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Research Article

Does the stock market provide enough incentives for companies to drive carbon reduction behaviour?

Borsa, şirketlerin karbon azaltma davranışını yönlendirmeleri için yeterli teşvik sağlar mı?

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Abstract

This study observes abnormal returns of stock prices after companies announced the establishment of wastewater and waste heat recovery systems in East Asia from 2000 to 2018. The capital expenditure on the wastewater and waste heat recovery system and the expected impact on revenue are also considered, and the stock market is analyzed to verify whether there is an additional evaluation after the company carries out such carbon emission reduction activity. The study finds that after more than a decade of technological advancement and promoting carbon reduction behaviours, the market has shown more positive reactions to carbon reduction measures, such as wastewater and waste heat recovery systems. However, the additional positive reaction in the markets of developing countries is lower than in developed countries. For developing countries desiring domestic manufacturers to adopt more carbon emission reduction activities, the government may need to offer more policy incentives, which will encourage investors in the market to support manufacturers in actively investing in carbon reduction measures. Certainly, manufacturers will be more motivated to implement or cooperate with voluntary carbon reduction measures. In addition, this study does not consider the possible impact of carbon rights trading and carbon fees on improving manufacturers' active treatment of wastewater and waste heat recovery, which will be a direction worthy of future research.

Keywords: Carbon Reduction, Market Reaction, Event Study

JEL Classification: Q01, Q20, Q40, Q53

Öz

Bu çalışma, şirketlerin 2000'den 2018'e kadar Doğu Asya'da atık su ve atık ısı geri kazanım sistemleri kurduklarını duyurmasının ardından hisse senedi fiyatlarının anormal getirilerini gözlemliyor. Atık su ve atık ısı geri kazanım sistemine yapılan sermaye harcaması ve gelir üzerinde beklenen etki de dikkate alınıyor ve Şirket bu tür bir karbon emisyonu azaltım faaliyeti gerçekleştirdikten sonra ek bir değerlendirme olup olmadığını doğrulamak için borsa analiz edilir. Çalışma, on yılı aşkın bir süredir teknolojik ilerleme ve karbon azaltma davranışlarını teşvik ettikten sonra, pazarın atık su ve atık ısı geri kazanım sistemleri gibi karbon azaltma önlemlerine daha olumlu tepkiler gösterdiğini ortaya koyuyor. Ancak, gelişmekte olan ülke piyasalarındaki ek olumlu tepki, gelişmiş ülkelere göre daha düşük. Yerli üreticilerin daha fazla karbon emisyonu azaltma faaliyeti benimsemesini isteyen gelişmekte olan ülkeler için, hükümetin daha fazla politika teşviki sunması gerekebilir; bu, piyasadaki yatırımcıları, üreticileri aktif olarak karbon azaltma önlemlerine yatırım yapma konusunda desteklemeye teşvik edecektir. Elbette, üreticiler gönüllü karbon azaltma önlemlerini uygulamak veya bunlarla işbirliği yapmak için daha fazla motive olacaklardır. Ek olarak, bu çalışma, karbon hakları ticaretinin ve karbon ücretlerinin, üreticilerin aktif atık su arıtımını ve atık ısı geri kazanımını iyileştirme üzerindeki olası etkisini dikkate almamaktadır; bu, gelecekteki araştırmalara değer bir yön olacaktır.

Anahtar Kelimeler: Karbon Azaltma, Piyasa Tepkisi, Vaka Çalışması

JEL Kodları: Q01, Q20, Q40, Q53

Introduction

The issue of global climate change is gaining increasing attention in today's society. The first volume (Climate Change 2013: The Physical Science Basis) of the fifth climate change assessment report released by the United Nations' Intergovernmental Panel on Climate Change (IPCC) on September 27, 2013, clearly stated that the scientific community believes at a more than 95% confidence level that increased carbon emissions by human activities has most likely led to global warming since 1950. Hence, carbon emissions have been deemed the main cause of climate change, as guaranteed by many studies. On July 6, 1976, the Human Environment Conference of the United Nations Framework Convention on Climate Change (UNFCCC) in Stockholm, Sweden, required member countries to reach their carbon emission reduction targets according to the conclusions of the meeting. The International Energy Agency (IEA) also provides specific policies and measures to help businesses and people understand carbon emission reduction targets. The ultimate goal is to avoid devastating consequences for humans and the planet by controlling carbon emissions (UNDP Annual Report, 2008, p. 28). However, some countries still worry about the possible impact of carbon emission reductions on their national economies (Yang et al. 2015). Therefore, the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change, held in Paris in 2021, aimed to seek a solution to balance carbon emissions, economic growth, and sustainable development.

In the early years, most of the environmental intervention policies implemented by countries for carbon emission reduction adopted a command-and-control administrative regulation method, which can directly limit emissions from pollution sources. However, most manufacturers will not invest more in pollution reduction once they have reached pollution emission standards due to a lack of further incentives. Therefore, the command-and-control method is not an effective policy to encourage manufacturers to invest in carbon reduction actively. For the past two decades, national environmental policies have gradually shifted from command-and-control methods to market-oriented environmental policy tools or market-based instruments (MBIs). The point is that MBIs possess economic incentives.

Voluntary agreement (VA) is one of the main environmental policies instruments the IEA recommends for pushing businesses to reduce carbon emissions (McEvoy & Stranlund, 2010). However, because the measures applied to decrease carbon emissions are very expensive (Hermundsdottir & Aspelund, 2021; Walley & Whitehead, 1994), if enterprises' inputs into carbon reduction can create more value for shareholders, enterprises would be willing to pay higher costs to reduce carbon emissions under the premise of maximizing shareholder interests (Sinkin et al. 2008). Naturally, shareholders will support enterprises in continuing their investment in carbon emission reduction measures, and VA can lift the effect of carbon emission reduction.

The previous literature regarding enterprises' carbon reduction largely agrees that corporate carbon reduction measures are valuable (Hermundsdottir & Aspelund, 2021), such as increasing waste recycling rate and using renewable materials, which can make a business obtain its internal and external managing advantage. Internally, as the company may have to redesign its production processes to reduce carbon emissions to promote carbon reduction measures, new production processes will result in material savings and reduced energy consumption (King & Lennox, 2002; Klassen & Whybark, 1999). This allows enterprises to improve production efficiency and reduce production costs, improving business performance (Christmann, 2000; Xie et al., 2019). Externally, actions adopted by the company toward carbon reduction measures and improved social responsibility performance can change the attitude of interested parties toward the company (Kanter and Brinkerhoff, 1981; Scott, 1995), improve the company's reputation (Barnett et al. 2020; Singh & Misra, 2021), and support the accumulation of moral capital (Godfrey, 2005; Peloza, 2006; Godfrey et al. 2009). For example, consumers may be willing to pay higher fees to businesses (Brown and Dacin, 1997; Creyer and Ross, 1997; Sen and Bhattacharya, 2001) or pay higher prices to buy products (Creyer & Ross, 1997), resulting in a distinct recognition with other companies' products (McWilliams & Siegel, 2001), or they may be more willing to continue to support the purchase of the company's products (Chen et al. 2021).

