Equity Market Response to Carbon Neutrality:
Evidence from China

Abstract

Climate change and carbon dioxide emissions reduction are attracting an increasing attention among policymakers globally. Many developed and emerging economies have committed to reducing carbon dioxide emissions and have implemented climate change policies in recent years. The relationship between environmental regulations and market performance has been widely discussed in existing literature. However, limited research is undertaken to examine the market response to environmental protection initiatives. In September 2020, China announced its carbon neutrality initiative that the country, which is the second largest economy in the world, will peak its carbon dioxide emissions before 2030 and achieve carbon neutrality by 2060. Our study investigates the impact of this event on China's stock market by using both the constituent stocks of the CSI 300 Index and those of the later established SEEE Carbon Neutral Index. Results indicate that stocks with a carbon-neutral concept respond positively to the Government's climate change commitment.

1.   Introduction

As the second-largest economy in the world, China has achieved significant economic and social development in the past three decades. With the proliferation of environmental protection globally, China made a commitment in September 2020 that the country aims to have its carbon dioxide emissions peak before 2030 and achieve carbon neutrality[1] by 2060. Past literature presents significant debate on the impact of firms' environmental behaviour on stock returns, and the impact of the Government's environmental regulations on capital markets. However, limited studies investigate the relationship between carbon neutrality initiatives and market quality, with mixed findings among the existing literature. This research aims to provide empirical evidence of the stock market response to the Government's climate change commitments.

The relationship between firms' environmental contribution and their financial performance is widely discussed in previous studies. Some researchers believe that environmental protection increases firms' costs, and their efforts lead to a reduction in productivity and harm overall profit (Filbeck and Gorman, 2004; Hassel, Nilsson, and Nyquist, 2005; Rassier and Earnhart 2010; Meric, Watson, and Meric, 2012; Ramiah, Martin, & Moosa, 2013; Waltho, Elhedhli and Gzara, 2019). Other studies discover that environmental protection can bring financial benefit to the firm (Russo and Fouts, 1997; Dowell, Hart, and Yeung, 2000; Clarkson, Li, Richardson, and Vasvari, 2011; Liu, Wu, Hafeez, Albaity and Ullah, 2022), and environmental unfriendly behaviour can harm stock market performance (Gupta and Goldar, 2005; Konar and Cohen, 2001).

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[1] Carbon neutrality represents that carbon dioxide emissions in a given period are equal to the amount of carbon dioxide eliminated.

Among the existing literature, there are also studies that examine stock market reactions to environmental policies and regulations. Khanna and Damon (1999) examine the US chemical industry and find environmental regulations are significantly associated with negative returns on company's investments in the short run. Guo, Kuai, and Liu (2020) examine the influence of environmental policies on stock market performance. They argue that environmental regulations can lead to the short-term decrease of heavily polluting firms' stock return. Similar results are also presented by Zeng, Dong, Zhou, and Jin (2021) and Wang, Xu, and Liang (2021). Ramiah, Martin, and Moosa (2013) analyse the Australian stock market's reaction to the government's carbon pollution reduction scheme. They divide the market into various industries and highlight that environmental policies affect 60% of the sectors, with most of the industries exhibiting negative abnormal returns; the remainder display positive abnormal returns.

However, limited studies investigate the market's response to carbon neutrality initiatives, with mixed findings from the few studies that do exist. Dong, Liu, Zhao, Tan, and Managi (2022) report that the stock market responds negatively to China's carbon neutrality commitment as a vision plan, while the market reacts positively when the specific guiding documents are released. Gilley, Worrell, Davidson, and El-Jelly (2000) do not observe a significant correlation between environmental initiatives and stock market performance. Chen, Wang, Wen, Du, Tan, Shi, and Ma (2021) also argue that there is no influence of green policy on the response of investors in both short-term and long-term returns.

This study investigates the impact of the Government's strategic climate change initiatives on stocks performance and liquidity in the equity market, using daily trading data of the constituent stocks of China Securities Index 300 Index ("CSI 300

Index") and the constituent stocks of the later established CSI SEEE Carbon Neutral Index ("SEEE Index"). The CSI SEEE carbon neutral index consists of 100 securities of listed companies having large market value in deep low-carbon areas and high carbon emission reduction potential in areas with high carbon emission (China Securities Index, 2021). In late 2020, China announced its carbon emission reduction initiative at the United Nations General Assembly. Our research discovers that the climate change commitment imposes a diverse range of impacts towards different segments of the stock market. Specifically, stocks with a concept of carbon neutrality respond positively to this commitment, exhibiting larger positive abnormal returns during the sample period compared to those stocks without a carbon emission reduction concept in China's stock market (non-SEEE stocks). This result persists up to 3-months after the announcement.

Further, this research examines the impact of being part of a major stock index (CSI 300) in China, as well as potential variation of being a government-owned enterprise on price performance. No strong correlation is discovered between these two factors and the announcement of China's carbon neutral initiatives. These results provide empirical evidence of stock market reactions to climate change commitments, and it offers potential policy implications to address various climate change issues to policymakers.

The remainder of this paper is structured as follows. Section 2 presents the institutional details and the announcement of carbon neutrality commitments in China. Section 3 highlights the data used in this study and Sections 4 details the research methodology employed. Section 5 presents and interprets the empirical results, including discussion of several additional tests. Overall conclusions and future areas for research are presented in Section 6.

2. Institutional Details, Recent Regulatory Changes and Hypotheses

2.1 Institutional Details

On 21 October 2021, China Securities Index (CSI) launched its new CSI Shanghai Energy and Environment Exchange (SEEE) Carbon Neutral Index. The CSI SEEE carbon neutral index consists of 100 securities of listed companies having large market value in deep low-carbon areas (such as clean energy and energy storage) and high carbon emission reduction potential in areas with high carbon emission (such as thermal power and steel) in the A-share market (China Securities Index, 2021).[2] The primary purpose of the index is to measure the performance of securities which make a significant contribution to carbon neutrality in the markets of Shenzhen and Shanghai. In addition, the CSI 300 is a market capitalisation weighted index that consists of 300 A-share stocks listed on the Shanghai Securities Exchange (SSE) and Shenzhen Securities Exchange (SZSE). The constituent stocks account for approximately 70% of the total capitalisation of both exchanges.

2.2 Carbon Neutrality Commitments

On 22 September 2020, President Xi Jinping of the People's Republic of China made the pledge in the meeting of the 75th United Nations General Assembly that China will become carbon neutral before 2060, and the country will begin reducing its carbon dioxide emissions over the next decade. This commitment surprised both

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[2] Previous research, including Dong et al. (2022), classify carbon neutral companies into 3 industry groupings: power; environment and manufacturing. These classifications include both companies that are shifting to low carbon methods and reducing carbon emissions, as well as those companies that are not making improvements in this area. We focus on the SEEE Index as this focuses on companies that are positively progressing in this area, allowing us to disentangle the effects that previous research has not been able to.

market practitioners and researchers who were not expecting such a bold target. It is China's first long-term climate goal. Since then, the carbon neutrality commitment has been emphasized as a priority mission in wide range of guidelines and action plans to promote low-carbon technologies, renewable energy, and green finance (Dong, Liu, Zhao, Tan, and Managi, 2022). This event provides unique opportunities to examine the stock market reaction to these strategic climate change initiatives.

