Firm-Value Effects of Carbon Emissions and Carbon Disclosures: Evidence from Taiwan

ABSTRACT

Extant accounting research based on data from the U.S., Europe, and Australia finds that increases in carbon emissions are associated with lower firm value. However, recent research indicates that investors' perspectives on corporate social responsibility (CSR) in other parts of the world differ from those of Western investors. This study investigates whether increases in carbon emissions, as one indicator of poor CSR performance, are also associated with lower firm value in Taiwan. Using carbon disclosure data from Taiwanese listed companies between 2012 and 2016, we find that firm value is positively associated with carbon emissions, which contrasts with the findings of extant research. Likewise, firm value is not associated with a combined measure of financial information and carbon emissions in Taiwan. Our findings suggest that international generalizations of the findings of the extant research on the relationship between carbon emissions and firm value should be undertaken with caution.

Keywords: Firm value, voluntary, carbon emissions and disclosures, Taiwan.
JEL Codes: G32, M4, M48, Q56.

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I. INTRODUCTION

Most extant studies in the field of accounting suggest that reductions in carbon emissions are associated with higher firm value (e.g., Chapple, Clarkson, and Gold 2013; Matsumura, Prakash, and Vera-Muñoz 2014; Clarkson, Li, Pinnuck, and Richardson 2015; Griffin, Lont, and Sun 2017; Cooper, Raman, and Yin 2018; Ott and Schiemann 2019). These studies focus on Western contexts, however, and there has been little analysis of non-Western settings.[1] Using cross-country data, Hassan and Romilly (2018) also find a negative relationship between carbon emissions and firm value in both developing and developed countries. Their results do not show major differences in the perceptions of carbon emissions among investors in different countries.

However, previous studies find that perceptions among investors in different countries of how well companies perform at disclosing social and environmental information may differ (e.g., Muirhead, Bennett, Berenbeim, Kao, and Vidal 2002; Chapple and Moon 2005; Orij 2010). In particular, Feng, Wang, and Huang (2015) provide empirical evidence that companies

[1] In this paper, Western and Eastern countries are distinguished on the basis of their respective cultural and historical backgrounds. Specifically, the Western countries mentioned in this paper include the US, European countries, and Australia, whereas the Eastern countries in this paper refer to countries in East Asia and South Asia, including Taiwan and India.

that perform better at social and environmental disclosure experience lower costs of capital in North America and in Europe, but the opposite is true in Asia, where firms incur higher costs of capital. Manchiraju and Rajgopal (2017) also document the negative impact of such evidence of corporate social responsibility (CSR) on stock prices in India. In addition, Chapple and Moon (2005) point out that, on average, Asian countries with very different institutional settings from those found in Western countries may find it more challenging to implement social responsibility. This academic viewpoint is also supported in practice. For instance, under the auspices of the United Nations (UN), the Principles for Responsible Investment (PRI) suggests that generally, investors and governments in Asia are not concerned about environmental and social issues to the degree that those in North America and Europe are.[2] Scholars also point out that the existing research on the impact of carbon disclosures on capital markets is limited, and they urge that further work be done to more fully understand this impact (Hahn, Reimsbach, and Schiemann 2015).

Hence, this study aims to extend the current research which focuses on Western countries (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018) by examining whether their results are valid in Asia. This paper investigates listed firms in Taiwan, a country where the per capita carbon emissions were the 19th highest in the world during the period under investigation (International Energy Agency 2017).[3] We

[2] See the report at: http://www.eco-business.com/news/how-asian-investors-can-step-up-their-esg-integration/
[3] This figure was even higher than those for Japan, China, and the OECD average. See the report at: https://www.worldometers.info/co2-emissions/taiwan-co2-emissions/

manually collect the data on the carbon emissions of Taiwanese companies from 2012 to 2016, with a final sample of 669 observations, and we examine whether each firm's level of carbon emissions affects its value. In contrast to earlier findings derived from Western settings, including the U.S., Europe and Australia (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018; Ott and Schiemann 2019), a positive relationship between carbon emissions and firm value is found in Taiwan. This finding supports the argument that investors in Asia, or at least those in Taiwan, have different perceptions of corporate environmental reporting than those observed in Western countries (Feng et al. 2015; PRI 2016). We further examine whether the decision to voluntarily disclose carbon emission levels affects firm value. In contrast to the findings of previous studies (Matsumura et al. 2014), we do not find any evidence to support the existence of a positive impact of voluntary carbon disclosures on firm value, compared with the non-disclosure of such information. Likewise, firm value is not associated with a combined measure of financial information and carbon emissions in Taiwan.

Several explanations are possible for the discrepancy between the situations in Taiwan and in Western countries. Firstly, Taiwanese regulators currently do not impose strict regulations on carbon emissions, and corporate environmental liability in Taiwan is not as stringent as it is in Western countries. For example, there is no specific cap on the carbon emissions produced by Taiwanese companies, and they are not required to disclose direct

carbon emissions, which is required in the U.S. and the U.K. (U.S. Environmental Protection Agency 2009, 2011; Downar, Ernstberger, Reichelstein, Schwenen and Zaklan 2021). Therefore, high carbon emissions may not significantly increase the potential legal risks and legal compliance costs of Taiwanese companies.

Secondly, compared with Western investors, Taiwanese investors are more likely to regard efforts involved in implementing the practice of carbon disclosures and in decreasing carbon emissions as additional costs that may lower corporate profits (PRI 2016). As indicated by Feng et al. (2015), in contrast to Western companies, Asian companies with a better CSR performance incur a higher cost of capital because Asian investors mainly emphasize the costs of CSR rather than its possible benefits. In Taiwan, prioritizing *cost reduction* is crucial to business operations, and local investors may not appreciate activities that increase corporate costs (Wang 2017). This is true particularly because the concept of environment sustainability is still undervalued in Taiwan.

Thirdly, many Taiwanese companies are involved in carbon-intensive industries, as defined by the Materiality Map of the Sustainability Accounting Standards Board (SASB) in the U.S. High carbon emissions suggest that a firm's production activities are active (Niu, Ding, Niu, Li, and Luo 2011; SASB 2017a), which signals to investors that the firm is operating soundly. Finally, the lack of public attention directed at corporate sustainability and the absence

of definite guidance from the government may also contribute to this result.[4]

The present study makes some contributions to both theory and practice. First of all, this paper expands the scope of the extant literature which documents a negative association between firm value and carbon emissions on the basis of data from the U.S., Europe and Australia (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Cooper et al. 2018; Griffin et al. 2017; Ott and Schiemann 2019). However, these studies look at Western capital markets whose stakeholders are much more mature in their understanding of CSR than their Eastern counterparts, and as such their conclusions do not necessarily apply to Eastern countries. For example, in contrast to research carried out in Western settings, Chen, Hung, and Wang (2018) show that mandatory CSR disclosures negatively impact the firm performance of Chinese companies. Manchiraju and Rajgopal (2017) also find negative market reactions to Indian firms which are required to spend money to ensure a good CSR performance in order to comply with the Indian Companies Act 2013. We provide incremental evidence to demonstrate that evidence of a lack of CSR such as an increase in carbon emissions fails to affect investors' decisions (like selling shares) in Taiwan. It must be stated that, to the best of our knowledge, this is the first time that a positive relationship between carbon emissions and firm value is found. This finding strengthens the contention in prior research (Muirhead et al. 2002; Feng et al. 2015; Manchiraju and Rajgopal 2017; Chen et al., 2018) that investors in Asia

[4] See the full text of a report on a public opinion poll at https://www.taiwannews.com.tw/ch/news/3370133

perceive CSR disclosures differently from those in Western countries. We thus suggest that the generalization of such conclusions as those derived from Western-based research settings should be made and interpreted with caution.

