I. Introduction

As seen in the literature, the changing global climate is attracting increasing attention (Schipper *et al.*, 2001; Asuka and Takeuchi, 2004; Nijkamp, Wang, and Kremers, 2005).　Greenhouse gases (GHGs) are one of the main causes of climate change, and one of the most important GHGs is carbon dioxide (CO_2).　To mitigate the greenhouse effect, the United Nations Framework Convention on Climate Change (UNFCCC) asks the contracting countries to achieve the carbon emission reduction target (CERT).　In recent years, some emerging countries have also become aware of these issues.　The Copenhagen accord claimed that developing countries should not necessarily promise to meet emission reduction targets.　Rather, the self-reduction actions of these countries should be based on the measure, report, and verify (MRV) principal.　Therefore, because of the MRV principle of the Copenhagen accord, not only developed countries but also developing countries must take greenhouse gas management actions.　The International Energy Agency (IEA) also provides several practical policy suggestions to help people understand the CERT better.

Most countries' governments have formulated clear energy-saving and carbon-reduction targets, as well as the relevant policies and legislation.　In order to achieve carbon reduction targets, the International Energy Agency (IEA) suggests that specific information about the policies and measures of each government, including policy processes such as strategic planning, information diffusion, and counseling, should be provided to businesses and the public at large to increase awareness.　Fiscal instruments such as an energy tax (carbon tax), tax credits, and policy incentives and subsidies should be used to encourage businesses to use new clean energy technologies. Regulatory instruments, such as carbon emissions and industrial energy consumption standards, should be set, and product and equipment markings should be implemented to enhance energy efficiency and reduce carbon emissions. Through consultations with manufacturers, these manufacturers should independently propose voluntary

agreements (VA) regarding energy savings or carbon reduction to establish other flexible mechanisms for emissions trading, green certificates, clean development mechanism (CDM), and joint implementation (JI).

Many governments have developed clear carbon reduction targets (Grossman and Krueger, 1995; Ganapati and Liu, 2008; Partridge and Gamkhar, 2010), along with relevant legislation and carbon reduction policies.   However, it is costly for enterprises to invest in environmental protection programs (Ingram and Frazier, 1980; Freedman and Jaggi, 1982; Walley and Whitehead, 1994).   Carbon emission reduction through strategies such as increased waste recycling and the use of renewable materials must generate enough value to motivate enterprises to invest in them.   The existing literature has highlighted the importance of carbon emission reduction (Wise *et al.*, 2009).   Studies have indicated that the increased recycling of waste and used materials can benefit enterprises both internally and externally.   Internally, enterprises can benefit from the reduced materials and production costs.   Externally, enterprises that undertake carbon emission reduction projects could lessen the concerns of the authorities and investors regarding environmental protection.   Furthermore, the stakeholders' carbon emission reductions also benefit enterprises in terms of the production market (Brown and Dacin, 1997; Sen and Bhattacharya, 2001).   For example, carbon-reducing firms may benefit from government regulations regarding the environment, increased competitive advantage, and better access to capital (Côté, Booth, and Louis, 2006).   Are these benefits certain enough to cover the large related costs that enterprises must pay? Extant studies do not provide a clear answer (Corbett and Klassen, 2006).

From the perspective of welfare economics, using government taxes, subsidies, or controls to force companies to take measures to reduce carbon emissions may, in addition to incurring very high implementation costs for companies, also lead to a dead-weight loss of social welfare (Kennedy, 1994; Ulph, 1996). Although emission right trading has higher cost-efficiency, the complex deal structure involved makes it

difficult to implement.   Thus, over the past ten plus years, VA has become one of the most important policies favored by most countries, but the results have not been as expected (McEvoy and Stranlund, 2010).

