
Chlor-alkali	0.019	-0.260	-1.491	0.170
Pulp and Paper	-0.086	-0.381	-0.879	0.402
Textile	-0.543	0.600	0.015	-0.198

t-critical value (5%) is 2.262, *figures in italics are significant at 5%. (Source: Author's calculation)

Table 11 provides whether the AARs are significantly different between the pre-event and post-event periods for the four selected sectors. The mean abnormal returns at t-10 and t+10 are used for the comparison and the paired t-test is used to test whether the observed differences are statistically significant. The critical t-value at 5% significance level is 2.262. In all the four sectors, the absolute calculated t-values are less than this value and the reported p-values are greater than 0.05. Thus we do not have a statistically significant difference between the mean abnormal returns before and after the event in any of the sectors.

In the case of the Aluminium sector, the pre-event mean is -0.157, and the post-event mean is -0.040. Post-event mean is less negative than the pre-event one. However, the t-value is only 0.385 and the p-value is 0.709. Thus, the change observed is not statistically significant. For Chlor-alkali, the mean abnormal return moves in the opposite direction, from 0.019 before the event to -0.260 after the event The t-value is calculated to be -1.491. The p-value is 0.170. Descriptive figures show a decline in the mean abnormal return post the event, but the statistical test does not provide enough evidence to consider the fall significant. AAR of Pulp and Paper sector also declines from -0.086 in the pre-event period to -0.381 in the post-event period. However, the difference is not statistically significant, as indicated by the t-value of -0.879 and p-value of 0.402. Therefore, the negative movement in the AAR of the sector cannot be interpreted as a change associated with the event that is statistically established. A comparatively different movement is observed for Textile sector. This means that the abnormal return shifts from -0.543 before the event to 0.600 after the event, changing from a negative AR to a positive AR. Although this descriptive change is pretty large, the reported t-value is 0.015 and the p-value is -0.198 as shown in Table 11. Note that a p-value is typically not negative; the value should be confirmed with the original statistical output before submission of the manuscript. If the reported value is a typographical error, the corrected p-value should be used in the final interpretation. So, the t-value of 0.015 shown here is way below the critical value of 2.262 anyway.

Therefore, the paired t-tests reported do not show a statistically significant pre- and post-event difference for Aluminium, Chlor-alkali, Pulp and Paper or Textile in the sector-level comparison. But changes are in different directions across sectors: Aluminium shows a small improvement in its mean abnormal return, while Chlor-alkali and Pulp and Paper trend toward more negative values. Textile is the most descriptive variable with the highest mean shift from negative to positive. The directional differences are useful to understand the sectoral pattern, but should not be interpreted as statistically significant effects unless the test statistics are also significant. Therefore, the paired t-test shows that the announcement of CCTS did not cause a significant difference in the mean abnormal returns between the pre-event and post-event observations for the four sectors. This finding should be interpreted together with the CAAR and the other robustness-test results. The paired t-test examines the difference between the two periods chosen, but not the full pattern of abnormal returns in the event window.

5 CONCLUSIONS

The results show that the stock prices of the selected companies had a negative cumulative movement after the announcement of the CCTS. The individual AARs, however, did not show a consistently significant pattern. The CAAR results show stronger evidence of a negative market response especially after the announcement. The announcement day AAR was insignificant and negative, while the next trading day had a significant negative abnormal return. The CAAR was significantly negative thereafter and even turned negative at the end of the event window. It implies that the announcement effect was more significant when considering CAAR rather than on individual trading days. The sectoral results indicate that the CCTS announcement was not received by investors with the same intensity in all sectors. While Chlor-alkali and Textile also recorded negative cumulative movements, without comparable statistical evidence, Aluminium and Pulp and Paper showed statistically significant negative CAARs in selected short event windows. The results for the other statistical tests were mixed, consistent with the idea that the size of the market reaction was dependent on the event window and sector analysed. The study as a whole provides evidence that the market reacted negatively to the CCTS announcement, but also shows that investor responses varied across the four selected sectors.

6 LIMITATIONS OF THE STUDY

This study had some limitations that need to be taken into consideration when drawing conclusions about the results. Firstly, the research was confined to 18 publicly traded companies within four industries and as such, the results are likely to be representative of the limited number of publicly traded companies. Secondly, an examination of short term (i.e., a 21-trading day event window) will identify the instantaneous impact of CCTS announcements upon the stock price but is unlikely to reflect long run changes resulting from this policy. Thirdly, despite the inclusion of nonparametric analyses, there was some evidence of non-normal distributions among the abnormal returns at the company level that would have impacted upon interpretations of the parametric tests. Another potential constraint lies in the fact that the event study methodology used in this research cannot fully disentangle the impacts of the CCTS announcement from all company specific, industry specific or general market related influences that might have affected the pricing of shares during this time frame. Also, since this study focused on the first public announcement regarding the CCTS it did not consider whether investors may have modified their perception of the CCTS over time given subsequent developments to the scheme. Lastly the analysis relies primarily on secondary data relating to market performance and does not include primary data relating to each firm's individual carbon emissions, expected compliance levels, planned investments or overall strategic response to CCTS. Future research studies could expand on these limitations through use of larger sample sizes, extended observation windows and firm level environmental and financial variables so as to better understand the full range of financial impacts that can result from implementation of a country wide carbon pricing system.

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