In addition, our results reinforce the suggestion of the PRI (2016) that it is difficult to achieve the goal of reducing carbon emissions without the support of investors in various parts of the world, particularly when the main industries in a given jurisdiction are carbon-intensive and when the concept of sustainability is undervalued, such as is the case in Taiwan. Our findings provide practical insights which can be used to inform policymakers and stakeholders (e.g., managers and investors) that promoting CSR is growing in popularity and indispensable in some Eastern countries. We urge regulators and researchers in Eastern countries to put more effort into enhancing the public's and the stakeholders' understanding of environmental, social and corporate governance (ESG). This paper also contributes to the literature on how carbon disclosures affect capital markets (Hahn et al. 2015). Current research often shows that carbon disclosures help to convey insider information, which reduces the information asymmetry between management and stakeholders (Schiemann and Sakhel 2019). However, as suggested by our findings, it may be difficult to understand the significance of raw data on carbon emissions or to make cross-country comparisons, for example between the U.S. and Taiwan. Furthermore, from the perspective of the information transfer function proposed by Eccles and Krzus (2014), it can be said that, for the purpose of making cross-firm comparisons,

stakeholders may consider using compared measures (e.g., the ratio of carbon emissions to sales) to further understand the environmental costs that firms incur when generating profits and so choose to invest in firms with lower environmental costs per unit.

This paper also provides insights into the current state of carbon emissions that could be useful for international authorities and policymakers. Even though the UN (2015) has actively promoted the Sustainable Development Goals (SDGs) in recent years, our results suggest that the commitment of companies around the world to reduce their carbon emissions has not been consistent. The lack of diligence in legally enforcing the Paris Agreements leaves companies with little incentive to change their production behaviors and internalize environmental costs (Bledsoe 2020), resulting in profit maximization still being the priority for certain companies. Our evidence shows that companies will not be fully incentivized to reduce their carbon emissions if they are merely required to disclose their carbon emissions. Regulators, especially those in Taiwan and other parts of Asia, should find more effective solutions (e.g., enforcing a specific cap on emissions, implementing a carbon tax, and designing reward systems for reducing emissions) in order to urge or encourage companies to control their carbon emissions. In addition, our results echo the suggestion made by the European Commission (2018) that it might be helpful to consider regional differences between investors when incorporating carbon emissions information into credit rating scoring systems as part of the EU's action plan for financing sustainable growth. This study also suggests that management reassess whether they

should voluntarily disclose their firm's carbon emissions. Since investors in Western countries (such as the U.S. and European countries) and in Asian countries (such as Taiwan) respond to carbon emissions disclosures very differently, managers should carefully consider the discrepancies between different markets and regional investors when making decisions related to social and environmental disclosures.

The rest of the paper is organized as follows: Section 2 explains background information on the issue of carbon emissions, including relevant regulations in Taiwan. Section 3 reviews the literature in this field and develops the research hypotheses. Section 4 discusses the research design and sample used. Section 5 analyzes the results using robustness tests. The final section summarizes the entire paper and identifies limitations of the study and directions for future research.

II. BACKGROUND

It is commonly acknowledged that carbon emissions increased rapidly and significantly after the Industrial Revolution (National Oceanic and Atmospheric Administration 2020; American Chemical Society 2021). This was mainly due to how fossil fuels were consumed by households and used for manufacturing, which has resulted in severe climate change and high environmental risks. Church et al. (2013) state that the sea level, before 2100, is expected to rise by 28 to 98 centimeters with the current targets for reducing carbon emissions. Hinkel et al. (2014) further point out that a huge number of assets, "$17 trillion in coastal assets" and

$210 trillion “in a more populous area”, will be endangered due to this rise in sea level.

In order to control carbon emissions and alleviate the negative impacts of climate change, countries across the world have developed various agreements cooperatively. The most significant agreements include the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 1997 Kyoto Protocol. In 2015, the UN (2015) announced the 2030 Agenda for Sustainable Development, which urges countries to respond expeditiously to climate change by implementing appropriate policies and strategies. Accordingly, there has been increasing interest in understanding how this issue affects capital markets and corporate disclosures (Stanny and Ely 2008; Matsumura et al. 2014).

Previous studies state that the topic of carbon emissions has recently received great attention from investors, managers, and credit rating institutions (Barley 2009; Fornaro, Winkelman, and Glodstein 2009; Matsumura et al. 2014). Investors and credit rating institutions integrate this environmental risk into their decisions regarding firm valuation. For example, Amel-Zadeh and Serafeim (2018) indicate the main reason for investors to use environmental, social, and governance information is that such information is relevant to evaluating the performance of their investments. This stimulates companies to respond more actively to calls for the reduction of carbon emissions because the potential costs, such as fines for violating regulations and higher capital costs, are significant. The lack of action taken by the U.S. government to reduce carbon emissions is inconsistent with the admirable efforts of

the public and businesses in the U.S. to tackle this issue. A case in point is the declaration made in 2017 by then-U.S. President Donald Trump that the U.S. would withdraw from the Paris Agreements.

Regulations in Taiwan

In 2012, the Taiwanese government announced that the *Management Regulations Governing Greenhouse Gas Emissions Reporting* would require all Taiwanese companies to report their carbon emissions through the Greenhous Gas (GHG) Registry platform (see Appendix I for the timeline of the enactment of relevant regulations in Taiwan). Exemptions are given to companies whose carbon emissions are less than 25,000 metric tons for five consecutive years or less than 15,000 metric tons for three consecutive years. The information on carbon emissions provided by companies is required to be certified by qualified institutions.[5] Although this information is not available to the public, the mandatory reporting of carbon emissions, on the one hand, helps reduce the information asymmetry between companies and regulators and, on the other, helps the government to better control carbon emissions and design and enforce relevant regulations (Minnis and Shroff 2017).