Carbon footprint disclosure is one of the main carbon emission reduction strategies.   The carbon footprint is the total amount of CO_2 and other greenhouse gases emitted over the full lifecycle of a process or product (U. K. Parliamentary Office of Science and Technology, 2006).   Firms' carbon footprint disclosure announcements contain information that is directly related to the product or service provided by the company, and this information regarding the product's carbon footprint becomes available to the consumer.   This may change consumers' consciousness of the environmental impacts of products that could be misperceived as being relatively harmful or benign in terms of the environment.   For example, one common misconception about the aquaculture industry is that fish farming methods reduce the stress on world fisheries. However, consumers are unaware that high-trophic-level fish require a large volume of fishmeal input.   Shrimp and salmon aquaculture products require two to four times their volume in fish products as inputs, which contributes to the exhaustion, rather than the augmentation, of fisheries resources (Naylor *et al.*, 1998).   Furthermore, aquaculture activities can be highly pollutant and detrimental to coastal nursery areas and adjacent ecosystems (Dierberg and Kiattisimkul, 1996; Paez-Osuna, 2001).   Consumers of the imported aquaculture products are largely unaware of the ecological damage that occurs in their places of origin.

While firms are willing to announce their products' footprints, this meaning that they must attempt to perform better than other firms in this regard.   If consumers could learn how much carbon emission is associated with their consumption and carbon emissions could become a part of their consumption decisions, both GHG emissions and carbon-reducing firms could benefit.   Carbon-reducing firms might enhance their reputations (Orlitzky, Schmidt, and Rynes, 2003) and accumulate moral capital (Godfrey, 2005; Peloza, 2006; Godfrey, Merrill, and Hansen, 2009).

Furthermore, consumers would be likely to pay higher returns (Brown and Dacin, 1997; Creyer and Ross, 1997; Sen and Bhattacharya, 2001), develop difference awareness (McWilliams and Siegel, 2001) regarding the carbon-reducing efforts of specific corporations, and thus prefer to continue to consume their products (Smith and Alcorn, 1991). Finally, these corporations have better financial and operational performance (Horváthová, 2010; Chen and Delmas, 2011).

The study did not make a direct comparison between the benefits and costs of enterprises' carbon-reducing actions, because that would be too difficult, especially in terms of deciding how to measure increased competitiveness as a result of carbon-reducing actions.   However, investors' reactions to corporate stock prices upon receiving messages regarding enterprises' carbon-reducing actions can indirectly show how parties of interest perform cost-benefit analyses after the announcement of carbon- reducing actions (Shane and Spicer, 1983; Jacobs, Singhal, and Subramanian, 2010).   Assuming that the market is efficient, if investors hold a positive view of the actions announced by the corporation, in other words, if they think the benefits that can be gained by the corporation from carbon reducing actions outweigh the costs, then the corporate stock price after the announcement will be higher than the normal level of change.   On the other hand, if the views held are negative, then the change in the corporate stock price after the announcement will be lower than the normal level of change.

This study applied an event study methodology to changes in the AR of corporate share prices after carbon-reducing action announcements to explore the views of the parties of interest on various carbon-reducing actions, in addition to the impact of investor valuation of corporate announcements of carbon-reducing actions on corporate market value.   Compared to other carbon emission reduction strategies, carbon footprint disclosure is less costly than improving the production process or revamping equipment.   Thus, carbon footprint disclosure has an external benefit.   This paper aims to determine how investors and consumers react to carbon footprint disclosure by

observing abnormal returns and the subsequent sales growth. The promotion of carbon emission reduction is proposed and executed over several years. If people become more aware of the importance of carbon emission reduction, then the market reaction is expected to become more positive in a later period.

II. Methods

In order to observe corporate share prices after carbon-reducing action announcements, this study applied an event study methodology. An event study is a market model return method.   We used the market model return method because it is based on the efficient market hypothesis (EMH).   In finance, the EMH asserts that financial markets are "informationally efficient."   In consequence of this, one cannot consistently achieve returns in excess of average market returns on a risk-adjusted basis, given the information available at the time the investment is made.   The EMH claims both that prices reflect all publicly available information and that prices instantly change to reflect new public information.

The event study methodology was first proposed by Ball and Brown (1968) and Fama *et al.* (1969), and it was mainly designed to investigate whether certain events (corporate dividend declarations or earnings statements) would trigger abnormal changes in stock prices, thus leading to abnormal returns (ARs).   ARs are also called excess returns, prediction errors, or residuals.   This information can be used to understand whether the market price of a security is associated with a particular event. It mainly uses statistical methods to test the status of an AR, that is, to determine whether the expected AR is zero.   The null hypothesis is $H_0 : E(R_i \mid event) - E(R_i) = 0$, where $E(R_i \mid event)$ and $E(R_i)$ represent the expected rate of return with and without the occurrence of event, respectively, in order to understand whether such an event could have an impact on the corporate share price.   In addition to ARs, this study also considered the cumulative abnormal return (CAR) variable to determine the cumulative effects of an event over a certain period.