Previous studies have shown that companies also have the support of interested parties because of improved social responsibility performance, which has a beneficial influence on companies (Abu Zayyad et al., 2021; Shiu & Yang, 2017) and can further enhance better-managing achievements (Chen & Delmas, 2011; Horváthová, 2010; Singh & Misra, 2021). However, considering the high cost of investment in carbon reduction, whether carbon reduction measures will bring in future benefits sufficient to cover the initial investment cost is why manufacturers are willing to invest in carbon emissions reduction. However, there is no definite answer to this question in the existing literature (Corbett & Klassen, 2006; Zhou & Wen, 2020).

Analyzing a company's stock price response to some policy messages received from the market is used in many financial studies to understand how the market evaluates a company's policies (Shane & Spicer, 1983; Jacobs et al., 2008). Therefore, by observing the abnormal returns caused by the company's announcement of some carbon reduction measures, we can assess whether there are enough incentives for manufacturers to continue investing in carbon reduction activities.

It has been decades since the Human Environment Conference was held in Stockholm in 1976. With technological advancement and the continuous promotion of the importance of carbon reduction, theoretically speaking, the internal and external advantages that can be obtained from carbon reduction measures should be clearer than in the past. However, a pertinent question remains: What is the real reaction of the market? Suppose the market responds more positively to an enterprise's carbon reduction activities than before. In that case, it indicates that promoting carbon reduction activities is effective and encourages enterprises to continue participating in carbon emission reduction actively.

There are many measures to reduce carbon in enterprises, such as reducing raw material consumption, waste reduction, revealing production processes or the carbon footprint of products, and using green energy resources. Based on the available data, this study adopts the announcement for settling wastewater and waste heat recovery systems as the research topic. We observe the additional influence of the enterprise's announcement related to carbon reduction on the enterprise value by assessing the abnormal returns of stock prices after the enterprise announced the establishment of a wastewater or waste heat recovery system. We also compare the results of some markets in different time backgrounds and economic development levels to understand whether there are differences in different markets. The published literature on wastewater and waste heat recovery systems mostly focuses on technical discussion, while the impact on corporate value is rarely considered. Beyond filling the gap in the existing literature related to the different market reactions to corporate carbon reduction measures, this study provides empirical evidence that the market reaction can motivate manufacturers to implement carbon reduction measures voluntarily.

Theory, literature review, and hypotheses

The purpose of business operations is to pursue profit maximization. In contrast, in operation, it is impossible to avoid emissions of pollutants or consumption of substances and energy, all of which will produce carbon emissions. These are the negative externalities or external costs of the environment caused by manufacturers' operations. In the past, these external costs were borne by the whole society, thus forming the so-called "deadweight loss of social welfare" in economic theory. If we neglect the social welfare deadweight loss caused by the manufacturer's operation process, social welfare or the country's economic growth will be affected (Chen et al. 2003).

The deadweight loss of social welfare harms the national economy; thus, reducing the deadweight loss of social welfare benefits the country's economic growth (Fullerton & Kim, 2008; Osang & Pereira, 1996; Walde & Wood, 2004). According to economic theory, governments can take some command-and-control means to correct the environmental externalities led by the manufacturers' production to avoid the deadweight loss of social welfare, such as the Pigouvian environmental tax (Chen et al. 2003) or direct control, prohibition, subsidy, compensation measures (Parry & Bento, 2000; Smulders & Gradus, 1996), etc. These measures can force manufacturers that have produced externalities to internalize the external costs they have caused. However, these command-and-control measures may generate administrative costs (Palmer et al. 1995).

The taxation method, which can force manufacturers to improve externalities, may also cause inflation (Glueck & Schleicher, 1995; Koeppl et al., 1996) or a rise in the consumer price index (Bosquet, 2000). Therefore, the administrative measures that directly interfere with the government, although probably reducing the deadweight loss of social welfare caused by externalities, will also lead to additional administrative costs and inflation. Considering the problems in which the government directly intervenes in the externalities of the manufacturers, VAs proposed by manufacturers for energy conservation or carbon emissions reduction have become one of the emission reduction policy measures recommended by the IEA. Apart from the industry's dynamic behaviour of internalizing external costs, which can prevent the problem of inflation and the rise of the consumer price index caused by environmental tax, VA can also save the administrative costs that must be spent to correct the externalities of the manufacturers. Thus, the government can transfer the resources saved to other sectors that are more beneficial to society (Gupta & Barman, 2009).

As shown in Figure 1, during internalizing external costs, both the government's command and control or the voluntary behaviour of the manufacturers should cause increased costs to the manufacturers (from PF to PE) and production volume reduction (from QF to QE). Thus, measures to reduce carbon

emissions will increase costs and reduce production. Therefore, as indicated by theory, if the measures reducing carbon emissions cause manufacturers' profits to decline, there will not be enough incentives for manufacturers to cooperate with VA actively.

Although implementing measures to improve corporate environmental performance, such as carbon emission reduction, will indeed increase manufacturers' costs, improving corporate environmental performance may enable manufacturers to gain internal and external competitive advantages and enhance their competitiveness. The so-called internal advantage means that when manufacturers implement measures to reduce carbon emissions, they sometimes have to redesign the production process, but the new production process may reduce pollutant emissions, save materials, and reduce energy consumption (Klassen & Whybark, 1999; King & Lennox, 2002). Manufacturers can enhance resource utilization efficiency and reduce operating costs due to new processes or measures, which in turn help them to increase their business performance (Xie et al. 2019).

In terms of external advantages, manufacturers can improve their environmental performance to change the attitude of stakeholders toward them (Kanter & Brinkerhoff, 1981; Scott, 1995), enhance their reputation (Barnett et al., 2020; Singh & Misra, 2021), or accumulate moral capital (Godfrey, 2005; Godfrey et al. 2009; Peloza, 2006). Consumers may also be willing to pay higher business fees (Brown & Dacin, 1997; Creyer & Ross, 1997; Sen & Bhattacharya, 2001) or higher prices to purchase goods (Creyer & Ross, 1997). This may result in a differentiation cognition with other companies' products (McWilliams and Siegel, 2001) or a willingness to continue to support their products (Chen et al. 2021). In other words, when companies gain the support of stakeholders due to improving environmental performance by reducing carbon emissions, it can be beneficial to the operation of the company (Sen & Bhattacharya, 2001; Shen et al., 2020) and may even yield financial and operational performance (Chen & Delmas, 2011; Horváthová, 2010; Singh & Misra, 2021).