In 2015, the Taiwanese government established a new regulation, the *Greenhouse Gas Reduction and Management Act*, with the aims of better adapting to climate change and ensuring the sustainable development of the country (Environmental Protection Administration

[5] These institutions need to satisfy the criteria (such as meeting ISO requirements and being a member of the International Accreditation Forum) set by the regulator (i.e., the Environmental Protection Administration of Taiwan) to obtain the regulator's approval for providing carbon certification services.

of Taiwan 2015). With the help of this new act, the authority also aims to effectively reduce and manage carbon emissions in order to (1) contribute to the global environment and enhance the country's international reputation, and (2) promote green (i.e., low-carbon) growth domestically. Following this, the *Enforcement Rules* were announced in 2016 which replaced the 2012 regulations while retaining the focus on carbon-intensive industries and companies with carbon emissions higher than 25,000 metric tons (see Appendix I). In conjunction with this new set of regulations, the authority also released a list of the first group of firms required to mandatorily report their carbon emissions.

The Taiwanese government also proposed the idea of "total amount control" for the first time in the 2015 *Greenhouse Gas Reduction and Management Act*, explaining that to effectively reduce carbon emissions within a specific period of time, limits on carbon emissions should be imposed on companies. The government also stated that the allowance for carbon emissions could be traded when the policy of "total amount control" is in place. However, this regulation is not specific enough, and the definition of the carbon emissions limit is very vague. In addition, it is not specified when "total amount control" will be implemented. Finally, the regulation does not address legal enforcement measures (e.g., fines) to be used against offenders if carbon emissions are higher than the limit. Hence, it is unclear whether or not this new regulation will really help to reduce overall carbon emissions.

III. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Matsumura et al. (2014) investigate the carbon emissions of American S&P 500 firms and find a negative association between carbon emissions and firm value. They explain that the environmental risks and costs involved in complying with regulations are increasing, which may affect investors' judgement of firm value. Additionally, high carbon emissions may have a significant negative impact on efforts to ensure the sustainability of a firm. The cause of this adverse effect is that investors may be concerned about the sustainability of companies with high carbon emissions, therefore resulting in a lower firm value (Thaler and Sunstein 2008). This argument is supported by other studies (Clarkson et al. 2015; Griffin et al. 2017; Hassan and Romilly 2018). For example, in an examination of the same issue with a different method, Griffin et al. (2017) find a negative association between firm value and carbon emissions in the U.S., a finding that Cooper et al. (2018) and Ott and Schiemann (2019) also observed using more recent data from the U.S. Other Western studies show similar results using data in European countries and Australia (Chapple et al. 2013; Clarkson et al. 2015), although Liesen, Figge, Hoepner, and Patten (2017) fail to identify a significant impact of carbon emissions on portfolio returns in Europe. Using data from both developing and developed countries, Hassan and Romilly (2018) also indicate that carbon emissions are negatively associated with firm value. As shown in Appendix II, most existing research focuses on Western data. Although Hassan and Romilly (2018) examine the relationship between carbon emissions and firm value

in both the developing and developed worlds, they do not investigate whether their results would be different in a non-Western setting.

As emphasized above, the prior research on carbon emissions focuses heavily on Western data and often documents a negative effect of carbon emissions on firm value, but there has been little discussion of such an impact of carbon emissions in non-Western settings. It is true that individual attitudes towards environmental protection often vary across countries. For example, using international data, Cahan, De Villiers, Jeter, Naiker, and Van Staden (2016) show that investors give more credit to the CSR disclosures of a company which is in a country with a weaker institutional setting in terms of politics, culture, and education. Furthermore, Muirhead et al. (2002) conduct a survey to examine whether senior managers agree that CSR performance contributes to the future success of firms internationally. The responses reveal that more than 50 percent of managers in Western countries believe that CSR is "extremely helpful" or "somewhat helpful." In contrast, more than 60 percent of managers in Asia consider CSR to be "not very helpful" or "not helpful at all" to the future success of firms.

These viewpoints are reinforced by empirical evidence. El Ghoul, Guedhami, Kwok, and Mishra (2011) and Feng et al. (2015) find that the cost of capital of Western companies is lower when their CSR performance is better. Nevertheless, Feng et al. (2015) further explore the situation in Asia and remarkably find that CSR performance and the cost of capital are positively correlated, suggesting that Asian investors do not appreciate companies putting

money into CSR. Similarly, Manchiraju and Rajgopal (2017) find that capital markets may respond negatively to CSR. Using data from India, they show that mandatory CSR spending leads to reduced stock prices. Conversely, focusing on Chinese data, Wang and Li (2016) document a positive relationship between first-time CSR disclosures and firm value. However, they do not further investigate whether any specific information or content disclosed in the CSR reports leads to this result. Since current findings on the impact of CSR in Asia are inconsistent and little is known about how Asian investors respond to carbon emissions disclosures, we aim to add to the existing research in this area (Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Hassan and Romilly 2018).

It should also be mentioned that the relatively loose regulations and the weaker legal enforcement practices related to carbon emissions in many Asian countries may lead to reports of a lower environmental risk for Asian companies, and thus investors regard this risk as immaterial. Companies with a better CSR performance also experience additional costs, such as those required for improving business processes and purchasing new equipment, which in the end may not guarantee a profit (PRI 2016).

Furthermore, carbon emissions may provide an indication of the level of production activities. For example, prior studies using country-level data document a positive relationship between carbon emissions and energy consumption (Ang 2007; Apergis and Payne 2009, 2010). Several scholars also find that the economic performance of a country is positively associated

with its level of carbon emissions (Halicioglu 2009; Menyah and Wolde-Rufael 2010; Niu et al. 2011; Arouri, Youssef, M'henni, and Rault 2012). Hence, the corporate disclosure of high carbon emissions could be viewed by investors as a positive sign of strong current productivity leading to future profits.

The factors discussed above suggest a positive relationship between carbon emissions and firm value; on the other hand, the theories and arguments provided by researchers addressing sustainability (Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018; Hassan and Romilly 2018; Ott and Schiemann 2019) suggest a negative relationship. Hence, we state the following hypothesis, without predicting a specific direction:

H_1: Firm value is associated with carbon emissions in Taiwan.

As indicated above, in the relevant literature, firm value is generally found to be negatively associated with carbon emissions. It is thus crucial to understand why firms would voluntarily disclose their carbon emissions if doing so has a negative impact on firm value (Matsumura et al. 2014; Griffin et al. 2017). Matsumura et al. (2014) show that firms which do not engage in such voluntary disclosure suffer from a lower firm value, and they suggest that managers decide to disclose this information voluntarily because the benefits of disclosure outweigh the costs. Furthermore, disclosing information on carbon emissions may reduce information asymmetry and mitigate agency conflicts, thus resulting in a higher firm value.

However, the disclosed information (e.g., information that suggests high environmental risks and costs) and the costs incurred to reveal it (e.g., the costs of ensuring the accuracy of the information and of purchasing measurement equipment) could negatively affect firm value. This negative impact may be augmented, particularly when investors do not appreciate or are not concerned about environmental issues (Feng et al. 2015; PRI 2016; Manchiraju and Rajgopal 2017). For these reasons, we propose the following hypothesis, without predicting the direction of the impact:

H_2: Voluntary carbon disclosure is associated with firm value in Taiwan.