To be more precise, an event study is a statistical method used to assess the impact of an event on the value of a firm. For example, the announcement of a merger between two business entities can be analyzed to determine whether investors believe the merger will create or destroy value. The fundamental goal is to find the abnormal return that is attributable to the event being studied by adjusting for the return that stems from the price fluctuation of the market as a whole.

Because the event methodology can be used to determine the effects of any type of event on the direction and magnitude of stock price changes, it is very versatile. Event studies are thus common in various research areas, such as accounting and finance, management, economics, marketing, information technology, law, and political science.

One factor often used to structure the overall body of event studies is the breadth of the studied event types. On the one hand, there is research investigating stock market responses to economy-wide events (i.e., market shocks, such as regulatory changes or catastrophic events). On the other hand, event studies are used to investigate stock market responses to corporate events, such as mergers and acquisitions, earnings announcements, debt or equity issues, corporate reorganizations, investment decisions, and corporate social responsibility (MacKinlay, 1997; McWilliams and Siegel, 1997).

In general, the event study methodology used to estimate the expected return on a stock is mainly divided into mean adjusted return, market-adjusted return, and market model return. According to Brown and Warner (1980; 1985), the results obtained from the three methods are not very different. This study used the most commonly applied method: market model return. According to the market model return method, the expected rate of return of corporate shares is expressed as shown in Eq. (1):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{1}$$

Where R_{it} represents the rates of return on the stock of company i during period t, R_{mt} represents the daily return of the market portfolio during period t, and α_i is the intercept. R_{mt} is the market risk-free rate of return during period t, β_i measures the systematic risk of the corporate stock during period t, and ε_{it} is the error term.

In terms of AR calculation, after using Eq. (1) to determine the expected daily return rate of company i's stock during period t, which is then compared to the actual daily return rate of company i's stock on the day of the carbon-reducing action announcement, the difference obtained is the AR resulting from company i's carbon reduction announcement, as in Eq. (2)

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

Also, CAR is simply the accrued daily AR of a specified period, as in Eq. (3).

$$CAR_{iE} = \sum_{j=1}^{E} AR_{ij} \tag{3}$$

Where E is the selected period for calculating CAR. The definitions of all related variables and the corresponding data resources are presented in Table 1.

In addition to observing corporate share prices after carbon footprint disclosure announcements, this study also used the change in sales growth to measure the production market reaction. To avoid the impact of outliers on stock returns, we used a 90 percent winsorisation to replace the observations from the 5th percentile and below, as well as from the 95th percentile and above.

This study uses the data of non-financial listed companies from nine East Asian countries: Taiwan, Japan, Hong Kong, Korea, Singapore, China, Indonesia, Malaysia, the Philippines, and Thailand. The number of sample companies is 2,385, and the number of carbon footprint disclosure announcements is 132. This study used the keyword "carbon footprint disclosure" and searched the main newspapers of those nine

East Asian countries. (Note 1)   The corporate share prices data then were collected from the Taiwan Economic Journal (TEJ) database (Taiwan Economic Journal, 2014). The TEJ was founded in April of 1990 in Taiwan.   It provides the most accurate and reliable data regarding companies throughout Asia.   In addition to the tremendous depth and breadth of the financial and corporate data, it offer the most timely updates on Asia countries, and it is one of the preferred data sources of the most sophisticated and demanding analysts in the world.   This is because only the TEJ now offers the most complete database for these nine major countries in Asia and carbon footprint data have been recorded in the TEJ event database since 2006.   Thus, our sample only included firms from Taiwan, Japan, Hong Kong, Korea, Singapore, China, Malaysia, the Philippines and Thailand from 2006 to 2011.