Based on the above discussion, we present the following arguments. First, manufacturers' measures to reduce carbon emissions are an action for internalizing external costs, increasing costs and reducing productive volume. Second, manufacturers' measures to reduce carbon emissions may yield internal and external competitive advantages. Therefore, measures to reduce carbon emissions will simultaneously cause two kinds of forces, leading to cost increases and internal and external competitive advantages.

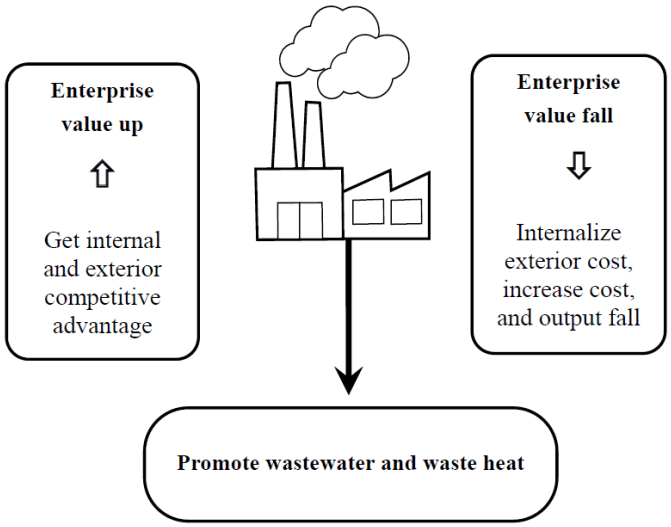

Figure 1: Establishing Wastewater and Waste Heat Recovery Systems may Increase and Decrease the Firm's Value

However, measuring the impact of carbon reduction measures on manufacturers is an important issue often encountered in corporate social performance (CSP)-related research (Chen & Delmas, 2011; Griffin & Mahon, 1997; Liao et al., 2018). This study adopts the 'event study' methodology to evaluate the influence of measures to reduce carbon emissions on businesses by observing the company's stock price reaction after the market has received the company's announcement about implementing carbon reduction measures. An event study based on the efficient-market hypothesis (EMH) (Fama, 1969) is a research method that many financial studies have adopted to understand the impact of specific market events on corporate value (Jacobs et al., 2008; Shane & Spicer, 1983). Another problem is that there are many types of carbon emission reduction measures for manufacturers, such as renewing production processes, reducing waste, and revealing carbon footprints. Based on the available data, this study

selected manufacturers' announcements about setting up wastewater and waste heat recovery systems as the research event and observed the abnormal stock price returns after the announcement. This is because the installation costs of wastewater and waste heat recovery systems are generally recognized as capital expenditures in the current year. Most enterprises would also announce the expected benefits of the wastewater and waste heat recovery systems; for example, the water bills may be reduced after the wastewater recovery facility is built, or the company may decrease energy purchases after the waste heat recovery system is established.

Based on the preceding discussion, the study advanced and verified the following hypotheses:

H: The market reacts extra to the company's announcement to set up wastewater and waste heat recovery systems.

Ha: The market reacted positively to the company's announcement to set up wastewater and waste heat recovery systems.

Hb: The market has a different negative reaction to the company's announcement to set up wastewater and waste heat recovery systems.

Thus, we convert the announcement that a company wanted to set up wastewater and waste heat recovery systems into an impact on the corporate value (stock price) based on the costs of establishing the systems and the expected future benefits disclosed in the announcement. Suppose the abnormal returns of the stock price minus the change in corporate value, estimated from the costs of establishing the systems and expected future benefit, are positive. In that case, the market has a different positive reaction regarding the company's declaration about setting up the wastewater and waste heat recovery system. On the contrary, if the abnormal return from stock price minus the change in company value is negative, the market has a different negative reaction.

Methodology and data sources

The research concept of the event study method was first proposed by Ball and Brown (1968) and Fama et al. (1969) to determine whether an abnormal variation in stock prices would exist when an event occurred, resulting in abnormal returns (AR). The statistical method was used to assess the abnormal return rate status, that is, to test whether the expected abnormal return rate was zero. Hence, the null hypothesis is $H0$: $E(R_i|event) - E(R_i) = 0$, with $E(R_i|event)$ and $E(R_i)$ respectively representing the expected return rates under whether the event occurs or not, to assess whether the event has an impact on the company's stock price.

The three main methods for estimating the expected return of stocks in event research are mean-adjusted return, market-adjusted return, and market model return. According to Brown and Warner (1980, 1985), the results obtained by these three methods are only slightly different. Therefore, to simplify the research process, this study uses the most commonly used method of market model return to estimate the expected stock return, as in Eq. (1):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (1)$$

R_{it} is the daily rate of return for the *i* company's stock in the t-th period. R_{mt} is the daily rate of return for the market portfolio in the t-th period. α_i is the intercept term. R_{mt} is the market risk-free daily rate of return for the t-th period. β_i is a measure of the systematic risk of a company's stock in the t-th period. ε_{it} is the error term. After calculating the expected daily rate of return of the *i* company's stock in the t-th period using Equation (1), and comparing it with the actual daily rate of return on the date on which the company announces the establishment of the wastewater and waste heat recovery system, the difference is consistent with the abnormal return due to the company's announcement about setting up a wastewater facility, as indicated in Eq. (2).

$$AR_{it} = R_{it} - \hat{R}_{it} = R_{it}(\hat{\alpha} + \hat{\beta} R_{mt}) \quad (2)$$

Cumulative abnormal return (CAR) is the cumulative amount of daily abnormal returns for a given period, as shown in Eq. (3):

$$CAR_{iE} = \sum_{j=1}^{E} AR_{ij} \quad (3)$$

where *E* is the period in which cumulative abnormal pay is calculated.

To determine the estimated period, if it is too short, it may worsen the model's predictive ability.

However, if the time is too long, structural changes in the data may occur, making the model unstable. Following Peterson's (1989) suggestion, this study attempted to set the estimated period to 120 days. Further, for extreme values that may affect the analysis results, this study used 90% winsorization to deal with extreme values of less than 5% and greater than 95% at the two ends.

Data sources

Companies' declaration data about building wastewater and waste heat recovery systems were obtained from LexisNexis, using "wastewater recovery systems" and "waste heat recovery systems" as the keywords and searching from data released between January 1, 2000, and December 31, 2018. Some information about the company's cost of setting up wastewater and waste heat recovery systems and the expected future benefits was found in the Datastream database. Considering the differences between culture and region, the companies included were all located in nine areas of East Asia: Taiwan, Japan, Hong Kong, Korea, Singapore, China, Malaysia, the Philippines, and Thailand. As the financial industry rarely needs to set up wastewater and waste heat recovery systems, financial companies were excluded from the search for listed companies in these areas.