In its conceptual framework, the International Integrated Reporting Council (IIRC 2013) states that "*...the ability of the organization to create value can best be reported on through a combination of quantitative and qualitative information*". This assessment is supported by the US SASB (2017b) which says that the connection between a firm's financial performance and its (non-financial) sustainability indicators is insufficiently disclosed in current practices of sustainability reporting. In reality, however, some companies, such as SAP in Germany, employ online interactive graphics to report the connectivity between their financial performance (e.g., net sales revenues and operating margins) and their sustainability performance (e.g., greenhouse gas emissions and total energy consumed). Recently, researchers who foresee the potential benefits of such connectivity information have increasingly been suggesting that all

stakeholders need to understand the interconnectedness between operating performance and the changing natural environment (Churet and Eccles 2014), because connectivity information may attract more long-term-oriented public investors and fewer transient public investors (Serafeim 2015). If connectivity disclosures are informative in Taiwan, investors are more likely to reward firms that produce relatively lower amounts of carbon emissions in order to create per unit sales and profits.

However, Eccles and Krzus (2014) examine top 500 international companies and find that this connectivity information is lower for firms in Asian countries. It is likely that the value creation resulting from disclosing a combined measure of financial and sustainability information that has been observed elsewhere in the world does not occur in Asia. Therefore, if connectivity disclosures are not taken seriously in Taiwan, investors will be less likely to reward firms that produce relatively lower amounts of carbon emissions in order to create per unit sales and profits. Hence, we propose the following hypothesis:

H_3: Firm value is associated with the amount of carbon emissions produced to create per unit sales and profits in Taiwan.

IV. METHOD

Although Taiwanese firms have been required to report their carbon emissions to the government through the GHG Registry since 2012, this information is not available to public

investors. For this paper, carbon emissions data are collected from the Taiwan Market Observation Post System (MOPS), where firms voluntarily disclose their carbon emissions. Therefore, to avoid incurring sample selection bias, we employ a two-stage Heckman model (1979).[6]

The first-stage Probit model is used to examine the determinants of the voluntary disclosure of carbon emissions (the disclosure-choice model), as shown in Equation 1. The design of this model is based on research by Matsumura et al. (2014).

$$DISC\_CO2_{i,t} = \beta_0 + \beta_1 LnTA_{i,t} + \beta_2 BM_{i,t} + \beta_3 LEV_{i,t} + \beta_4 II_{i,t} + \beta_5 LagDISC\_CO2_{i,t} + \beta_6 EnvISO_{i,t} + \beta_7 EnvIrreg_{i,t} + \beta_8 FRNSALE_{i,t} + \beta_9 IndVolDisc_{i,t} + \beta_{10} EPA_{i,t} + ExchangeD_{i,t} + IndustryD_{i,t} + YearD_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where *DISC_CO2* equals one if a firm voluntarily discloses its carbon emissions, and zero otherwise.[7] *LnTA,* the natural logarithm of total assets, is used to measure firm value, which is

[6] Matsumura et al. (2014) also face potential sample selection bias in their setting. They use the Full Information Maximum Likelihood (FIML) method by simultaneously estimating and reporting two-stage results. We instead report the second stage (Model 2) results after controlling for the Inverse Mills Ratio (IMR) estimated on the basis of the first stage (Model 1) in a step-by-step approach. Although Tucker (2010) indicates that the FIML method is more efficient because it uses all information at once and that formulas might be misused when the IMR is calculated, this study suggests that the IMR method is more popular due to its simplicity of use and its requiring less computing power. In addition, Chiburis and Lokshin (2007) argue that the step-by-step approach of the Heckman model is more robust and has fewer limitations than the simultaneous approach of the FIML. Puhani (2000) also indicates that the two-step method provides reasonable results. Therefore, this method is widely used by other important studies (Omer, Bedard, and Falsetta 2006; Srinidhi, Gul, and Tsui 2011; Goncharov and Peter 2019; Cook, Kim, and Omer 2020). Nevertheless, we still report results based on the FIML method as our robustness tests in the additional analyses.

[7] Although firms whose carbon emissions exceed the threshold (see details in Appendix I) are required to report them to the government, our carbon emissions data are obtained from the MOPS, where firms voluntarily disclose their carbon emissions. Therefore, *DISC_CO2* effectively captures the effect of voluntary disclosures.

often positively correlated with carbon emissions (Stanny and Ely 2008; Stanny 2013). *BM* is the book value divided by the market value, and *LEV* is the leverage, calculated as total liabilities divided by total assets. Sengupta (1998) finds that companies that enjoy a lower cost of debt usually exhibit better reporting quality. Thus, a positive association between *LEV* and *DISC_CO2* is predicted. *II* is the proportion of a firm's shares held by institutional investors. If company shares are mainly held by institutional investors, who often urge companies to practice more transparent reporting (Plumlee, Brown, Hayes, and Marshall 2015), the firms in question may be more likely to disclose their carbon emissions. On the other hand, if companies do not have many institutional investors, they may voluntarily disclose their carbon emissions in order to attract such investors. Hence, the sign of the *II* coefficient is ambiguous. We also control for environmental strengths and concerns by adding *EnvISO* and *EnvIrreg*. *EnvISO* equals one if the firm has obtained ISO certification for its production of greenhouse gases, and zero otherwise. *EnvIrreg* equals one if the firm is involved in irregular environmental activities, and zero otherwise. *EnvISO* and *EnvIrreg* are predicted to be positively and negatively associated with *DISC_CO2*, respectively.

Stanny and Ely (2008) find that EU companies that depend highly on foreign sales are more likely to disclose their carbon emissions. Similarly, Matsumura et al. (2014) indicate that American S&P 500 firms with a higher percentage of foreign sales tend to voluntarily provide information related to their carbon emissions. Accordingly, *FRNSALE,* foreign sales divided

by total sales, is controlled in this model, and its coefficient is expected to have a positive sign. *IndVolDisc* is the proportion of firms in a particular industry that voluntarily disclose their carbon emissions. *EPA* is intended to capture the effect of the mandatory reporting to the GHG Registry. *EPA* equals one if a firm is on the list of the companies in the first group to mandatorily report their carbon emissions or if the carbon emissions it discloses in the MOPS are higher than 25,000 metric tons, and zero otherwise.[8] We anticipate that a positive coefficient of *EPA* will be found. Matsumura et al. (2014) show that firms having previously voluntarily reported their carbon emissions are very likely to continue to do so in the following year. *LagDISC_CO2* aims to capture this effect. It equals one if companies voluntarily disclosed their carbon emissions in the previous year, and zero otherwise. We also use dummy variables to control for the fixed effects of the stock exchange[9], the industry, and year on carbon disclosures.