2.3   *Hypotheses development*

Prior studies report mixed findings on the impact of carbon neutrality commitments on stock market returns (Dong et al., 2022; Li et al., 2023; Xie et al., 2022). The current paper further investigates the impact of China's carbon neutrality commitments on the stock returns of different market segments. Li et al. (2023) argue in their study that carbon neutrality initiatives generate a significant average abnormal return (AAR) on the announcement date and that they improve firms' value in the long term. Therefore, stocks of firms with a carbon neutral concept are expected to react more significantly (positively) towards the announcement.

Hypothesis 1: Stocks from firms with a carbon neutral concept respond more positively in the market to China's Carbon Neutrality Initiative announcement than stocks from their non-carbon neutral counterparts.

In addition to stock returns, this study investigates the impact of carbon neutrality commitments on stocks' price volatility and trading volume in China, examining abnormal volatility and abnormal volume. Previous studies demonstrate that stock price volatility and trading volume tend to experience a large degree of movement in

response to new information or a policy change (H. Chen et al., 2004; Elliott & Warr, 2003; Harris & Gurel, 1986). Stocks that are more closely related to the new information are expected to react more significantly than the rest in the stock market.

Hypothesis 2: The price volatility of stocks with a carbon neutral concept is greater after China's Carbon Neutrality Initiative announcement.

Hypothesis 3: Stocks with a carbon neutral concept are traded more frequently after China's Carbon Neutrality Initiative announcement.

Further, this study tests market liquidity after China's Carbon Neutrality Initiative announcement, by measuring the illiquidity ratio. Amihud (2002) argues that stocks with excess returns increase the expected illiquidity of the stock market. Combined with Hypothesis 1 above, stocks with positive abnormal returns are expected to have lower liquidity after the announcement of China's Carbon Neutrality Initiative.

Hypothesis 4: Stocks with a carbon neutral concept are less liquid after China's Carbon Neutrality Initiative announcement.

3.   Data and Descriptive Statistics

3.1   Data

This research utilises the daily trading data of the constituent stocks of both the CSI 300 Index and the later established SEEE Index from the China Stock Market &

Accounting Research Database (CSMAR).[3] The data contain (i) the open, close, highest, and lowest prices of each stock for each trading day; (ii) the market capitalisation and trading volume of each stock for each trading day; and (iii) the open, close, highest, and lowest prices of the CSI 300 Index each trading day. The sample period in this study ranges from 100 trading days before to 3 months after the announcement of China's Carbon Neutrality Commitments in September 2020. Specifically, the sample period adopted in this study starts from 28 April 2020 and ends on 23 December 2020.

3.2   Descriptive Statistics

Chart 1 illustrates the average daily price of SEEE Index constituent stocks and CSI 300 Index constituent stocks that are not within SEEE Index from 28 April 2020 to 23 December 2020. During this period, the average price of SEEE Index stocks has increased significantly from approximately $20 in the month of May 2020 to around $34 in the month of December 2020. A large part of these prices increases occur after the announcement in October 2020. However, their counterparts in CSI 300 Index have increased less, from approximately $51 in the month of May 2020 to about $67 in the month of December 2020.

<center>**<INSERT CHART 1>**</center>

Chart 2 demonstrates the average daily trading volume (million) of SEEE Index constituent stocks and CSI 300 Index constituent stocks that are not within SEEE Index from 28 April 2020 to 23 December 2020. The average trading volume of SEEE Index constituent stocks has increased drastically from 20 million shares per day in

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[3] It is important to note that the SEEE Index did not exist at the time of the announcement. We use the subsequent creation of the index to identify stocks that are used in the analysis but do not examine the actual creation of the index and any associated impact.

the month of May 2020 to 37 million shares per day in the month of December 2020, with again a large part of the increase occurring after the announcement. The average trading volume of CSI 300 Index stocks has increased moderately from 34 million shares per day in the month of May 2020 to 45 million shares per day in the month of December 2020.

<center>**<INSERT CHART 2>**</center>

4.   Research Design

4.1   Abnormal Return Calculation

This research utilises an event study methodology to investigate how China's stock market responds to the Government's climate change initiative. Within this framework, the average abnormal return (AAR) is used to capture stock market reactions to the event via the market model method. The market model follows Hegde and McDermott (2003). This model assumes that there is a linear relationship between stock returns and market benchmark returns, as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}, \text{ with } \mathrm{E}\left[\epsilon_{it}\right] = 0 \text{ and } \mathrm{VAR}\left[\epsilon_{it}\right] = \sigma_{\mathrm{it}}{}^2, \tag{1}$$

where R_{it} is the price return of stock i on day t, and R_{mt} is return of the market benchmark on day t; α_i and β_i are the ordinary linear squares (OLS) parameters estimated for stock i using historical data, R_{it} and R_{mt}, in the estimation period. In this study, we take 100 trading days to 10 trading days before the event as the estimation period (i.e. from 28 April 2020 to 7 September 2020), with reference to Hegde and McDermott (2003).

The estimated stock return $\mathrm{E}[R_{it}]$ of stock i on day t of the event period is then calculated by this established model using R_{mt}, the market benchmark's return on day

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t of the event period. Finally, the abnormal return of stock i on day t, AR_{it}, is calculated as following:

$$AR_{it} = R_{it} - E[R_{it}] = R_{it} - [\alpha_i + \beta_i R_{mt}] \tag{2}$$

with the abnormal return, AR_{it}, calculated using the market model. The average abnormal return AAR_i of stock i across the sample period $[t_1, t_2]$ is calculated as:

$$AAR_i = \sum_{t=t_1}^{t_2} AR_{it} / t \tag{3}$$

where t_1 and t_2 denote the beginning and the end of the event window, respectively.

The average abnormal return, AAR, demonstrates the daily average influence of an event over a period of time t_1 and t_2; here t_1 and t_2 note the start and the end of the sample period, respectively. Thus $t = t_2 - t_1$ is the event window. Specifically, in this study, we define the event window as [0,20], including 20 trading days (approximately 1 trading month) after the announcement of the Carbon Neutrality Initiative (i.e. from 23 September 2020 to 28 October 2020).

4.2   Abnormal Volatility Calculation

Abnormal volatility is also examined in this study and is calculated as follows:

$$\text{Volatility Ratio} = \frac{Volatility_{it}}{Volatility_{mt}} \Bigg/ \frac{Volatility_i}{Volatility_m} = \frac{Volatility_{it}}{Volatility_{mt}} \cdot \frac{Volatility_m}{Volatility_i} \tag{4}$$

where $Volatility_{it}$ is defined as the natural logarithm of the highest price divided by lowest price of stock i on day t; $Volatility_{mt}$ is the natural logarithm of the highest price divided by lowest price of the CSI 300 Index on day t; $Volatility_i$ is the 90-day average volatility of stock i between 100 trading days and 10 trading days prior to the event, and $Volatility_m$ is the 90-day average of the CSI 300 Index's volatility during this corresponding pre-event period (i.e. from 28 April 2020 to 7 September 2020). Therefore, if the calculated average Volatility Ratio over the sample period is larger

than 1, the price of stock i is more volatile than the pre-event level; a ratio of less than 1 indicates a lower volatility than pre-event period levels.