Table 1. Variables, definitions, and data sources

Variable	Notation	Definition	Data resource
Stock return of company i	R_{it}	The rates of return on the stock of company i in period t	TEJ
Stock return of market	R_{mt}	The daily return of a market portfolio in period t; it is also the market risk-free rate of return in period t	TEJ
Intercept	α_i	Intercept	
Systematic risk	β_i	The systematic risk of corporate stock in period t	
Error term	ε_{it}	Error term	
Abnormal return	AR	The market price of a security is associated with a particular event; it is the difference between the actual return of a security and the expected return on the event day	TEJ
Cumulative abnormal return	CAR	The market price of a security is associated with a particular event; it is the sum of all the differences between the actual return of a security and the expected return up to a given point in time	TEJ

Source: Arranged by this study.

III. Results and Discussion

All samples of the distribution status and descriptive statistics for each country regarding carbon footprint disclosure announcements are listed in Table 2. Table 2 shows the various statuses of carbon footprint disclosure announcements in nine East Asian countries. Japan has the highest total announcement frequency, with the Philippines, Malaysia, and Thailand being the countries with lower announcement frequencies. In terms of the average announcement frequency per company, Japan and Singapore have the highest, and Hong Kong, Korea, and Taiwan are in second. China follows, with the Philippines, Malaysia, and Thailand being the countries with the lowest announcement frequency per company. The average announcement frequency per company seems to be related to the level of national economic development because the more countries with higher announcement frequencies, Japan, Singapore, Hong Kong, Korea, and Zealand, are all developed countries, while developing countries, such as China, the Philippines, Malaysia, and Thailand, have lower announcement frequencies per company.

The total numbers of carbon footprint disclosure announcements for the countries are as follows: Hong Kong had 15, Japan had 43, Korea had 19, Singapore had 11, Taiwan had 13, China had 22, Malaysia had four, the Philippines had two, and Thailand had three. However, in both developed countries and developing countries, the percentage of carbon footprint disclosure announcements is low. The percentage of overall sample is 5.53% (132/2385). Among developed countries, Hong Kong's is 3.77% (15/398), Japan's is 9.31% (43/462), Korea's is 5.19% (19/366), Singapore's is 5.70% (11/193), Taiwan's is 4.61% (13/282); among developing countries, China's is 3.69% (22/596), Malaysia's is 10.81% (4/37), the Philippines's is 9.09% (2/22), and Thailand's is 10.34% (3/29).

Table 2. Carbon footprint disclosure announcement distribution situation and descriptive statistics of AR and CAR

Descriptive statistics of AR and CAR	Country								
	China	Hong Kong	Japan	Korea	Malaysia	Singapore	Philippines	Taiwan	Thailand
Average AR of the firms' carbon footprint disclosure	0.0310	0.0583	0.0396	0.0407	0.0353	0.0406	0.0198	0.0354	0.0295
Max AR of the firms' carbon footprint disclosure	0.0801	0.0669	0.0722	0.0650	0.0770	0.0735	0.0421	0.0565	0.0594
Min AR of the firms' carbon footprint disclosure	-0.0211	-0.0249	-0.0136	0.0206	-0.0198	0.0120	-0.0160	-0.0108	-0.0082
Average CAR (3,3) of the firms' carbon footprint disclosure	0.0522	0.0692	0.0554	0.0605	0.0571	0.0536	0.0386	0.0622	0.0502
Max CAR (3,3) of the firms' carbon footprint disclosure	0.1355	0.1064	0.1409	0.0967	0.1590	0.1170	0.0924	0.1917	0.1302
Min CAR (3,3) of the firms' carbon footprint disclosure	0.0098	0.0110	0.0223	0.0326	0.0144	0.0289	0.0073	0.0361	0.0232
Average CAR (5,5) of the firms' carbon footprint disclosure	0.0534	0.0658	0.0510	0.0664	0.0620	0.0491	0.0406	0.0594	0.0517
Max CAR (5,5) of the firms' carbon footprint disclosure	0.1407	0.1197	0.1274	0.1058	0.1678	0.1203	0.1105	0.1760	0.1244
Min CAR (5,5) of the firms' carbon footprint disclosure	0.0162	0.0064	0.0183	0.0401	0.204	0.0167	0.0141	0.0288	0.0260
Number of listed sample companies	596	398	462	366	37	193	22	282	29
Number of announced companies	22	15	43	19	4	11	2	13	3
Percentage %	3.69	3.77	9.31	5.19	10.81	5.70	9.09	4.61	10.34

Source: Estimate by this study

Notes: Sample period: January 1, 2006 ~ December 31, 2011. The unit of AR and CAR is percentage. Total number of observations is 132.