The second-stage model is a balance sheet valuation model based on the studies of Barth and McNichols (1994) and Matsumura et al. (2014). It is developed to examine the first hypothesis that firm value is associated with carbon emissions in Taiwan, as shown in Equation 2. The Inverse Mills Ratio (IMR) derived from the first-stage Probit model is incorporated into

[8] Since 2012, all Taiwanese firms, except those producing fewer than 25,000 metric tons of carbon emissions in five consecutive years or fewer than 15,000 metric tons in three consecutive years, have been required to report their carbon emissions to the GHG Registry. In 2016, the Taiwanese government announced the list of the first group of firms that are required to report their carbon emissions to the GHG Registry because they exceed 25,000 metric tons. Because the complete list of companies under the obligation of reporting to the GHG Registry is not available, we design the EPA variable to mimic the mandatory reporting requirement.

[9] Some of our firms are listed on the OTC market, which is under governance pressure from regulators at a different level than the pressure applied to the Taiwan Stock Exchange (TSE). Hence, we control for this fixed effect of the stock exchange (Iatridis 2013).

this firm-value model to control for the potential problem of endogeneity.

$$MKT_{i,t} = \beta_0 + \beta_1 TCO2_{i,t} + \beta_2 ASSET_{i,t} + \beta_3 LIAB_{i,t} + \beta_4 OPINC_{i,t} + \beta_5 IMR_{i,t} + ExchangeD_{i,t} + IndustryD_{i,t} + YearD_{i,t} + \varepsilon_{i,t}, \quad (2)$$

where *MKT* is the market value of a firm (in millions of New Taiwan dollars [NTD]) and *TCO2* denotes carbon emissions in thousands of metric tons. This model also controls for total assets (*ASSET*), total liabilities (*LIAB*), and operating income (*OPINC*), as in Matsumura et al. (2014). Following the example of Barth and McNichols (1994), Campbell, Sefcik, and Soderstrom (2003), and Matsumura et al. (2014), we use unscaled market values, which are believed to better capture potential effects compared to scaled market values. Dummy variables for the stock exchange, industry, and year are also included in this model.

To examine the second hypothesis, we first match the firms that disclose their carbon emissions (the disclosing firms) and the firms that do not do so (the non-disclosing firms) with a propensity score, which is estimated with Equation 1. More specifically, we run this equation and obtain the estimated probability of a firm disclosing its carbon emissions for both the disclosing firms and the non-disclosing firms. We then build a matching sample by selecting the non-disclosing firms with the estimated probability that is closest to the probability associated with the disclosing firms. Finally, we run a t-test to determine whether there is a difference in firm value between the disclosing and non-disclosing firms.

To examine the third hypothesis, we adjust Equation 2 by changing the variable of interest, *TCO2*. To control for the potential problem of endogeneity, we also control for *IMR* estimated with Equation 1 to develop the following equation:

$$MKT_{i,t} = \beta_0 + \beta_1 TCO2X_{i,t} + \beta_2 ASSET_{i,t} + \beta_3 LIAB_{i,t} + \beta_4 OPINC_{i,t} + \beta_5 IMR_{i,t} + ExchangeD_{i,t} + IndustryD_{i,t} + YearD_{i,t} + \varepsilon_{i,t}, \quad (3)$$

where *TCO2X* is *TCO2REV*, *TCO2GM*, *TCO2OPINC*, and *TCO2NI*respectively. *TCO2REV* is calculated by dividing carbon emissions by total sales; *TCO2GM* is calculated by dividing carbon emissions by gross margins; *TCO2OPIC* is calculated by dividing carbon emissions by operating income; and *TCO2NI* is calculated by dividing carbon emissions by net income. These variables measure the carbon usage required for the generation of sales and profits.

V. SAMPLE DATA

Our carbon emissions data[10] are manually collected from the MOPS, an official platform managed by the TSE (see Aobdia, Lin, and Petacchi 2015). The MOPS is open to the public and is a major and valid resource allowing investors to access company information. The financial data for Taiwanese listed firms are obtained from the Taiwan Economic Journal (TEJ)

[10] As the regulations in Taiwan do not require companies to indicate whether their carbon emissions are direct emissions (Scope 1 emissions that are directly produced by the reporting entity) or indirect emissions (Scope 2 emissions that come indirectly from the generation of purchased energy), some companies only disclose their total carbon emissions (Greenhouse Gas Protocol 2020). As a result of the lack of specificity of the available data, total carbon emissions, including both direct and indirect, were used in this research.

database. The MOPS and TEJ specialize in Taiwanese data and are widely used in research based in Taiwan (e.g., Chin, Chen, and Hsieh 2009; Aobdia et al. 2015). Our sample period extends from 2012, when carbon emissions data first became available, to 2016. The sample selection process and distribution are shown in Table 1. There is a total of 8,164 firm-year observations, excluding data for financial institutions.[11] After eliminating firms with missing financial data, the final sample comprises 7,350 observations, among which 669 provide carbon emissions data, leaving 6,681 without such data.[12] The observations that include information on carbon emissions account for 9.1 percent of the sample.

[Insert Table 1 here]

VI. RESULTS

Table 2 presents the descriptive statistics for the sample. All continuous variables are winsorized at the top and bottom one percent. Panel A of Table 2 reports the statistics regarding Equation 2 (i.e., the firm-value model). The mean of *TCO2* is 737.74, which is higher than its median value (36.74), and its standard deviation is 2,361.86, which suggests that carbon emissions vary highly across firms. As in Matsumura et al. (2014), we divide the sample with carbon emissions data (669 observations) into EPA firms (*EPA* = 1) and non-EPA firms (*EPA* =

[11] Following the example of previous studies, we omit financial firms because they have very different firm characteristics, which are included in our regression models. For example, we control for firm leverage in Model 1. However, financial firms have very different leverage ratios than non-financial firms do due to their industry-specific characteristics (Fama and French 1992; Foerster and Sapp 2005).

[12] Our sample is composed of 1,584 distinct firms, 212 of which disclose their carbon emissions. The untabulated industry distribution shows that 52.82 percent of our sample observations are technology firms.

0). The mean and median values of all variables (including firm size and carbon emissions) for the EPA firms are higher than those for the *EPA* = 0 firms.

Panel B of Table 2 shows the descriptive statistics for Equation 1 (i.e., the disclosure-choice model). Again, we divide the full sample (7,350 observations) into firms voluntarily disclosing their carbon emissions (*DISC_CO2* = 1) and those that do not do so (*DISC_CO2* = 0). Companies providing carbon disclosures (*LnTA* = 16.83) are significantly larger, in terms of firm value, than companies that do not (*LnTA* = 15.20). Finally, companies that voluntarily disclose their carbon emissions tend to have a higher percentage of institutional ownership (*II* = 0.49) than those that do not do so (*II* = 0.37).

[Insert Table 2 here]

Table 3 presents correlation analyses, with the Spearman's coefficients presented below the diagonal, and the Pearson coefficients presented above the diagonal. Both correlation coefficients show that *TCO2* is significantly and positively associated with *MKT* (Spearman's coefficient = 0.532, $p < 0.01$; Pearson coefficient = 0.491, $p < 0.01$). These results suggest that firms with higher carbon emissions have higher firm values. It can also be observed that *ASSET*, *LIAB*, and *OPINC* are significantly correlated with *MKT*.