4.3 Abnormal Volume Calculation

The volume effects are calculated with reference to Harris and Gurel (1986), Elliott and Warr (2003), and Chen, Noronha and Singal (2004), and the volume ratio measure is defined as following:

$$Volume\ Ratio = \frac{\frac{V_{it}}{V_{mt}}}{\frac{V_i}{V_m}} = \frac{V_{it}}{V_{mt}} \cdot \frac{V_m}{V_i} \tag{5}$$

where V_{it} is the trading volume of stock i on day t, and V_{mt} is the total trading volume of CSI 300 Index constituent stocks on day t; V_i is the 90-day average trading volume of stock i between 100 trading days and 10 trading days before the event, and V_m is the 90-day average of CSI 300 Index constituent stocks' total trading volume during the same pre-event period (i.e. from 28 April 2020 to 7 September 2020). Therefore, if the calculated average $Volume\ Ratio$ is larger than 1, the trading volume of stock i over the study period is larger than pre-event levels; a less than 1 average $Volume\ Ratio$ indicates a smaller trading volume than pre-event period levels.

4.4 Stock Illiquidity Calculation

Market illiquidity is calculated with the most used Amihud illiquidity measure (Amihud, 2002), and the stock illiquidity ratio for each stock i on day t is defined as:

$$ILLIQ_{i,t} = \frac{R_{i,t}}{Volume_{i,t}} \tag{6}$$

where R_{it} is the price return of stock i on day t and $Volume_{it}$ is defined as the natural logarithm of the dollar value of stock i traded on day t. The ratio of illiquidity for each stock i after the event relative to its illiquidity pre-event is defined as follows:

$$\text{Illiquidity Ratio} = \frac{\frac{ILLIQ_{it}}{ILLIQ_{mt}}}{\frac{ILLIQ_i}{ILLIQ_m}} = \frac{ILLIQ_{it}}{ILLIQ_{mt}} \cdot \frac{ILLIQ_m}{ILLIQ_i} \qquad (7)$$

where $ILLIQ_{it}$ is the stock illiquidity of stock i on day t, and $ILLIQ_{mt}$ is the stock illiquidity of CSI 300 Index constituent stocks on day t; $ILLIQ_i$ is the 90-day average stock illiquidity of stock i between 100 days and 10 days before the event, and $ILLIQ_m$ is the 90-day average of CSI 300 Index constituent stocks' total trading volumes during the same pre-event period (i.e. from 28 April 2020 to 7 September 2020). If the calculated average Illiquidity Ratio over the sample period is larger than 1, stock i is more liquid than the pre-event levels; a ratio of less than 1 indicates a lower liquidity than pre-event period levels.

4.5   Multivariate Analysis

To isolate the impact of the event on the stock return, the following regression is estimated –

$$AAR_i = \alpha + \beta_1 * SEEE_i + \beta_2 * \text{Volatility}_i + \beta_3 * \text{Volume}_i +$$

$$\beta_4 * \text{Share Price}_i + \beta_5 * \text{Market Cap}_i + \varepsilon \qquad (8)$$

where the unit of observation is a trading day. AAR_i represents the average abnormal return over the event window. For listed stocks, if the stock is within the scope of the SEEE Index, $SEEE_i$ equals 1, otherwise, $SEEE_i$ equals 0. Volatility_i is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. Volume_i is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. Share Price_i is the natural logarithm of the average closing price of stock i. Market Cap_i is the natural logarithm of the average market capitalisation of stock i divided by 100. Table 1 presents correlation coefficients between each pair of variables. The correlation matrix table

indicates that several of the independent variables are correlated, although the levels of correlation are relatively low for most variables.

<INSERT TABLE 1>

## 5.	**Empirical Results**

*5.1	Core analysis*

Table 2 compares the average abnormal returns for SEEE Index constituent stocks and the CSI 300 Index constituent stocks that are not within the SEEE Index. In the sample period (20-trading days after the Event), the abnormal return of SEEE constituent stocks averages 0.02% (not statistically significant different from zero), compared to a negative 0.12% for non-SEEE stocks (statistically significantly different from zero at the 1% level). This demonstrates that the returns of stocks with carbon neutral concept do not change significantly after the announcement of the Carbon Neutrality Initiative in late 2020. However, stocks without carbon neutral concept recorded a lower return, compared to the pre-event benchmark period, indicating that the SEEE stocks outperformed during the 20-days after the announcement.

The abnormal volatility of SEEE stocks is greater than 1.0 during the sample period (not statistically significant). In contrast, the abnormal volatility of non-SEEE stocks is less than 1.0 (and statistically significant at the 1% level), illustrating that the price of non-SEEE stocks is less volatile than during the pre-event period in 2020. For abnormal volume, there are no clear patterns for both stock groups during the sample period, as the mean of abnormal volume of neither group is statistically significant, suggesting no change in trading activity after the event.

In addition, both groups of stocks demonstrate a lower illiquidity ratio compared to that in the pre-event benchmark period, which is statistically significant at the 1%

level. This indicates that stocks from both groups are more liquid after the announcement of the Carbon Neutrality Initiative in September 2020.

<INSERT TABLE 2>

Table 3 reports the regression results of abnormal return, abnormal volatility, abnormal volume and illiquidity ratio over the following four independent variables: stock volatility, trading volume, share price and market capitalisation. For abnormal return, the coefficient of SEEE is positive and statistically significant at the 1% level. This demonstrates that the SEEE Index constituent stocks outperform their non-SEEE Index counterparts within the CSI 300 Index, following the announcement of China's Carbon Neutrality Initiative on 22 September 2020. This suggests that stocks with a carbon neutral concept respond more positively to the carbon neutrality announcement than their non-carbon neutral counterparts in the market.

Volatility is positively correlated with daily abnormal return, which is statistically significant at the 1% level. Trading volume and share price of individual stocks are not significantly related to the stock abnormal return. Market capitalisation demonstrates a positive correlation with abnormal returns. This indicates that larger stocks tend to outperform their smaller capitalisation counterparts after the announcement of the Carbon Neutrality Initiative in September 2020.

<INSERT TABLE 3>

A similar impact is observed for abnormal volatility. The coefficient of SEEE is positive and statistically significant at the 5% level. During the sample period, SEEE Index constituent stocks exhibit larger price volatility than non-SEEE counterparts. This supports the Hypothesis 2 that the price volatility of stocks with a carbon neutral concept is larger after the announcement. Both stock volatility and trading volume are positively correlated to abnormal volatility.

However, no strong correlation is found between the abnormal trading volume and those two stock groups. This indicates that the trading volume of SEEE Index constituent stocks and non-SEEE stocks do not differ significantly during the sample period. From a liquidity perspective, the coefficient of SEEE is positive and statistically significant at the 5% level. During the sample period, SEEE Index constituent stocks demonstrate a lower liquidity than their non-SEEE counterparts after the announcement of the Carbon Neutrality Initiative in late 2020.

5.2   Additional Test – Sample Period

To examine the persistence of the core results, this study adopts both a shorter (i.e. 10-trading days) and a longer sample period (i.e. 3 trading months) after the Event date. Table 4 compares the average abnormal returns for SEEE Index stocks and the CSI 300 Index constituent stocks that are not within the SEEE Index for a sample period of 10-days after the Event (i.e. from 23 September 2020 to 14 October 2020). The abnormal return of SEEE constituent stocks is 0.18% (statistically significant at the 10% level), compared to a negative 0.07% for non-SEEE stocks (statistically significant at the 5% level). This is broadly consistent with the 20-day sample results above in that the return performance of the SEEE stocks is greater than non-SEEE stocks. This demonstrates that stocks with a carbon neutral concept outperform their counterparts within 10-days after the Event.