Stock price data were taken from the S&P Compustat Research Insight (Compustat) database. Compustat is issued by Standard & Poor's, a US-based credit rating company that provides operational and financial data about more than 9,900 companies in North America. It is currently one of the most commonly used firm-level databases for financial research.

Estimation of the market's extra reaction

The abnormal returns after firms announce the need to set up wastewater and waste heat recovery systems generally contain two parts. The first is the theoretical influence on the company's accounting books, including the setup costs and expected future benefits. The theoretical influence can be estimated through the company's major event announcement or by monthly, quarterly, and annual reports and other major capital expenditure statements. The second is the different reaction retrieved from the market when the manufacturer invests in corporate responsibility activities, such as wastewater and waste heat recovery systems. Therefore, to estimate the different reactions from the market, the steps of this study are as follows:

1. In LexisNexis, "wastewater recovery systems" and "waste heat recovery systems" were keywords to search for non-financial listed companies in the nine selected areas in East Asia.

2. We confirmed that the event declarations searched in LexisNexis in the previous step were related to establishing wastewater or waste heat recovery systems. If the report has a quantitative cost and benefit evaluation for establishing wastewater or waste heat recovery systems, the event report is selected as a research sample. The event announcement date was set as the baseline for calculating the abnormal return and the cumulative abnormal return (actual abnormal return and actual cumulative abnormal return) in the event study. If there was no quantitative data in LexisNexis, we repeated the search using another Datastream database. If the cost and benefit evaluation of the wastewater or waste heat recovery systems was found in Datastream, we collected it as a research sample. Certainly, if there were no related quantitative data found in Datastream, the item was removed.

3. The cost and benefit evaluation amount of the wastewater or waste heat recovery systems for a specific company found in the second step was divided by the number of shares in the current year (referring to Compustat) and set as the theoretical abnormal return of the research sample.

4. We calculated the market's reactions to a specific company's wastewater or waste heat recovery systems by subtracting the theoretical abnormal return from the actual abnormal return for each event.

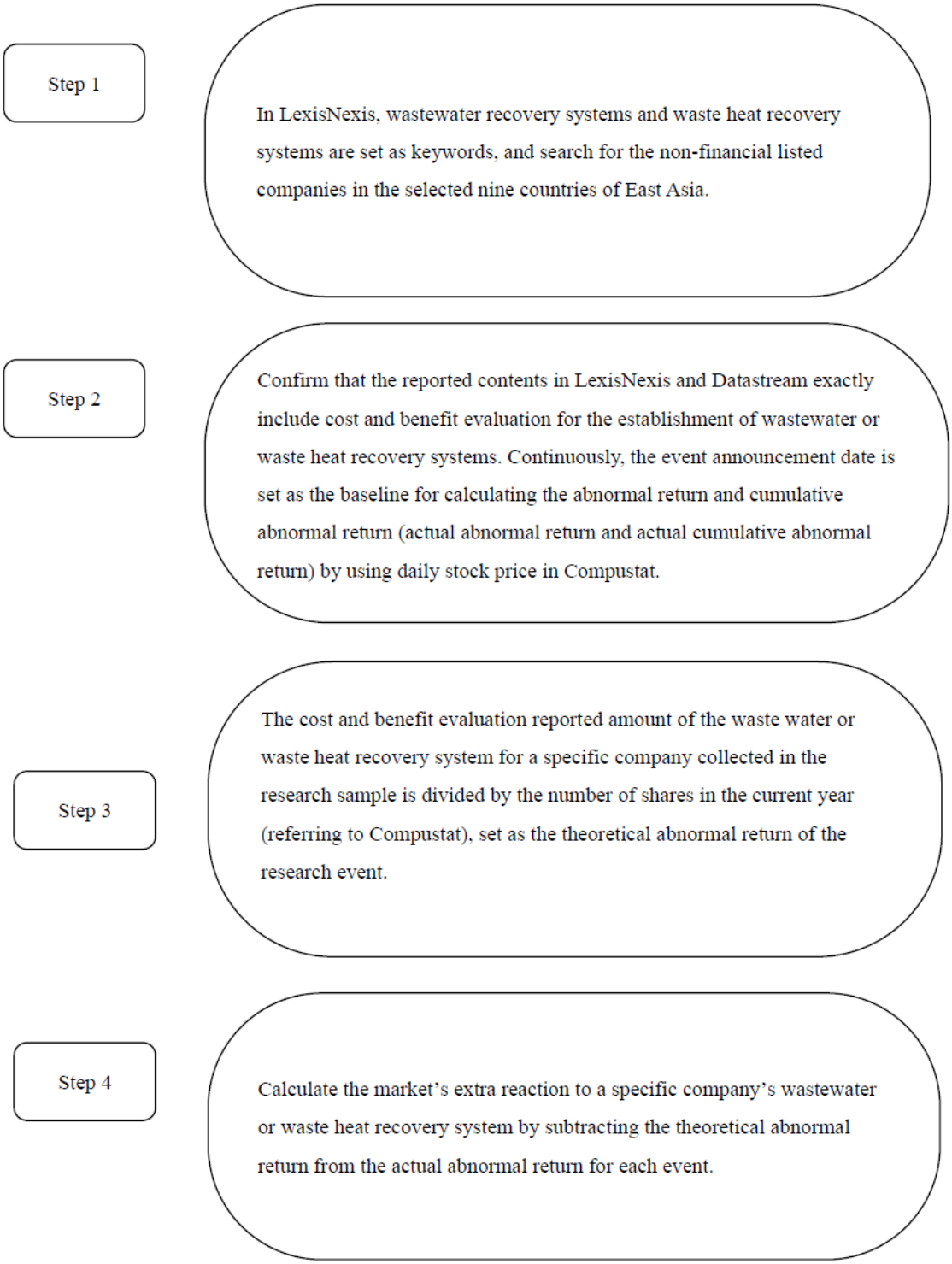

Figure 2: Steps of Estimating the Extra Reaction of the Market

Empirical analysis and discussion

Variables and sample descriptive statistics

The variable names, definitions, acronyms, and data sources shown in Table 1 were used for the empirical analysis of the data.