Table 3 shows AR, CAR, and sales growth rate after the firms' carbon footprint disclosure during 2006-2011, Table 4 shows the significant changes linked to the firms' carbon footprint disclosure.

Table 3. AR, CAR, and sales growth rate after the firms' carbon footprint disclosure: 2006 to 2011

Type of sample	2006	2007	2008	2009	2010	2011
Overall sample						
AR (%)	0.0335	0.0132	0.0488	0.0642	0.0741*	0.0757*
CAR (3,3) (%)	0.0679	0.0625	0.0922	0.1101	0.1379*	0.1457*
CAR (5,5) (%)	0.0839	0.0857	0.1084	0.1241	0.1411*	0.1452*
Difference in sales growth rate	-0.0112	0.1342	0.0263	-0.0937	0.0312	0.0755
Developed countries						
AR (%)	0.0589	0.0436	0.0612	0.0683	0.0824*	0.0792**
CAR (3,3) (%)	0.0967	0.1019	0.1130	0.1226	0.1563*	0.1665*
CAR (5,5) (%)	0.1113	0.1186	0.1322	0.1440	0.1678*	0.1721*
Difference in sales growth rate	0.0239	0.0545	-0.0274	-0.0861	-0.0290	0.0169
Developing countries						
AR (%)	-0.0354	-0.0497	0.0138	0.0492	0.0513	0.0664*
CAR (3,3) (%)	-0.0104	-0.0190	0.0334	0.0645	0.0871	0.0896*
CAR (5,5) (%)	0.0096	0.0174	0.0410	0.0512	0.0673	0.0728*
Difference in sales growth rate	-0.1066	0.2992	0.1785	-0.1218	0.1972	0.2335

Source: Estimated by this study

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The total number of observations is 132.

In Table 3, we set the event window to be three days or five days from the announcement date to calculate the abnormal return resulting from the carbon footprint disclosure.　We report the empirical results separately to control for differences between the developed countries (Japan, Singapore, Hong Kong, Korea, and Taiwan) and the emerging countries (China, the Philippines, Malaysia, and Thailand) (Sharfman and Fernando, 2008).　Table 2 shows that the abnormal return in developed countries was significantly positive in 2010 and 2011.　However, in

both developed and developing countries, neither the abnormal return nor the cumulative abnormal return for carbon footprint disclosure announcements are significant before 2010 (2006, 2007, 2008, 2009); on the other hand, the abnormal return in emerging countries was only significantly positive in 2011.   There was no significant change in the sales growth rate after carbon footprint disclosure before 2010.

In Table 4, we compared the abnormal return and the change in the sales growth rate for each year.   Table 4 also shows that the abnormal stock return and the change in sales growth improved over time.   The difference between the abnormal return and the change in sales growth in 2006 and those in 2011 is significant.   However, the extent of the increase is limited.

Table 4. Significant changes linked to the firms' carbon footprint disclosure

Type of sample	2006– 2007	2007– 2008	2008– 2009	2009– 2010	2010– 2011	2006– 2011
Overall sample						
ΔAR (%)	-0.0203	0.0356*	0.0154	0.0099	0.0016	0.0422*
ΔCAR (3,3) (%)	-0.0053	0.0297*	0.0179	0.0278*	0.0078	0.0778*
ΔCAR (5,5) (%)	0.0017	0.0228	0.0156	0.0170	0.0042	0.0613*
Δdifference in sales growth rate	0.1454	-0.1079	-0.1201	0.1248	0.0444	0.0867
Developed countries						
ΔAR (%)	-0.0153	0.0176	0.0071	0.0141	-0.0032	0.0203*
ΔCAR (3,3) (%)	0.0052	0.0111	0.0096	0.0337*	0.0102	0.0698*
ΔCAR (5,5) (%)	0.0073	0.0136	0.0118	0.0238*	0.0043	0.0608*
Δdifference in sales growth rate	0.0306	-0.0819	-0.0586	0.0570	0.0459	-0.0070
Developing countries						
ΔAR (%)	-0.0142	0.0635*	0.0354*	0.0021	0.0151	0.1018**
ΔCAR (3,3) (%)	-0.0086	0.0524*	0.0311*	0.0226*	0.0025	0.1001**
ΔCAR (5,5) (%)	0.0078	0.0236*	0.0102	0.0161*	0.0055	0.0632*
Δdifference in sales growth rate	0.4058	-0.1207	-0.3003	0.3190	0.0363	0.3401