The abnormal volatility of SEEE stocks is greater than 1.0 (not statistically significant). The abnormal volatility of non-SEEE stocks is less than 1.0 and statistically significant at the 1% level. This is consistent with the 20-day sample results. The abnormal volume for both the SEEE stocks and their non-SEEE counterparts are not statistically significant. Therefore, it is unlikely that the announcement in

September 2020 is fundamentally affecting stocks' trading activity. In addition, non-SEEE stocks demonstrate a lower illiquidity ratio in the 10-day sample period compared to that in the pre-event benchmark period, which is statistically significant at the 1% level. This indicates that those stocks are more liquid after the announcement of the Carbon Neutrality Initiative in September 2020.

<INSERT TABLE 4>

Table 5 reports the regression results of abnormal return, abnormal volatility, abnormal volume and illiquidity ratio during the 10-days after the Event. For abnormal return, the coefficient of SEEE is positive and statistically significant at the 1% level. This demonstrates that the SEEE Index constituent stocks outperform their non-SEEE Index counterparts within the CSI 300 Index, following the announcement of China's Carbon Neutrality Initiative on 22 September 2020. This result is consistent with the 20-day analysis presented previously. Stock trading volume and share price of individual stocks do not appear to be related to the stocks' abnormal return. Market capitalisation demonstrates a positive correlation with abnormal returns. This shows that larger stocks tend to outperform their small capitalisation counterparts after the announcement of the Carbon Neutrality Initiative in September 2020.

A similar impact is observed for abnormal volatility. The coefficient of SEEE is positive and statistically significant at the 5% level. During the sample period, SEEE Index constituent stocks demonstrate larger price volatility than non-SEEE counterparts. Market capitalisation is positively correlated to abnormal volatility, while trading volume and share price are negatively correlated to abnormal volatility. No strong correlation is found between abnormal trading volume and the SEEE variable. This indicates that the trading volume of SEEE Index constituent stocks and non-SEEE stocks do not differ significantly during the sample period. This result is

consistent with the 20-day sample period above. From a liquidity perspective, the coefficient of SEEE is positive and statistically significant at the 1% level. During the sample period, SEEE Index constituent stocks demonstrate a lower liquidity than their non-SEEE counterparts after the announcement of the Carbon Neutrality Initiative in 2020.

<INSERT TABLE 5>

Table 6 compares the abnormal returns for SEEE Index stocks and the CSI 300 Index constituent stocks that are not within the SEEE Index for a longer sample period of 3-months after the Event (i.e. from 23 September 2020 to 23 December 2020). The daily average abnormal return of SEEE constituent stocks is 0.09% (statistically significant at the 10% level), compared to a negative 0.10% for non-SEEE stocks (statistically significant at the 1% level). This demonstrates that stocks with a carbon neutral concept continue to outperform their non-SEEE counterparts up to 3-months after the Event. Both groups of stocks demonstrate lower illiquidity ratio in the sample period compared to that in the pre-event benchmark period, which is statistically significant at the 5% level for SEEE stocks and the 1% level for non-SEEE stocks. This indicates that stocks from both stock groups are more liquid after the announcement of the Carbon Neutrality Initiative in September 2020. Results for volatility, trading activity and liquidity are similar to both the 10-day and 20-day results.

<INSERT TABLE 6>

Table 7 reports the regression results of abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for the 3-month sample period. For abnormal return, the coefficient of SEEE is positive and statistically significant at the 1% level. This demonstrates that, consistent with the 10-day and 20-day results reported previously, the SEEE Index constituent stocks outperform their non-SEEE Index

counterparts within the CSI 300 Index, following the announcement of China's Carbon Neutrality Initiative on 22 September 2020. Regression results for volatility, trading activity and liquidity are consistent with the 10-day and 20-day results presented previously.

<INSERT TABLE 7>

5.3   Additional Test - Index Constituency Results

This study examines the impact of being part of an index on results. Within the 97 constituent stocks of SEEE Index examined in the paper, 39 of these stocks are also constituents of the CSI 300 Index (referred to as "Joint"), with the remaining 58 stocks outside of the CSI 300 Index. The effects of index inclusion on share prices is widely discussed in prior literature. A company's inclusion in an index is generally associated with positive returns and increased trading volume (Cai, 2007; Chen, Noronha, and Signal, 2004; Mase, 2007; Wang, Murgulov, and Haman, 2015). We examine these two groups of stocks separately to determine if index constituency has any impact on the reaction to the Carbon Neutrality Initiative announced on 22 September 2020.

Table 8 compares the abnormal returns for the SEEE Index constituent stocks that are within (Joint Stocks) and outside the CSI 300 Index (Outside Stocks), respectively, during the 20 trading days after the announcement. The average abnormal return of Joint stocks is 0.18% (statistically significant at the 10% level), compared to a negative 0.09% for Outside stocks, which is not statistically different from zero. This suggests that SEEE Index constituent stocks which are part of the CSI 300 Index achieve a positive abnormal return during the 20-days after the Event, while stocks outside of the Index do not exhibit an abnormal return.

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The abnormal volatility of Joint stocks is greater than 1.0 during the sample period (and statistically significant at the 1% level). This indicates that the price of these stocks is more volatile than during the pre-event period. However, the abnormal volatility of Outside stocks is less than 1.0 during the sample period (and statistically significant at the 5% level). This shows that the price of Outside stocks is less volatile than the pre-event benchmark period. The abnormal volume for the Joint stocks is greater than 1.0 and their Outside counterparts are less than 1.0, both statistically significant at the 1% level. This suggests that Joint stocks are traded more frequently than the pre-event benchmark period, while non-Joint stocks are traded less frequently after the event in 2020, consistent with the literature that examines index constituency. The illiquidity ratio for the non-Joint stocks is less than 1.0, and statistically significant at 1% level. This indicates that Outside stocks are less liquid after the Event than during the pre-event benchmark period. The illiquidity ratio for the Joint stocks does not differ significantly from the pre-event benchmark period.

<INSERT TABLE 8>

Table 9 reports the regression results of abnormal return, abnormal volatility, abnormal volume and illiquidity ratio across 20-days after the Event (i.e. from 23 September 2020 to 28 October 2020). We introduce a new dummy variable, Joint, which is equal to one if the stock is jointly listed in the SEEE Index and the CSI300 Index, zero otherwise. This variable attempts to capture the impact of being in both indexes on the various independent variables of interest. For the abnormal return regression, the coefficient of Joint is not statistically significant. This demonstrates that, after controlling for changes in volatility, trading activity and liquidity, joint index constituency is not a key driver of the positive abnormal return of the SEEE Index constituent stocks identified in the previous analysis presented in the paper. Similar

results are observed for abnormal volatility, abnormal volume and illiquidity ratio. The coefficients of Joint are not statistically significant. The results indicate that joint index constituency is not a significant driver of differences in volatility, volume and liquidity of the SEEE Index constituent stocks.

<INSERT TABLE 9>

5.4   Additional Test - Government Owned Enterprises

Within the 97 constituent stocks of the SEEE Index, 43 companies are controlled by various levels of the Chinese government (e.g. central, provincial, and local governments), referred to as "GOE stocks" in this study. The remaining 54 companies are controlled by private sector entities. Prior literature examines the impact of government ownership on corporate finance (e.g., Wu, 2019) and also discusses the relationship between government ownership and firms' exposure to political uncertainty and policy changes and their resulting differences across a range of trading characteristics including prices, trading activity and volatility (e.g., Zhou, 2017; Cui, Wang, Liao, Fang and Cheng, 2021). We examine these two groups of stocks separately to determine if government ownership has any impact on the reaction to the Carbon Neutrality Initiative announced on 22 September 2020.