Table 1: Variable Names, Acronyms, Definitions, and Data Sources

Variable names	Acronyms	Definitions	Data sources
Theoretical abnormal return	TAR	The cost and benefit evaluation reported amount of the wastewater or waste heat recovery systems for a specific company collected in the research the sample is divided by the number of shares in the current year	LexisNexis Datastream
Actual abnormal return	AAR	Based on the event study, the abnormal return from the stock price on the event announcement date when a specific company announces to build a wastewater or waste heat recovery system	Compustat
Actual cumulative abnormal return (0,2)	ACAR (0,2)	Based on the event study, the cumulative abnormal return from stock price from the event announcement date when a specific company announces to build a wastewater or waste heat recovery system to the consecutive second date	Compustat
Extra reaction from the market to firms	ERMF	The market's extra reaction to a specific company's wastewater or waste heat recovery systems by subtracting the theoretical abnormal return from the actual abnormal return for each event	Compustat, Datastream

According to the empirical research steps described in Section 3.3, this study uses the keywords "wastewater recovery" and "waste heat recovery system" to screen the LexisNexis database for the major event announcements of the non-financial listed companies in the nine areas of East Asia, retrieving data released between January 1, 2000, and December 31, 2016. After excluding repeated reports with the same event, the study also referred to Peterson (1989) and McWilliams and Siegal (2001) to add two exclusion conditions to avoid impact from other major events:

1. If other major event announcements took place within one month before the announcement date of the selected event, such as making financial reports public, new product announcements, strategic alliances, or mergers and acquisitions, the selected event was excluded.

2. The selected event was excluded if other major events were announced during the estimated period, such as making public financial reports, new product announcements, strategic alliances, or mergers and acquisitions.

Based on the outlined steps using the indicated keywords, the initial search yielded 802 pieces of announced events. By applying the two exclusion conditions indicated above, 271 announcements were excluded. Of the remaining 531 announcements, 229 were excluded because their cost and benefit quantitative evaluation of the wastewater or waste heat recovery systems could not be found in LexisNexis or Datastream. Therefore, the number of effective sample events was 302 in the final empirical analysis. The distribution and descriptive statistics of the sample events are shown in Table 2.

Table 2: The Distribution of the Sample Events by Time and Countries

	Developed countries	Developing countries	Number of sample events
2000–2008	69	30	99
2009–2018	151	52	203
Number of sample events	220	82	Total Events 302

This study took the 2008 global financial crisis as a time break point and the degree of national development as a threshold to distinguish these sampling events, as shown in Table 2. 220 event samples belonged to developed countries, with 69 sample events occurring before the financial crisis (2000–2008) and 151 samples taking place after the financial crisis (2009–2018). By contrast, there were 74 event samples from developing countries, including 30 sample events that happened before the financial tsunami (2000–2008) and 52 samples that happened after the financial tsunami (2009–2018). From the

concept of distribution, samples from the developed countries were significantly more than those from the developing countries, and the samples that occurred between 2009–2018 were also significantly more than those from 2000–2008.

Empirical analysis

We initially assessed whether the announcement about establishing wastewater or waste heat recovery systems certainly led to abnormal returns in the whole sample market, as shown in Table 3.

Table 3: Analysis of Abnormal Returns for all Samples

Date	Actual abnormal return (%)	T-value
-5	0.10	0.71
-4	0.06	0.54
-3	-0.04	-0.93
-2	0.10	0.46
-1	-0.09	-0.97
0	-0.07	-2.06**
1	-0.03	-1.78*
2	-0.04	-1.72*
3	0.06	1.35
4	-0.05	-1.09
5	-0.08	-0.78

*Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

According to Table 3, the abnormal return of all samples on the announcing day was -0.07, reaching a significant level of 5%. On the first day and the second day after the announcement, the abnormal returns were -0.03 and -0.04, respectively, at a significant level of 10%. This indicates an abnormal return exists when manufacturers declare they want to build a wastewater or waste heat recovery system. The negative announcement effect indicates that when the market investors received the message that the manufacturer had announced establishing a wastewater or waste heat recovery system, they generally believed that the impact of this information on corporate value would be evaluated as negative. In addition, the negative effect on the announcing day was the most obvious and largest, lasting for two days but gradually reducing after that. Thus, the immediate response from market investors regarding the announcement of establishing a wastewater or waste heat recovery system was negative. After one or two days, market investors slowly change their evaluations.

We further made a distinction concerning the degree of time and national development. We observed the market's reaction regarding establishing wastewater or waste heat recovery systems, as shown in Table 4 and Table 5.

Table 4: Analysis of Abnormal Returns by Time

	2000–2008		2009–2016	
Date	Actual abnormal return (%)	T-value	Actual abnormal return (%)	T-value
-5	0.19	0.87	0.05	0.79
-4	0.08	0.93	0.04	1.46
-3	-0.14	-1.10	0.02	0.82
-2	0.08	0.97	0.11	1.16
-1	-0.13	-1.26	-0.07	-0.88
0	-0.18	-2.35***	-0.03	-1.94*
1	-0.04	-1.98**	-0.02	-1.49
2	-0.05	-1.82*	-0.02	-1.32
3	-0.02	-0.78	0.10	1.54
4	-0.13	-1.33	-0.03	-0.97
5	-0.04	-0.94	-0.10	-0.86

*Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

The research interval was divided into 2000–2008 and 2009–2018, as shown in Table 4. We found that the abnormal returns on the announcing day were also negative: -0.18 at the significance level of 1% and -0.03 at the significance level of 10%. The abnormal return value between 2009–2018 was significantly smaller than that between 2000–2008. The abnormal return between 2009-2018 is only statistically significant on the announcing day. However, the abnormal return between 2000–2008 was significantly negative on the announcing day and the following two days. This showed a negative declaration effect between 2000–2008 and 2009–2018 when the manufacturer announced the establishment of wastewater or waste heat recovery systems. The results indicate that the market doubted whether the

announcement of the wastewater or waste heat recovery systems could affect corporate value. However, as the years passed, such doubts gradually weakened, and the negative lasting time of abnormal return also became shorter. This suggests that the market or investors slowly changed the negative evaluation of establishing wastewater or waste heat recovery systems.

Table 5: Analysis of Abnormal Returns by Country Development

	Developing countries		Developed countries	
Date	Actual abnormal return (%)	T-value	Actual abnormal return (%)	T-value
-5	0.11	0.83	0.06	0.85
-4	0.07	0.76	0.03	0.64
-3	-0.02	-0.81	-0.04	-1.13
-2	-0.04	-0.72	0.10	0.67
-1	-0.10	-1.22	-0.07	-1.20
0	-0.14	-2.56***	-0.04	-1.77*
1	-0.04	-2.09**	-0.02	-1.48
2	-0.05	-1.78*	-0.03	-1.52
3	0.12	1.42	0.03	1.37
4	-0.08	-0.96	-0.04	-1.16
5	-0.13	-0.80	-0.05	-0.94

*Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

Table 5 shows the values of abnormal returns based on the degree of national development. The abnormal returns from the developed and developing countries' markets on the day of the announcement were negative. Compared with the markets of developing countries, the abnormal returns and the significance level on the announcing day in developed countries were both lower. The number of days it took the abnormal return statistically to reach significance in the developing countries was also greater than that in the developed countries, continuing until two days after the announcement. This means that the markets of both developed and developing countries experienced a negative effect when manufacturers declared that they wanted to build wastewater or waste heat recovery systems. However, markets in developed countries had better evaluations of establishing wastewater recovery or waste heat recovery systems than in developing countries.