[Insert Table 3 here]

Table 4 reports the results for the Heckman (1979) model. Panel A of Table 4 presents the results from the first-stage Probit model. It shows that the coefficient for *LnTA* is significantly positive (coefficient = 0.143, $p < 0.01$), indicating that on average the larger the firm, the more likely it is to disclose its carbon emissions. *LagDISC_CO2* also has a significant and positive association with carbon disclosure (coefficient = 2.687, $p < 0.01$), which means that firms that disclosed their carbon emissions in the previous year often continue to disclose this information. The coefficient for *EnvIrreg* is significantly negative in the one-tailed test (coefficient = -0.323, $p = 0.15$), suggesting that firms which are involved in irregular environmental activities are less likely to disclose their carbon emissions. Finally, the coefficient for *EPA* is significant and positive, which suggests that the decision of whether or not to disclose carbon emissions data is affected by regulations that are in place and that firms under the obligation to report to the GHG Registry are more likely to voluntarily make such disclosures to the public.

As in Matsumura et al. (2014), we further divide the sample into two subsamples (*EPA* = 1 and *EPA* = 0) according to whether firms are listed on the GHG Registry in order to explore the determinants of voluntary carbon disclosure. In the case of firms for which it is mandatory to report their carbon emissions to the GHG Registry (*EPA* = 1), the coefficients for *BM* and *II* are significantly negative. These findings show that on average firms with a lower growth rate or a higher proportion of institutional ownership are less likely to voluntarily disclose their carbon emissions. However, for firms not listed on the GHG Registry (*EPA* = 0), the percentage

of institutional ownership appears to not have a significant influence on voluntary disclosures.

Panel B of Table 4 presents the results of the OLS regression while controlling for endogeneity using the IMR obtained from the first-stage Probit model. The results show that *TCO2* (coefficient = 2.839, $p < 0.01$) has a significantly positive effect on firm value, supporting Hypothesis 1 which proposes that, in general, higher carbon emissions lead to higher firm value. This finding is not consistent with those of prior studies focusing on Western settings (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018; Ott and Schiemann 2019).[13] Our evidence reinforces the suggestion by Feng et al. (2015) that Asian investors often respond to issues related to the environment and CSR differently from those in Western countries.

We further analyze the two subsamples, *EPA* = 1 and *EPA* = 0. For firms compelled to report to the GHG Registry (*EPA* = 1), *TCO2* still has a significant and positive impact on firm value (coefficient = 1.940, $p < 0.01$). However, the coefficient for *TCO2* (coefficient = 59.572, $p = 0.59$) is not significant for the other subsample (*EPA* = 0). Similar to Matsumura et al. (2014), we find that *TCO2* is significantly associated with firm value only in cases when reporting of carbon emissions is mandatory. It should be noted, however, that the difference lies in the fact that we observe a positive relationship instead of a negative one.

[13] The differences in the magnitude of the coefficients between our study and Matsumura et al. (2014) may be the result of the currencies used. In our sample, the firm value is measured in New Taiwan dollars rather than US dollars. The converted coefficients using the average exchange rate during our sample period are comparable to those in Matsumura et al. (2014).

These results may be explained by the fact that the current regulations in Taiwan do not indicate a specific cap for carbon emissions, and legal liabilities imposed on firms (such as fines) resulting from carbon emissions are not definite. Hence, high carbon emissions do not significantly increase the legal risks faced by companies. In addition, cost reduction strategies are widely employed in Taiwan (Wang 2017). Investing in CSR and disclosing carbon emissions are perceived as cost-increasing activities by investors (PRI 2016), and thus are believed to result in lower firm value and higher equity costs (Feng et al. 2015). There is also the fact that the majority of Taiwanese companies fall into what the SASB categorizes as carbon-intensive industries such as the electronics, steel, and petrochemical industries. The carbon emissions that are reported may mirror the number of purchase orders companies receive and their level of production, thus possibly being considered as a leading indicator of the future performance of companies (Niu et al. 2011). In this situation, companies with higher carbon emissions are likely to be viewed as performing better by investors, which leads to higher firm values.

Another possible explanation is that Asian investors are not fully aware of the importance of sustainability, and local authorities do not establish clear policies and programs with which to guide and educate the public (Feng et al. 2015; PRI 2016).[14] For example, a survey conducted by the Taiwan Institute for Sustainable Energy (TISE) (2018) shows that 99.2

[14] See the full text of a relevant report at https://www.taiwannews.com.tw/ch/news/3370133

percent of Taiwanese respondents did not know about the government's goal of reducing carbon emissions by the year 2050. The results of our study suggest there is an urgent need for the governments of Taiwan and other Asian countries to increase the public's awareness and understanding of environmental issues.

[Insert Table 4 here]

We further examine Hypothesis 2 in order to investigate whether the decision to disclose carbon emissions voluntarily is associated with firm value in Taiwan. We employ propensity score matching to construct the control sample, and obtain 1:1, 1:2, and 1:3 samples to show the robustness of our results. Panel A of Table 5 presents the descriptive statistics for the variables used in the propensity score matching. It can be observed that in the 1:1 and 1:2 samples, there is no significant difference in firm size between the two groups of firms (Difference = 0.104, p = 0.23; Difference = 0.034, p = 0.65). However, in the 1:3 sample, companies voluntarily disclosing their carbon emissions are, on average, significantly larger than those that do not do so (16.825 > 16.638, Difference = 0.187, $p < 0.01$). Finally, in all of these samples, the *BM* of companies making carbon disclosures is significantly higher (i.e., lower growth) than that of firms not doing so.

[Insert Table 5 here]

Panel B of Table 5 provides the results of the effect of voluntary carbon disclosures on firm value. In the 1:1 sample, the firm value of companies disclosing their carbon emissions (NTD 41,44b) is lower than that of companies that do not do so (NTD 44,67b). However, this difference is not significant. Similarly, the result for the 1:2 sample shows that the difference in mean firm value between companies choosing to make carbon disclosures and those choosing not to do so is positive but not significant (Difference = 149.54, p = 0.96). Conversely, the result obtained for the 1:3 sample suggests that companies disclosing their carbon emissions tend to have higher firm values than those who do not do so. However, this significant difference (p = 0.02) in firm value might be caused by the positive and significant difference in total assets, as shown in Panel A. Overall, a consistent relationship between firm value and carbon disclosures is not found in our study. This is inconsistent with the findings of Matsumura et al. (2014) and does not support Hypothesis 2. This inconsistency may be due to the loose regulations in place in Asian countries to control carbon emissions (suggesting lower environmental risks) and the little attention and weight given by Asian investors to environmental issues (PRI 2016).

Table 6 shows the impact that the carbon usage (i.e., the amount of carbon emissions produced) required to generate sales and profits has on firm value. The coefficients for the four variables of interest are all positive, but most of them are not significant, with the exception of *TCO2GM*, suggesting that market investors do not appraise these variables negatively in

relation to firm value. At this stage of our analysis, we also split the sample into the *EPA* = 1 and *EPA* = 0 subgroups. However, the results are consistently not significant regardless of whether the firms are required to report their carbon emissions or not. Overall, the results do not support Hypothesis 3 and continue to be inconsistent with those found in Western countries.