Table 10 compares the abnormal returns for the SEEE Index constituent stocks that are controlled by the Chinese government and private sector, respectively, during the 20 trading days after the announcement. The average abnormal return of GOE stocks is negative 0.216% (statistically significant at the 1% level), compared to 0.56% for non-GOE stocks (not statistically significant). This suggests that Government-owned Enterprises underperform against the pre-event benchmark period during the 20-days after the Event, while privately owned Enterprises do not exhibit any clear

return pattern. The abnormal volatility and abnormal volume of GOE stocks and non-GOE stocks are not statistically significant during the 20-day sample period. This indicates that the price volatility and trading activity for both stock groups do not differ significantly against their pre-event benchmark period. In addition, the illiquidity ratio of GOE stocks is less than 1.0 and statistically significant at the 1% level, which demonstrates that GOE stocks are more liquid after the Event. Privately owned stocks do not exhibit such clear patterns during the 20-day sample period.

\<INSERT TABLE 10\>

Table 11 reports the regression results of abnormal return, abnormal volatility, abnormal volume and illiquidity ratio. We introduce a new dummy variable, GOE, which is equal to one if the company is controlled by some level of the Chinese government, zero otherwise. This variable attempts to capture the impact of being government owned on the various independent variables of interest. For the abnormal return regression, the coefficient of GOE is not statistically significant. This demonstrates that, after controlling for changes in volatility, trading activity and liquidity, abnormal returns do not differ significantly across the two stock groups following the announcement of China's Carbon Neutrality Initiative on 22 September 2020. Therefore, there is no clear evidence that being a government owned entity significantly affects stock returns after the announcement. Trading volume, share price and market capitalisation of individual stocks are not significantly related to abnormal returns. Stocks' volatility demonstrates a positive correlation with abnormal returns, statistically significant at the 5% level. This indicates that stocks with a higher price volatility tend to outperform after the announcement of the Carbon Neutrality Initiative.

For abnormal volatility, the coefficient of GOE is positive and statistically significant at the 1% level. During the sample period, Government-owned Enterprise

stocks demonstrate larger price volatility than non-government counterparts. For abnormal volume, the coefficient of GOE is positive and statistically significant at the 1% level. Government-owned enterprise stocks demonstrate higher trading activity than non-government counterparts. Stock volatility is positively correlated to abnormal volume. From a liquidity perspective, the coefficient of GOE is positive and statistically significant at the 1% level. During the 20-day sample period, Government-owned enterprises demonstrate lower market liquidity than their non-government counterparts after controlling for stock volatility, trading volume and market capitalisation.

<INSERT TABLE 11>

5.5   *Additional Test - Pre-Event Price Analysis*

There is anecdotal evidence that there is the potential for information leakage within government ranks, and that companies controlled by the Chinese government were made aware of the announcement in advance of the meeting in September 2020. If this occurred, it is possible that the price of Chinese government owned enterprises exhibits abnormal behaviour prior to the announcement in September 2020. To examine the possibility of information leakage for GOE and its impact on abnormal returns before the Event, we adjust the pre-event benchmark period to 60 days from $[t - 100, t - 41]$ and then repeat the analysis above with a focus on the lead-up to the announcement. We specifically examine three time periods pre-announcement: $[t - 30, t - 21]$ – Period A; $[t - 20, t - 11]$ – Period B; and $[t - 10, t - 1]$ – Period C.

Table 12 compares the abnormal returns for the SEEE Index constituent stocks that are GOE and non-GOE during the three pre-event sample periods. For Period A, the average abnormal return of GOE stocks is 0.08%, compared to 0.29% for non-

GOE stocks. For Period B, the average abnormal return of GOE stocks is negative 0.02%, compared to a negative 0.04% for non-GOE stocks. For Period C, the abnormal return of GOE stocks is 0.06%, compared to a negative 0.07% for non-GOE stocks. None of the returns reported for the pre-announcement periods for both the government and non-government-controlled groups are statistically different from zero. These results indicate that the abnormal returns of GOE and non-GOE stocks do not exhibit any evidence of information leakage.

<INSERT TABLE 12>

Table 13 reports the regression results of abnormal return over the following four independent variables: stock volatility, trading volume, share price and market capitalisation during the three sample periods prior to the announcement. Across all three sample periods, coefficients of the GOE dummy variable are not statistically significant. There is no evidence that government owned enterprises experience information leakage prior to the announcement of China's Carbon Neutrality Initiative in September 2020.

<INSERT TABLE 13>

6.   Conclusions

With a proliferation of climate change awareness globally, an increasing number of major economies have committed to reduce their carbon dioxide emissions in recent years. Existing literature contains a wide discussion over the relationship between capital market performance and environmental policies and regulations. However, limited research is undertaken that examines the market response to climate change initiatives. In late 2020, China announced its carbon neutrality initiatives that its carbon emissions will peak in 2035 and achieve carbon neutrality by 2060. This

event provides us an opportunity to conduct an empirical analysis, and therefore contribute to the literature in this rapidly growing area.

We find that stocks with a carbon neutral concept in China, which are included in the SEEE Index, achieve larger positive abnormal returns after the announcement of the Carbon Neutrality Initiative in September 2020 than those CSI 300 Index constituent stocks that are not in the SEEE Index. This result persists for shorter (10 trading days) and longer (3 months) periods after the Event. In addition, stocks with a carbon neutral concept demonstrate higher price volatility and greater liquidity than their non-carbon neutral counterparts in China's stock market after the announcement of the commitment in late 2020.

We find no evidence that being part of the CSI 300 Index significantly affect stocks' abnormal return, abnormal volatility, abnormal volume or market liquidity. In addition, we do not observe strong evidence that being a Government-owned Enterprise significantly affect stocks' abnormal return. However, Government-owned Enterprise stocks tend to be more volatile, more actively traded, while less liquid than their non-Government-owned counterparts following the announcement of China's carbon neutral initiatives. Finally, there is no evidence of any information leakage prior to governments announcement in September 2020 with no abnormal returns evident in advance of the Event. Overall, these results provide empirical evidence of significant stock market reactions to climate change commitments.

This research offers potential policy implications to address various climate change issues to policymakers. Given the positive reaction of stocks with a carbon neutral concept to the climate change commitment, companies are incentivised to commit to reducing their carbon emissions or contributing to the broad climate change management. In addition, policy change is expected to exert an equal impact to stocks

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in the capital market, regardless of government ownership or being a part of a major index. Further tests can be performed to examine the specific climate change regulation implementation impact on stock performance and investigate the impact of similar climate change initiatives in other major economies globally.

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Table 1
Correlation Matrix

This table presents the correlation matrix of the independent variables for the regressions in this study. China's Carbon Neutrality Initiative was first announced on 22 September 2020. The sample period is 20 trading days after the event date, from 23 September 2020 to 28 October 2020. SEEE takes the value of zero if stocks are within CSI 300 Index while not within SEEE Index, and one if stocks are within SEEE Index. Volatility is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for each stock. Volume is the natural logarithm of the average trading volume of each stock during the sample period divided by 100. Share Price is the natural logarithm of the average closing price of each stock. Market Cap is the natural logarithm of the average market capitalization of each stock divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parentheses.