All the results in Tables 3, 4, and 5 were obtained by observing the abnormal returns when the manufacturers declared building the wastewater or waste heat recovery systems and assessing the influence on the company's value in the market. Notably, this abnormal return consists of two parts. One is the cost and future benefit estimated for establishing the wastewater or waste heat recovery system; the other is the market's reaction to the company's announcement of this measure. Suppose the market does not respond to the measures announced by the company. In that case, the abnormal return considers only the influence of the actual benefits of the measure on the company's value. Therefore, the market's different reaction to the manufacturer's announcement, which is the market's actual perception of the manufacturer's work regarding wastewater or waste heat recovery systems, can be obtained using the abnormal return minus the change in corporate value influenced by the actual benefits of building wastewater or waste heat recovery systems.

Table 6: Relative Abnormal Returns by the Announcement of Wastewater or Waste Heat Recovery Systems

Variables	Average	Maximum	Minimum
Theoretical abnormal return	-0.07***	0.04	-0.28
Actual abnormal return	-0.09**	0.14	-0.37
Actual cumulative abnormal return (0,2)	-0.16*	0.18	-0.53
Market's extra reaction	-0.02**	0.28	-0.23
Market's extra reaction (0,2)	-0.09*	0.18	-0.26

Note:

1. *Unit: per cent*
2. **, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

Table 6 provides information on abnormal returns from all 302 selected event declarations about establishing wastewater or waste heat recovery systems. The theoretical abnormal return in the first row was calculated by dividing the effectiveness evaluation reported in the firm's announcement by the number of outstanding shares in the current year. The unit applied here is per cent. The average value was -0.07, the maximum value was 0.04, and the minimum value was -0.28. The real abnormal return in

the second row is the abnormal return of the stock price on the manufacturer's announcement date. The average value was -0.09, the maximum value was 0.14, and the minimum value was -0.37. The third row shows the real cumulative abnormal returns (0, 2) obtained by summing up the abnormal returns for the announcement day and the following two days. The average value was -0.16, the maximum value was 0.18, and the minimum value was -0.53. The fourth row shows the different market reactions: the abnormal return of stock price on the manufacturer's announcement date minus the benefit evaluation amount divided by the company's number of current shares. The average value was -0.02, the maximum value was 0.28, and the minimum value was -0.23. The fifth row is the market's other reaction (0, 2), obtained by subtracting the first row's value from the third row's value and calculating the market's different reaction for three days from the announcement date. The average value was -0.09, the maximum value was 0.18, and the minimum value was -0.25.

Table 6 shows that the average values of the actual and accumulated abnormal returns were negative. In other words, the market's reaction to establishing wastewater or waste heat recovery systems may be mistaken if only the abnormal return on the announcement date is considered. The theoretical abnormal return is the actual benefit the manufacturer obtains by establishing a wastewater or waste heat recovery system. Although it was also negative, it may be attributed to the fact that the company's share price should have dropped originally on the announcement day. After deducting this part from the actual abnormal or accumulated abnormal return, we observed that although the different market reaction was still negative, this value became higher than the actual abnormal or accumulated abnormal return on the announcement date. This reflects the market's response to establishing a wastewater or waste heat recovery system.

Similarly, the time point of the financial tsunami and the degree of national development is set to distinguish and observe the market's other reaction to establishing wastewater or waste heat recovery systems, as shown in Tables 7 and 8.

Table 7: Relative Abnormal Returns by the Time

			2000–2008
Variables	Average	Maximum	Minimum
Theoretical abnormal return	-0.15***	-0.08	-0.28
Actual abnormal return	-0.17***	0.03	-0.35
Actual cumulative abnormal return (0,2)	-0.26**	0.05	-0.53
Market's extra reaction	-0.03***	0.12	-0.21
Market's extra reaction (0,2)	-0.11**	0.10	-0.26
			2009–2016
Variables	Average	Maximum	Minimum
Theoretical abnormal return	-0.05**	0.04	-0.21
Actual abnormal return	-0.03**	0.14	-0.22
Actual cumulative abnormal return (0,2)	-0.04*	0.18	-0.53
Market's extra reaction	-0.03**	0.28	-0.14
Market's extra reaction (0,2)	-0.07**	0.26	-0.24

Note:

1. Unit: per cent

*2. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

From Table 7, the theoretical abnormal returns from both periods (2000–2008, 2009–2018) were negative, indicating that the manufacturer's capital expenditure for constructing the wastewater or waste heat recovery systems was still higher than the increase in expected future revenue during the two periods. However, the theoretical abnormal return between 2009–2018 was greater than that between 2000–2008, which indicates that the actual benefits from the construction of the system between 2009–2018 were better than those between 2000–2008.

The results also show that the actual abnormal and accumulated abnormal returns between 2009 and 2018 were higher than those between 2000 and 2008. The fourth and fifth rows display the market's different reactions, and the values between 2009–2018 were also higher than those between 2000– 2008. The fourth field shows that the market's row reaction on the day of the announcement even turned positive. The fifth row shows the market's different reaction on the announcement day, with the following two days showing an increase from -0.11 between 2000–2008 to -0.07 between 2009–2018. This indicates that between 2009–2018, the market was more willing to give manufacturers positive support for establishing wastewater and waste heat recovery systems than between 2000–2008.

Table 8: Relative Abnormal Returns by the Degree of Country Development

Developing countries

Variables	Average	Maximum	Minimum
Theoretical abnormal return	-0.15***	-0.08	-0.28
Actual abnormal return	-0.17***	0.03	-0.35
actual cumulative abnormal return (0,2)	-0.26**	0.05	-0.53
Market's extra reaction	-0.03***	0.12	-0.21
Market's extra reaction (0,2)	-0.11**	0.10	-0.26

Developed countries

Variables	Average	Maximum	Minimum
Theoretical abnormal return	-0.04**	0.02	-0.25
Actual abnormal return	-0.03**	0.13	-0.21
actual cumulative abnormal return (0,2)	-0.08*	0.16	-0.38
Market's extra reaction	0.02**	0.20	-0.15
Market's extra reaction (0,2)	-0.04*	0.26	-0.10

Note:

1. *Unit: per cent*
2. **, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

As shown in Table 8, the theoretical abnormal returns in both developed and developing countries were negative. However, the value of developed countries was higher than that of developing countries, indicating that developed countries experienced more actual benefits in building wastewater and waste heat recovery systems. Moreover, the actual abnormal and accumulated abnormal returns for developed countries were also higher than in developing countries. The market's additional reaction value was also higher in developed and developing countries. The other reaction of the market in developed countries on announcement day was positive, which indicates that the markets in developed countries were willing to give manufacturers positive support for wastewater and waste heat recovery systems. The markets in developing countries were less supportive of manufacturers.