Source: Estimate by this study

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

IV. Conclusion

This study tested the reaction of the capital market and the production market to firms' carbon footprint disclosures. Based on our empirical results, the market reaction to carbon footprint disclosures is not significant. After 2010, the stock market reaction to carbon footprint disclosure and the increase in abnormal returns were significantly positive, but the magnitude of the abnormal returns was small. There was no significant increase in sales.

Market investors are especially interested in whether corporate decision brings direct and significant profits. Investors obviously have their doubts regarding the profit generated by carbon footprint disclosure because there is no significant improvement in the sales growth rate after carbon footprint disclosure. When we observe the evidence over the long run, there is no significant sales growth from 2006 to 2011 for firms that announced carbon footprint disclosure. However, the abnormal stock return increased significantly for carbon footprint disclosure announcements. The results show that investors still expect potential profits from carbon footprint disclosure; even there is no significant increase in sales growth.

A further point of interest is how firms treat the market reaction. According to voluntary disclosure theory (Milgrom, 1981; Verrecchia, 1994), firms with superior performance have more motivation to disclose information. Our results imply that the market reaction is minor, even for firms with a lower carbon footprint. The Carbon Emissions Reduction Act is voluntary. Because the market reaction is minor now, it may be necessary to adopt a more aggressive policy to provide firms with motivation to disclose their carbon footprints. In other words, the government could attempt to increase the profit of firms that disclose their carbon footprints. PAS 2050, created by the British Standards Institution, and ISO 14067, created by the International Organisation for Standardisation, are influential production

regulations in every country.   Furthermore, the government could provide preferential tax treatment for firms that disclose their carbon footprints or set restrictions on the sale of products without carbon footprint disclosure.   These are the feasible strategies that governments can use to promote carbon emission reduction.

According to the results, the magnitude of the abnormal returns was small, and there was no significant increase in sales growth.   However, according to the discussion with Brown and Dacin (1997), Sen and Bhattacharya (2001), and Côté, Booth and Louis(2006), the certainty and size of the benefits to carbon-reducing firms are not great enough to cover the related costs.   However, through carbon footprint disclosure, consumers can learn how much carbon emissions are associated with their consumption, and carbon emissions can become a part of their consumption decisions (Limnios *et al.*, 2009).   We think that carbon-reducing firms should have optimistic expectations for the future.

Endnotes

1. The main newspapers included Taiwan: Taipei Times, The China Post, Taiwan News; Japan: The Japan Times, The Daily Yomiuri, NIKKEI NEWS; Hong Kong: Hong Kong Economic Times, Wenweipo, The-Sun; Korea: JoongAng Ilbo English News, The CHOSUNILBO, The Korea Herald; Singapore: AsiaOne; China: People, XINHUANET, XINMIN; Indonesia: ANTARA news; Malaysia: The Star Online; Philippines: Manila Bulletin, Manila Times, Philippine Star; Thailand: Bangkok Post, The Nation ETNA.

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市場對於廠商碳足跡揭露的反應
—東亞九國的證據

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　　本研究測試了資本市場和產品市場對於廠商進行碳足跡披露的反應，以九個東亞國家由 2006 年至 2011 年的資料進行。資本市場部分，廠商進行碳足跡披露宣告所產生的異常報酬在 2010 年以後是正值，但程度很小。而在產品市場方面，碳足跡披露對於廠商的銷售成長率並沒有造成顯著變化。證據顯示，碳足跡揭露的利益是不顯著。因此有必要訂定更完善的法律或規範，以促進廠商的碳排放披露。

關鍵詞：碳足跡揭露、市場反應、事件研究法、東亞

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