	SEEE	Volatility	Volume	Share Price	Market Cap
SEEE	1.000	0.1338**	-0.1320**	-0.1953***	-0.5185***
		(0.0123)	(0.0136)	(0.0002)	(<.0001)
Volatility	0.1338**	1.000	-0.2242***	0.5645***	-0.1281**
	(0.0123)		(<0.0001)	(<.0001)	(0.0167)
Volume	-0.1320**	-0.2242***	1.000	-0.5560***	0.3851***
	(0.0136)	(<0.0001)		(<.0001)	(<.0001)
Share Price	-0.1953***	0.5645***	-0.5560***	1.000	0.2562***
	(0.0002)	(<.0001)	(<.0001)		(<.0001)
Market Cap	-0.5185***	-0.1281**	0.3851***	0.2562***	1.000
	(<.0001)	(0.0167)	(<.0001)	(<.0001)	

Table 2
Descriptive Statistics

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 20 trading days after the event date, from 23 September 2020 to 28 October 2020. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method during the sample period. Abnormal volatility is stock's price volatility during the sample period relative to that prior to the event. Abnormal volume is the stock's trading volume during the sample period relative to that prior to the event. Illiquidity ratio is stock's price return over its volatility during the sample period relative to that prior to the event.
*/**/*** denotes statistical significance at 10%/5%/1% level.

	SEEE Index stocks	CSI 300 Index Stocks (excl. SEEE Stocks)
Panel A: Returns (%)		
N (stocks)	97	252
Mean	0.0200	-0.1152***
Standard Deviation	0.6697	0.6897
Minimum	-1.6349	-4.9367
Median	-0.0870	-0.0615
Maximum	3.272	1.471
Panel B: Volatility		
N (stocks)	97	252
Mean	1.007	0.9609***
Standard Deviation	0.2541	0.2133
Minimum	0.4336	0.5249
Median	0.9925	0.9342
Maximum	1.662	1.699
Panel C: Volume		
N (stocks)	97	252
Mean	0.9984	0.9997
Standard Deviation	0.0261	0.0206
Minimum	0.9254	0.9402
Median	1.002	0.9995
Maximum	1.079	1.061
Panel D: Illiquidity Ratio		
N (stocks)	97	252
Mean	0.8962***	0.8152***
Standard Deviation	0.2487	0.2220
Minimum	0.3328	0.2496
Median	0.8636	0.7887
Maximum	1.561	2.056

Table 3
Multivariate Analysis

This table reports the regression results for the abnormal return, abnormal volatility, abnormal volume, and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within the SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 20 trading days after the event date, from 23 September 2020 to 28 October 2020. $SEEE_i$ takes the value of zero if stocks are within CSI 300 Index while not within SEEE Index, and one if stocks are within SEEE Index. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share Price_i$ is the natural logarithm of the average closing price of stock i. $Market Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

	Constant	$SEEE_i$	$Volatility_i$	$Volume_i$	$Share Price_i$	$Market Cap_i$	R^2	N
Abnormal Return	-0.0228***	0.0023***	0.0915**	-0.0007	-0.0009	0.0018***	0.0290	349
	(0.0004)	(0.0035)	(0.0110)	(0.2360)	(0.1548)	(0.0017)		
Abnormal Volatility	-0.5183**	0.0458**	14.67***	-0.0374***	-0.0935***	0.1062***	0.4520	349
	(0.0149)	(0.0240)	(<0.0001)	(0.0051)	(<0.0001)	(<0.0001)		
Abnormal Volume	0.7879***	0.0026	1.0164***	0.0027*	-0.0040**	0.0081***	0.3503	349
	(<0.0001)	(0.2429)	(<0.0001)	(0.0806)	(0.0102)	(<0.0001)		
Illiquidity Ratio	-0.0148	0.0510**	12.60***	-0.0208	-0.0635***	0.0540***	0.3423	349
	(0.9486)	(0.0296)	(<0.0001)	(0.1324)	(<0.0001)	(0.0026)		

Table 4
Descriptive Statistics – 10 Trading Days

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 10 trading days after the event date, from 23 September 2020 to 14 October 2020. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method during the sample period. Abnormal volatility is stock's price volatility during the sample period relative to that prior to the event. Abnormal volume is the stock's trading volume during the sample period relative to that prior to the event. Illiquidity ratio is stock's price return over its volatility during the sample period relative to that prior to the event. */**/*** denotes statistical significance at 10%/5%/1% level.

	SEEE Index stocks	CSI 300 Index Stocks (excl. SEEE Stocks)
Panel A: Returns (%)		
N (stocks)	97	252
Mean	0.1801*	-0.0670**
Standard Deviation	1.0051	0.7461
Minimum	-1.8807	-3.4468
Median	-0.0757	-0.0983
Maximum	3.9416	1.9167
Panel B: Volatility		
N (stocks)	97	252
Mean	1.0400	0.9544***
Standard Deviation	0.2825	0.2131
Minimum	0.4591	0.4976
Median	1.0172	0.9269
Maximum	1.9174	1.7137
Panel C: Volume		
N (stocks)	97	252
Mean	0.9986	1.0000
Standard Deviation	0.0267	0.0211
Minimum	0.9259	0.9415
Median	0.9988	0.9997
Maximum	1.0870	1.0683
Panel D: Illiquidity Ratio		
N (stocks)	97	252
Mean	0.9849	0.8466***
Standard Deviation	0.2959	0.2366
Minimum	0.4147	0.3017
Median	0.9475	0.8084
Maximum	1.8980	1.8619

Table 5
Multivariate Analysis – 10 Trading Days

This table reports the regression results for the abnormal return, abnormal volatility, abnormal volume, and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within the SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 10 trading days after the event date, from 23 September 2020 to 14 October 2020. $SEEE_i$ takes the value of zero if stocks are within CSI 300 Index while not within SEEE Index, and one if stocks are within SEEE Index. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share Price_i$ is the natural logarithm of the average closing price of stock i. $Market Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

	Constant	$SEEE_i$	$Volatility_i$	$Volume_i$	$Share Price_i$	$Market Cap_i$	R^2	N
Abnormal Return	-0.0307***	0.0037***	0.1842***	-0.0006	0.0003	0.0018**	0.1456	349
	(0.0005)	(0.0010)	(0.0026)	(0.4509)	(0.6544)	(0.0177)		
Abnormal Volatility	-0.2430	0.0529**	16.27***	-0.0443***	-0.1045***	0.0976***	0.5262	349
	(0.2796)	(0.0250)	(<0.0001)	(0.0008)	(<0.0001)	(<0.0001)		
Abnormal Volume	0.7958***	0.0019	0.9537***	0.0043**	-0.0013	0.0060***	0.3477	349
	(<0.0001)	(0.4377)	(<0.0001)	(0.0203)	(0.4656)	(0.0009)		
Illiquidity Ratio	-0.1759	0.1004***	13.30***	-0.0111	-0.07554***	0.0576***	0.3458	349
	(0.5005)	(0.0012)	(<0.0001)	(0.5018)	(<0.0001)	(0.0015)		

Table 6
Descriptive Statistics – 3 Trading Months

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 3 months after the event date, from 23 September 2020 to 23 December 2020. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method during the sample period. Abnormal volatility is stock's price volatility during the sample period relative to that prior to the event. Abnormal volume is the stock's trading volume during the sample period relative to that prior to the event. Illiquidity ratio is stock's price return over its volatility during the sample period relative to that prior to the event. */**/*** denotes statistical significance at 10%/5%/1% level.