Discussion

Several phenomena can be observed by analyzing the results in Tables 3 to 8. First, there is an announcement effect when the market receives a message that a firm declares to set up wastewater and waste heat recovery systems. However, all the average values of the actual abnormal returns at the time of declaration are negative, indicating that most markets hold a more negative view of wastewater or waste heat recovery systems.

However, this situation slightly improves over time. Such change may come from more people paying attention to the green concept of environmental protection or because the technology of wastewater or waste heat recovery systems is becoming more mature. In recent years, the valuation of wastewater and waste heat recovery systems has become much better than in the past. Based on the increasing value of theoretical abnormal returns, the actual benefits of current manufacturers in building the system are better than in the past. The market also believes establishing wastewater and waste heat recovery systems can increase enterprise value.

Regarding the degree of country development, manufacturers in developed countries benefit better than those in developing countries from setting up wastewater and waste heat recovery systems. Although it may not be sufficient to cover the input cost, the market is willing to show a higher positive extra reaction. Understandably, such a situation exists in developed countries. As found in the previous literature, the higher the degree of economic development, the other society would support carbon emissions reduction, such as wastewater and waste heat recovery systems. However, in developing countries, seeking economic development still occupies the most important role in society. In Table 8, the market's different reaction was negative; thus, markets in developing countries offer lower support for manufacturers to set up wastewater and waste heat recovery systems. Therefore, if developing countries desire their domestic companies to be more active in reducing carbon emissions, the government needs to set clearer policy incentives, including rewards for reducing more carbon emissions and penalties for violating carbon emissions reduction requirements. Therefore, market investors in developing countries can be encouraged to support manufacturers actively involved in reducing carbon emissions. Certainly, manufacturers are more likely to implement or cooperate with voluntary carbon reduction measures.

From another point of view, under the current market mechanism, manufacturers' active recycling of wastewater and waste heat cannot bring obvious economic benefits to manufacturers because carbon emissions have not been included in the market mechanism. Suppose manufacturers' carbon emissions are included in the market mechanism through carbon rights trading or carbon fees. In that case, even if the current wastewater and waste heat recovery technology is still immature, manufacturers' active recycling of wastewater and waste heat will still be affected by carbon emissions. Benefit from the reduction. Therefore, establishing a carbon right trading system or collecting carbon fees can also improve manufacturers' active recycling of wastewater and heat.

Conclusion

This study is based on the event study method, which observes the abnormal stock return after manufacturers from areas in East Asian countries announce the establishment of wastewater and waste heat recovery systems. Considering the capital expenditure and the expected impact on revenue for wastewater and waste heat recovery systems, the market's view of the actions that companies implement measures for carbon reductions was also evaluated.

Based on the results of the study, several conclusions can be drawn. First, establishing a wastewater and waste heat recovery system has a declaratory effect. Second, manufacturers currently receive relatively higher positive extra reactions than in the past when they announce setting up wastewater and waste heat recovery systems. Third, manufacturers in developed countries receive a relatively higher positive extra reaction from the market than those in developing countries when they declare a plan to set up wastewater and waste heat recovery systems. The analysis results prove that after more than a decade of technological advancement and promoting carbon reduction behaviours, the market has a more positive extra reaction to carbon reduction measures, such as wastewater and waste heat recovery systems. However, we also found that markets in developing countries still lack extra positive reactions regarding carbon reduction measures. In other words, governments in developing countries must set more explicit policy incentives, including rewards, to encourage manufacturers to invest in reduction measures of carbon emissions and penalties to prevent violations of carbon reduction. These measures can encourage market investors to support manufacturers actively in reducing carbon emissions, and manufacturers are more likely to implement or work on voluntary carbon reduction projects. However, this study strongly recommends that developed and developing countries consider implementing carbon trading or imposing carbon fees. The technology is still immature, and manufacturers' active recycling of wastewater and waste heat can still bring benefits due to reducing carbon emissions, thereby increasing manufacturers' willingness to recycle wastewater and waste heat actively.

This study shows that market reactions can motivate manufacturers to implement voluntary carbon reduction measures. However, due to limited data, we analyzed only the market's response to manufacturers' declarations for wastewater and waste heat recovery systems. For future research, we suggest adopting other carbon reduction activities, such as decreasing raw material consumption, reducing waste, exposing the carbon footprint of production processes or products, using green energy, and determining how governments can develop clearer and more effective policy incentives. The possible impact of carbon rights trading or carbon fees on manufacturers' behaviour will also be an important and interesting research direction.

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References

Abu Zayyad, H. M., Obeidat, Z. M., Alshurideh, M. T., Abuhashesh, M., Maqableh, M., & Masa'deh, R.

E. (2021). Corporate social responsibility and patronage intentions: The mediating effect of brand credibility. *Journal of Marketing Communications*, *27*(5), 510–533.

Ball, R., & Brown, P. (1968). An empirical evaluation of accounting income numbers. Journal *of Accounting Research*, *6*, 159–77.

Barnett, M. L., Henriques, I., & Husted, B. W. (2020). Beyond good intentions: Designing CSR initiatives for greater social impact. *Journal of Management*, *46*(6), 937–964.

Brown, S. J., & Warner, J. B. (1980). Measuring security price performance. *Journal of Financial Economics*, *8*(3), 205–258.

Brown, S. J., & Warner, J. B. (1985). Using daily stock returns: The case of event studies. *Journal of Financial Economics*, *14*(1), 3–31.

Brown, T. J., & Dacin, P. A. (1997). The company and the product: Corporate associations and consumer product responses. *Journal of Marketing*, *61*, 68–84.

Bosquet, B. (2000). Environmental tax reform: Does it work? A survey of the empirical evidence.

Ecological Economics, *34*(1), 19–32.

Chen, C. M., & Delmas, M. (2011). Measuring corporate social performance: An efficiency perspective.

Production and Operations Management, *20*, 789–804.

Chen, J. H., Lai, C. C., & Shieh, J. Y. (2003). Anticipated environmental policy and transitional dynamics in an endogenous growth model. *Environmental and Resource Economics, 25(*2), 233–254.