[Insert Table 6 here]

VII. ADDITIONAL ANALYSES

Change Analysis

Following the example of Matsumura et al. (2014), we employ a change analysis model to solve the endogeneity problem and to ensure the robustness of the testing. This model (presented in Equation 4) is based on the firm-value model (see Equation 2), with the variables highlighting the differences between the previous year and the current year.

$$D\_MKT_{i,t} = \beta_0 + \beta_1 D\_TCO2_{i,t} + \beta_2 D\_ASSET_{i,t} + \beta_3 D\_LIAB_{i,t} + \beta_4 D\_OPINC_{i,t} + ExchangeD_{i,t} + IndustryD_{i,t} + YearD_{i,t} + \varepsilon_{i,t}, \quad (4)$$

Table 7 reports the results of the change analysis model. It shows that *D_TCO2* is positively associated with *D_MKT* at a one percent significance level. This suggests that if the carbon emissions of a firm increase during a given year, it tends to have a higher firm value for that year. This result is consistent with that shown in Table 4.

We further analyze the *EPA* = 1 and *EPA* = 0 subsamples. The results again are in accordance with our earlier observations (see Table 4): For the *EPA* = 1 subsample, *D_TCO2* (coefficient = 16.493, $p < 0.01$) significantly and positively affects the changes in firm value. For the *EPA* = 0 subsample, on the other hand, *D_TCO2* (coefficient = 8.136, $p = 0.46$) does not have a significant impact on *D_MKT*.

[Insert Table 7 here]

We also use the change analysis model to examine the relationship between *D_MKT*, on the one hand, and *D_TCO2REV, D_TCO2GM, D_TCO2OPINC*, and *D_TCO2NI*, on the other. Consistent with the results presented in Table 6, we find no significant results for the four variables of interest, suggesting that investors in Taiwan do not value carbon emission for generation of sales and profits.

The FIML Method

Furthermore, we employ the FIML method to ensure our results are not affected by the choice of methods used to deal with the potential issue of endogeneity (Tucker 2010; Matsumura et al. 2014). Our untabulated results are again consistent with our main findings (see Table 4), suggesting that the positive association between carbon emissions and firm value is not sensitive to the use of the two-stage Heckman model or the FIML method.

Furthermore, we run Model 2 with the sample obtained with the propensity score

matching (PSM) to test for robustness. Please note that we do not have carbon emissions data for the non-disclosing firms. Therefore, we first employ the approach proposed by Griffin et al. (2017) to predict the carbon emissions of the non-disclosing firms based on a regression analysis of the reported carbon emissions of the disclosing firms.[15] We then apply the PSM method to test Hypothesis 2 and to create a matching (control) sample which does have a predicted amount of carbon emissions. Finally, we regress firm value on reported or predicted carbon emissions for both the disclosing and non-disclosing firms. Consistent with our main findings, the untabulated results show that the association between firm value and carbon emissions is positive and significant (coefficient = 3.187, $p < 0.01$), suggesting that our results are not driven by sample selection bias.

Members of the Carbon Disclosure Project and SASB-listed Carbon-intensive Industries

We divide the sample into (a) Carbon Disclosure Project (CDP) members and non-CDP members and into (b) U.S. SASB-listed carbon-intensive industries and non-carbon-intensive industries, and then run the two-stage model (see Table 4) to examine whether these categories affect the results.

We manually collected the CDP membership data for Taiwanese listed companies from the CDP website. Among the 669 firm-year observations with carbon emissions, 220 included

[15] Although the use of predicted carbon emissions levels in the case of non-disclosing firms is expected to reduce the potential for a selection bias, Griffin et al. (2017) indicate that the decision to disclose a firm's emissions also reflects attributes of the firm which are omitted in the firm value estimation model. Therefore, they provide an additional analysis with the Heckman approach.

CDP members and 449 did not. The untabulated results show that the CDP members with higher carbon emissions have higher firm values (coefficient = 4.517, p = 0.01), but no significant result is found for the non-CDP members (p = 0.23). In order to assess the possible effects of the perceptions of regional investors, we examine whether the positive correlation that we identify between carbon emissions and firm value remains the same for Taiwanese firms cross-listed on Western stock exchanges. Surprisingly, we consistently find a positive association for 115 cross-listed firm-year observations (coefficient = 5.301, p < 0.01, untabulated). Overall, our results suggest that the effectiveness of local jurisdictions in controlling carbon emissions may play a more important role in investors' decisions than corporate carbon disclosures. More specifically, as a lax regulatory system and a weak legal enforcement system seemingly have little impact on the carbon liabilities of firms, investors may view carbon emissions as less important than operational performance for investees in Taiwan. Our results are consistent with the argument that investors evaluate differences associated with legal jurisdiction, and thus their assessments are affected by the stringency and intensity of judicial regimes (Clarkson et al. 2015).

As in the research of Khan, Serafeim, and Yoon (2016), we adopt the definition proposed by the SASB for carbon-intensive industries, and we classify companies into a carbon-intensive group and a non-carbon-intensive group. The untabulated results reveal that carbon emissions have a significant and positive impact on firm value in the case of the carbon-intensive firms,

which is not the case for the non-carbon-intensive firms. These findings suggest that investors consider carbon emissions when evaluating the performance of carbon-intensive companies, whereas carbon emissions seem to be irrelevant to the valuations given by investors to non-carbon-intensive companies. Similar to Khan et al. (2016), our findings suggest that investors focus more on relevant information when assessing firm value.

PRI Investors

We also intended to examine the role of PRI investors, but this proved impossible to do directly because only one sampled firm has a PRI investor.[16] Therefore, an alternative measure is required, which is obtained by examining the role of investors who are signatories of the Taiwanese Stewardship Principles for Institutional Investors (TSPII). As Taiwanese institutional investors cannot sign the UN-sponsored PRI, the TSE Corporate Governance Center published the TSPII in 2016 to promote responsible investment. Because the TSPII was published quite recently, there are still few observations on TSPII signatories. Nevertheless, our untabulated results still show a positive association between carbon emissions and firm value, suggesting that TSPII signatories do not value carbon emissions differently from other investors in Taiwan.