	SEEE Index stocks	CSI 300 Index Stocks (excl. SEEE Stocks)
Panel A: Returns (%)		
N (stocks)	97	252
Mean	0.0857*	-0.1047***
Standard Deviation	0.5193	0.5441
Minimum	-1.2600	-4.9600
Median	0.0100	-0.0600
Maximum	2.2200	1.0000
Panel B: Volatility		
N (stocks)	97	252
Mean	1.0425*	0.9785*
Standard Deviation	0.2413	0.2065
Minimum	0.3396	0.5462
Median	1.0363	0.9424
Maximum	1.7273	1.9110
Panel C: Volume		
N (stocks)	97	252
Mean	1.0013	0.9995
Standard Deviation	0.0256	0.0196
Minimum	0.9210	0.9430
Median	1.0025	0.9995
Maximum	1.0635	1.0623
Panel D: Illiquidity Ratio		
N (stocks)	97	252
Mean	0.9507**	0.8602***
Standard Deviation	0.2268	0.2039
Minimum	0.2948	0.2076
Median	0.9113	0.8500
Maximum	1.6153	1.8130

Table 7
Multivariate Analysis – 3 Trading Months

This table reports the regression results for the abnormal return, abnormal volatility, abnormal volume, and illiquidity ratio for SEEE Index constituent stocks (97 stocks) and CSI 300 Index constituent stocks which are not within the SEEE Index (252 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 3 months after the event date, from 23 September 2020 to 23 December 2020. $SEEE_i$ takes the value of zero if stocks are within CSI 300 Index while not within SEEE Index, and one if stocks are within SEEE Index. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share Price_i$ is the natural logarithm of the average closing price of stock i. $Market Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

	Constant	$SEEE_i$	$Volatility_i$	$Volume_i$	$Share Price_i$	$Market Cap_i$	R^2	N
Abnormal Return	-0.0175***	0.0024***	0.0732**	-0.0002	-0.0005	0.0010**	0.0398	349
	(0.0011)	(0.0001)	(0.0110)	(0.7516)	(0.4060)	(0.0356)		
Abnormal Volatility	-0.5999**	0.0620***	13.32***	-0.03899**	-0.1229***	0.1193***	0.3609	349
	(0.0111)	(0.0047)	(<0.0001)	(0.0107)	(<0.0001)	(<0.0001)		
Abnormal Volume	0.8220***	0.0030	1.035***	0.0005	-0.0075***	0.0086***	0.2968	349
	(<0.0001)	(0.2208)	(<0.0001)	(0.7358)	(<0.0001)	(<0.0001)		
Illiquidity Ratio	-0.2118	0.0683***	11.29***	-0.0226	-0.0936***	0.0752***	0.2804	349
	(0.3686)	(0.0025)	(<0.0001)	(0.1567)	(<0.001)	(<0.001)		

Table 8
Descriptive Statistics – Index Constituency

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent stocks that sit in (39 stocks) and out of (58 stocks) the CSI 300 Index. The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 20-days after the event date, from 23 September 2020 to 28 October 2020. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method during the sample period. Abnormal volatility is stock's price volatility during the sample period relative to that prior to the event. Abnormal volume is the stock's trading volume during the sample period relative to that prior to the event. Illiquidity ratio is stock's price return over its volatility during the sample period relative to that prior to the event. */**/*** denotes statistical significance at 10%/5%/1% level.

	Joint Stocks	CSI 300 Index Stocks (excl. SEEE Stocks)
Panel A: Returns (%)		
N (stocks)	39	58
Mean	0.1787*	-0.0867
Standard Deviation	0.5743	0.7119
Minimum	-0.7237	-1.6349
Median	0.0229	-0.1115
Maximum	1.4293	3.2721
Panel B: Volatility		
N (stocks)	39	58
Mean	1.1205***	0.9306**
Standard Deviation	0.2371	0.2377
Minimum	0.6293	0.4336
Median	1.0926	0.8799
Maximum	1.6615	1.5479
Panel C: Volume		
N (stocks)	39	58
Mean	1.0107***	0.9901***
Standard Deviation	0.0208	0.0262
Minimum	0.9725	0.9254
Median	1.0049	0.9897
Maximum	1.0547	1.0789
Panel D: Illiquidity Ratio		
N (stocks)	39	58
Mean	0.9994	0.8267***
Standard Deviation	0.2463	0.2269
Minimum	0.5937	0.3328
Median	0.8936	0.7726
Maximum	1.5611	1.5369

Table 9
Multivariate Analysis – Index Constituency

This table reports the regression results for the abnormal return, abnormal volatility, abnormal volume, and illiquidity ratio for SEEE Index constituent stocks which are included in (39 stocks) and excluded from (58 stocks) the CSI 300 Index. The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 20 days after the event date, from 23 September 2020 to 28 October 2020. $Joint_i$ takes the value of zero if stocks are within SEEE Index while not in the CSI 300 Index, and one if stocks are within both the SEEE Index and CSI 300 Index. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share\ Price_i$ is the natural logarithm of the average closing price of stock i. $Market\ Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

	Constant	$Joint_i$	$Volatility_i$	$Volume_i$	$Share\ Price_i$	$Market\ Cap_i$	R^2	N
Abnormal Return	-0.0098	-0.0015	0.1397**	0.0004	-0.0005	-0.0001	0.0785	97
	(0.5327)	(0.3745)	(0.0448)	(0.7818)	(0.7263)	(0.9605)		
Abnormal Volatility	-0.3297	0.0245	13.56***	-0.0324	-0.0836***	0.0933***	0.5351	97
	(0.5139)	(0.6313)	(<0.0001)	(0.1260)	(0.0023)	(0.0074)		
Abnormal Volume	0.7697***	-0.0021	1.050***	0.0025	-0.0050*	0.0097**	0.4635	97
	(<0.0001)	(0.7087)	(<0.0001)	(0.4450)	(0.0844)	(0.0158)		
Illiquidity Ratio	0.0442	0.0694	12.99***	-0.0130	-0.0912***	0.0483	0.4682	97
	(0.9358)	(0.2305)	(<0.0001)	(0.5506)	(0.0002)	(0.1948)		

Table 10
Descriptive Statistics – Government-Owned Enterprises

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent which are government-owned (43 stocks) and private-owned (54 stocks). China's Carbon Neutrality Initiative was first announced on 22 September 2020. The sample period is 20 trading days after the event date, from 23 September 2020 to 28 October 2020. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method during the sample period. Abnormal volatility is stock's price volatility during the sample period relative to that prior to the event. Abnormal volume is the stock's trading volume during the sample period relative to that prior to the event. Illiquidity ratio is stock's price return over its volatility during the sample period relative to that prior to the event. */**/*** denotes statistical significance at 10%/5%/1% level.