Chen, L., Qie, K., Memon, H., & Yesuf, H. M. (2021). The empirical analysis of green innovation for fashion brands, perceived value and green purchase intention—mediating and moderating effects. *Sustainability, 13*(8), 4238.

Christmann, P. (2000). Effects of 'best practices' of environmental management on cost advantage: The role of complementary assets. *Academy of Management Journal, 43*(4), 66–680.

Corbett, C. J., & Klassen, R. D. (2006). Extending the horizons: Environmental excellence as key to improving operations. *Manufacturing & Service Operations Management, 8*(1), 5–22.

Creyer, E. H., & Ross, W. T. Jr. (1997). The influence of firm behaviour on purchase intention: Do consumers really care about business ethics? *Journal of Consumer Marketing, 14*, 419–432.

Fama, E. F., Fisher, L., Jensen, M., & Roll, R. (1969). The adjustment of stock prices to new information.

International *Economic Review, 10,* 1–21.

Fullerton, D., & Kim, R. S. (2008). Environmental investment and policy with distortionary taxes, and endogenous growth. *Journal of Environmental Economics and Management*, *56*(2),141–154.

Glueck, H., & Schleicher, S. P. (1995). Endogenous technical progress induced by CO_2 reduction policies: Simulation results for Austria. *Environmental and Resource Economics*, *5*(2), 151–163.

Godfrey, P. C. (2005). The relationship between corporate philanthropy and shareholder wealth: A risk management perspective. *Academy of Management Review* 30(4): 777-798.

Godfrey, P. C., Merrill, C. B., & Hansen, J. M. (2009). The relationship between corporate social responsibility and shareholder value: An empirical test of the risk management hypothesis. *Strategic Management Journal, 30*(4), 425–445.

Griffin, J. J., & Mahon, J. F. (1997). The corporate social performance and corporate financial performance debate: Twenty-five years of incomparable research. *Business and Society, 36,* 5–31.

Gupta, M. R., & Barman, T. R. (2009). Fiscal policies, environmental pollution and economic growth.

Economic Modelling, 26(5), 1018–1028.

Hermundsdottir, F., & Aspelund, A. (2021. Sustainability innovations and firm competitiveness: A review. *Journal of Cleaner Production, 280*, 124715.

Horváthová, E. (2010). Does environmental performance affect financial performance? A meta-analysis.

Ecological Economics, *70*, 52–59.

Jacobs, W. B., & Singhal, R. V., & Subramanian, R. (2008). An empirical investigation of environmental performance and the market value of the firm. http://ssrn.com/abstract=1320721

Kanter, R., & Brinkerhoff, D. (1981). Organizational performance: Recent developments in measurement.

Annual Review of Sociology, 7, 321–349.

King, A., & Lenox, M. (2002). Exploring the locus of profitable pollution reduction. *Management Science, 48*(2), 289–299.

Klassen, R. D., & Whybark, D. C. (1999). The impact of environmental technologies on manufacturing performance. *Academy of Management Journal, 42*(6), 599–615.

Koeppl, A., Kratena, K., Pichl, C., Schebeck, F., Schleicher, S., & Wueger, M. (1996). Macroeconomic and sectoral effects of energy taxation in Austria. *Environmental and Resource Economics*, *8*(4), 417–430.

Liao, P. C., Shih, Y. N., Wu, C. L., Zhang, X. L., & Wang, Y. (2018). Does corporate social performance pay back quickly? A longitudinal content analysis on international contractors. *Journal of Cleaner Production, 170*, 1328–1337.

McEvoy, D. M., & Stranlund, J. K. (2010). Costly enforcement of voluntary environmental agreements. *Environmental and Resource Economics, 47*(1), 45–63.

McWilliams, A., & Siegel, D. (2001). Corporate social responsibility: A theory of the firm perspective. *Academy of Management Review*, *26*(1), 117–127.

Osang, T., & Pereira, A. (1996). Import tariffs and growth in a small open economy. *Journal of Public Economics*, *60*, 45–71.

Palmer, K., Oates, W. E., & Portney, P. R. (1995). Tightening environmental standards: The benefit-cost or the no-cost paradigm? *Journal of Economic Perspectives*, *9*(4), 119–132.

Parry, I. W. H., & Bento, A. M. (2000). Tax deductions, environmental policy, and the 'double dividend' hypothesis. *Journal of Environmental Economics and Management*, *39*, 67–96.

Peloza, J. (2006). Using corporate social responsibility as insurance for financial performance. *California Management Review*, *48*, 52–72.

Peterson, P. P. (1989). Event study: A review of issues and methodology. *Quarterly Journal of Business and Economics*, *28*, 36–66.

Scott, R. (1995). *Institutions and organizations.* Sage Publications.

Sen, S., & Bhattacharya, C. B. (2001). Does doing good always lead to doing better? Consumer reactions to corporate social responsibility. *Journal of Marketing Research*, *38*(2), 225–243.

Shane, P. B., & Spicer, B. H. (1983). Market response to environmental information produced outside the firm. *The Accounting Review, LVIII*, 521–538.

Shen, Y., Su, Z. W., Huang, G., Khalid, F., Farooq, M. B., & Akram, R. (2020). Firm market value relevance of carbon reduction targets, external carbon assurance and carbon communication. *Carbon Management*, *11*(6): 549–563.

Shiu, S. M., & Yang, S. L. (2017). Does engagement in corporate social responsibility provide insurance-like effects? *Strategic Management Journal, 38*(2), 455–470.

Singh, K., & Misra, M. (2021). Linking corporate social responsibility (CSR) and organizational performance: The moderating effect of corporate reputation. *European Research on Management and Business Economics, 27*(1), 100139.

Sinkin, C., Wright, C. J., & Burnett, R. D. (2008). Eco-efficiency and firm value. *Journal of Accounting and Public Policy*, *27*, 167–176.

Smulders, S., & Gradus, R. (1996). Pollution abatement and long-term growth. *European Journal of Political Economy*, *12*(3), 505–532.

Walde, K., & Wood, C. (2004). The empirics of trade and growth: Where are the policy recommendations? *International Economics and Economic Policy*, *1*, 275–292.

Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review*, *May–June*, 46– 52. Wilcox, R. (2003). *Applying contemporary statistical techniques*. Academic Press.

Xie, X., Huo, J., & Zou, H. (2019). Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research* 101: 697-706).

Yang, S. L., Wu, P. I., & Lee, C. I. (2015). Will economic growth of a country be impeded by more corporate environmental performances? *Environmental Economics*, *6*(1), 44–52.

Zhou, P., & Wen, W. (2020). Carbon-constrained firm decisions: From business strategies to operations modeling. *European Journal of Operational Research, 281*(1), 1–15.