	Government-Owned Enterprises	Private Enterprises
Panel A: Returns (%)		
N (stocks)	43	54
Mean	-0.1574***	0.1613
Standard Deviation	0.3777	0.8084
Minimum	-1.6349	-1.6111
Median	-0.1236	0.0619
Maximum	0.5097	3.2721
Panel B: Volatility		
N (stocks)	43	54
Mean	0.9485	1.0535
Standard Deviation	0.2150	0.2744
Minimum	0.6004	0.4336
Median	0.9287	1.0175
Maximum	1.4391	1.6615
Panel C: Volume		
N (stocks)	43	54
Mean	0.9943	1.0016
Standard Deviation	0.0224	0.0285
Minimum	0.9311	0.9254
Median	0.9975	1.0033
Maximum	1.0440	1.0789
Panel D: Illiquidity Ratio		
N (stocks)	43	54
Mean	0.8422***	0.9392
Standard Deviation	0.1937	0.2793
Minimum	0.5689	0.3328
Median	0.8010	0.8673
Maximum	1.4201	1.5611

Table 11
Multivariate Analysis – Government-Owned Enterprises

This table reports the regression results for the abnormal return, abnormal volatility, abnormal volume, and illiquidity ratio for SEEE Index constituent stocks which are government-owned (43 stocks) and private-owned (54 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. The sample period is 20 trading days after the event date, from 23 September 2020 to 28 October 2020. GOE_i takes the value of one if companies are controlled by Chinese governments, and zero otherwise. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share Price_i$ is the natural logarithm of the average closing price of stock i. $Market Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

	Constant	GOE_i	$Volatility_i$	$Volume_i$	$Share Price_i$	$Market Cap_i$	R^2	N
Abnormal Return	-0.0176	-0.0012	0.1357**	0.0003	-0.0007	0.0006	0.0787	97
	(0.1375)	(0.3359)	(0.0447)	(0.8296)	(0.5989)	(0.6395)		
Abnormal Volatility	-0.6472	0.1379***	14.95***	-0.0206	-0.0583**	0.0908***	0.5829	97
	(0.1552)	(0.0012)	(<0.0001)	(0.3680)	(0.0218)	(0.0049)		
Abnormal Volume	0.7638***	0.0156***	1.184***	0.0037	-0.0020	0.0076**	0.5221	97
	(<0.0001)	(0.0011)	(<0.0001)	(0.2762)	(0.4894)	(0.0128)		
Illiquidity Ratio	-0.5207	0.1145***	14.38***	-0.0027	-0.0716***	0.0640**	0.4953	97
	(0.2529)	(0.0021)	(<0.0001)	(0.9130)	(0.0071)	(0.0560)		

Table 12
Descriptive Statistics – Pre-Event

This table reports descriptive statistics for the abnormal return, abnormal volatility, abnormal volume and illiquidity ratio for SEEE Index constituent which are government-owned (43 stocks) and private-owned (54 stocks). China's Carbon Neutrality Initiative was first announced on 22 September 2020. Three samples are tested, which are Period A [t – 10, t – 1], Period B [t – 20, t – 11], and Period C [t – 30, t – 21]. The abnormal return measures the difference between stock's price return and its estimated return as per the market model method. */**/*** denotes statistical significance at 10%/5%/1% level.

	GOE	Non-GOE
Period A - Return (%)		
N (stocks)	43	54
Mean	0.0780	0.2863
Standard Deviation	0.3820	0.8410
Minimum	-0.9896	-1.2835
Median	0.0819	0.2594
Maximum	0.8715	3.1306
Period B - Return (%)		
N (stocks)	43	54
Mean	-0.0191	-0.0410
Standard Deviation	0.3511	0.7110
Minimum	-0.8956	-1.5519
Median	0.0044	-0.1340
Maximum	0.7995	2.5744
Period C - Return (%)		
N (stocks)	43	54
Mean	0.0566	-0.0699
Standard Deviation	0.3616	0.5703
Minimum	-0.9556	-0.9103
Median	0.0959	-0.1112
Maximum	0.7061	2.4387

Table 13
Multivariate Analysis – Pre-Event

This table reports the regression results for abnormal return for SEEE Index constituent stocks which are government-owned (43 stocks) and private-owned (54 stocks). The Carbon Neutrality Initiative was announced on 22 September 2020. Three samples are tested, which are Period A [t − 10, t − 1], Period B [t − 20, t − 11], and Period C [t − 30, t − 21]. GOE_i takes the value of one if companies are controlled by Chinese governments, and zero otherwise. $Volatility_i$ is defined as the average of the natural logarithm of the daily highest stock price divided by the daily lowest stock price for stock i. $Volume_i$ is the natural logarithm of the average trading volume of stock i during the sample period divided by 100. $Share Price_i$ is the natural logarithm of the average closing price of stock i. $Market Cap_i$ is the natural logarithm of the average market capitalization of stock i divided by 100. */**/*** denotes statistical significance at 10%/5%/1% level. The p-values are reported in parenthesis. R^2 is the adjusted R-squared. N is the number of observations.

Abnormal Return	Constant	GOE_i	$Volatility_i$	$Volume_i$	$Share Price_i$	$Market Cap_i$	R^2	N
Period A	-0.0355***	0.0001	0.1598**	0.0014*	-0.0007	0.0006	0.1460	97
[t - 10 ~ t - 1]	(0.0003)	(0.9140)	(0.0020)	(0.0913)	(0.5095)	(0.5131)		
Period B	-0.0209*	0.0002	-0.0025	0.0001	-0.0002	0.0011*	0.0159	97
[t - 20 ~ t - 11]	(0.0742)	(0.8670)	(0.9752)	(0.9119)	(0.8205)	(0.0687)		
Period C	-0.0024	-0.0004	-0.0761	-0.0006	-0.0009	0.0010	0.0305	97
[t - 30 ~ t - 21]	(0.7839)	(0.7513)	(0.3021)	(0.3204)	(0.3617)	(0.1096)		

Chart 1 – Average daily price of SEEE Index constituent stocks and CSI 300 Index constituent stocks (excluding SEEE Index stocks)

Legend: SEEE Index Consituent Stocks — CSI300 Index Consituent Stocks (excl. SEEE stocks)
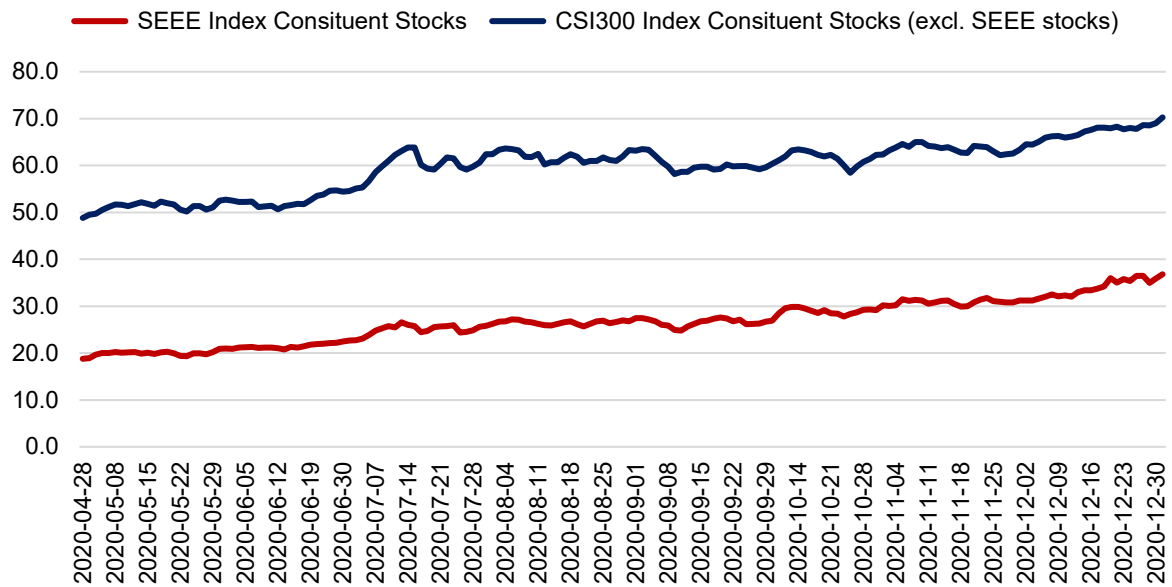
Chart 2 – Average daily trading volume (million) of SEEE Index constituent stocks and CSI 300 Index constituent stocks (excluding SEEE Index stocks)