The Data Inconsistency Issue

Goldhammer, Busse, and Busch (2017) point out the issue of the inconsistency across

[16] Please note that this number may be an underestimation as the names of majority shareholders in Taiwan are reported in Chinese, which presents the obstacle of cross-referencing them with the PRI investor list where company names are written in English.

databases of the data on carbon emissions. In order to test robustness, we compare our data, which we obtained from the Taiwan-based MOPS, with data from Thomson Reuters Asset4. As Asset4 provides limited coverage of the carbon emissions of Taiwanese firms, we have a relatively small overlap with which to check consistency and create a subsample. Out of our 669 firm-year observations with carbon emission disclosures, only 164 have emissions data available at Asset4. The inconsistency rate is then calculated as the absolute value of the difference between the amounts of carbon emissions reported in the two databases divided by the amounts disclosed in the MOPS. We subtract the inconsistency rate from 1 and calculate that the consistency of the data between the two databases is 92.4 percent. As the data coverage is limited in Asset4, we use the MOPS data that is the best available data on Taiwanese companies in order to run our main regression analyses. To evaluate robustness, we run the regression with an overlapped subsample (where the carbon emissions data is from the MOPS) and control for inconsistency across databases and the ESG effect, which is represented by the log value of the ESG score obtained from Asset4.[17] We also use emissions data from Asset4 to reexamine the relationship between carbon emissions and firm value. The untabulated results show that our findings generally hold and are not sensitive to the different sources of data.

The Combination of Equity and Debt Market Value

In addition to equity value, investors also pay attention to enterprise value, which

[17] Because the coverage of Taiwanese data in these databases is limited, we are unable to calculate fair propensity scores, which requires a large sample, because we cannot control for the ESG factor in the first-stage model. Instead, using the reduced sample size, we control for the inconsistency and ESG effects in the second-stage model.

combines equity and debt market values (*EDMV*). To examine whether the association holds, we replace our dependent variable with the combined enterprise value and rerun the regression analysis. Our untabulated results show that *TCO2* is still positively (coefficient = 1.736) and significantly (p-value < 0.01) associated with *EDMV*, suggesting that our results hold for another measure of firm value.

VIII. CONCLUSION

Extending the scope of the extant research (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018; Ott and Schiemann 2019), this paper explores whether the negative relationship between carbon emissions and firm value found in Western markets also exists in Asian markets. We use data on companies listed in Taiwan, the majority of which fall in the category of carbon intensive industries. Based on our analysis of manually collected carbon emissions data for the period 2012-2016, we find that carbon emissions are positively associated with firm value. However, we fail to find any evidence of the same relationship between voluntary carbon disclosures and firm value. Likewise, firm value is not associated with a combined measure of financial information and carbon emissions in Taiwan. These findings are opposite to those of prior studies conducted in Western settings (Chapple et al. 2013; Matsumura et al. 2014; Clarkson et al. 2015; Griffin et al. 2017; Cooper et al. 2018; Ott and Schiemann 2019), but they support the findings of prior studies on cultural differences associated with CSR (Feng et al. 2015; PRI 2016). As far as we

know, ours is the first study to document a positive relationship between carbon emissions and firm value.

These inconsistencies between research settings can be attributed to Asian investors, on the one hand, paying little attention to CSR and environmental protection and, on the other, showing little appreciation for the importance of these issues (Feng et al. 2015; Manchiraju and Rajgopal 2017; Chen et al. 2018). In contrast to their Western counterparts who tend to appreciate efforts towards CSR and to show concern for environmental issues, Asian investors often assign too little weight to environmental and social factors when making decisions (PRI 2016). This may apply to the Taiwanese context, which may be the reason why a positive relationship between firm value and carbon emissions is found using Taiwanese data, whereas the opposite is consistently found in research on Western data. Furthermore, the current regulations in Taiwan do not impose a cap on carbon emissions, require information on direct carbon emissions (as required by the U.S. and UK authorities, cf. U.S. Environmental Protection Agency 2009, 2011; Downar et al. 2021), or specify fines. Therefore, high carbon emissions do not result in a high legal risk.

It should be noted that the Taiwanese government does not do enough to promote reductions in carbon emissions (TISE 2018). During the period observed by Matsumura et al. (2014), no national caps on carbon emissions or financial penalties for producing carbon emissions were in place in the U.S., and the reporting of carbon emissions was not mandatory

at the national level. The same can be said about the study conducted in Australia by Chapple et al. (2013). In fact, some Taiwanese firms are required to report their carbon emissions to the government (i.e., when carbon emissions exceed the officially set threshold), but this information is only accessible to certain groups. Likewise, the information on carbon emissions contained in the MOPS is also voluntarily disclosed and selectively accessible. As in the American-set study by Matsumura et al. (2014) and the Australian-set study by Chapple et al. (2013), there was no specific carbon emissions cap in Taiwan during the period under observation (although a cap is defined in the regulations of 2015). Our results suggest that governmental enforcement and investor attitude may be more factors than the amount of carbon emissions disclosed. Hence, even though it was mandatory to report carbon emissions in Taiwan, and Taiwanese investors can easily access the voluntary carbon disclosures found in the MOPS, the positive relationship between carbon emissions and firm value is still found. For this reason, we argue that the difference between the Western and Taiwanese findings may result from the lax attitude of local government officials and the reporting by regional investors of their perceptions towards CSR (e.g., Feng et al. 2015). Therefore, this issue is of less concern to the public than it should be.

Prior studies also point out that Asian investors regard acting according to the principles of CSR to be a costly non-value-added activity (PRI 2016). In Taiwan, where cost reduction is central to running a business, investors may not appreciate a company investing its resources

for the benefit of the environment. Additionally, high carbon emissions may be perceived by investors as an indicator of active production activities and a positive sign of a firm's future performance. Although Taiwan has enacted the *Greenhouse Gas Reduction and Management Act*, our findings indicate that firms with higher carbon emissions tend to enjoy higher firm values, which shows a lack of concern on the part of investors for this environmental issue. Taiwanese authorities are strongly advised to design better regulations with which to effectively control carbon emissions and educate investors about the corporate risks caused by the lack of sustainability resulting from high carbon emissions. This can be done more effectively through the power of institutional investors and by providing companies with incentives to do so (Matos 2019). This recommendation reflects the statement in the EU action plan for financing sustainable growth (European Commission 2018) that it is crucial both to "clarify institutional investors' duties" in terms of sustainability (see EU action 7) and to incorporate sustainability into "prudential requirements and credit rating" (see EU actions 8 and 6). Providing a proper benchmark (e.g., a "standard" cap on carbon emissions for different industries), which is the focus of EU action 5 for financing sustainable growth, may also help investors better understand the risks involved when they evaluate carbon emission disclosures. International investors can also contribute to a reduction in carbon emissions by making global investments even if Asian countries and Asian investors lag behind their Western counterparts in this respect (Chapple and Moon 2005).

This paper sheds much needed light on how carbon emissions and the corporate decisions determining whether or not to make carbon disclosures are interpreted by international investors (Hahn et al. 2015). Its findings also contribute to a growing body of literature on CSR, environmental issues, and cultural differences associated with CSR (Muirhead et al. 2002; Matsumura et al. 2014; Clarkson et al. 2015; Feng et al. 2015; PRI 2016; Griffin et al. 2017; Hassan and Romilly 2018). More specifically, this paper warns that generalizations of the results of the extant research on the relationship between carbon emissions and firm value, which are mainly based on Western settings, to other cultural contexts should be done with caution, and that regulators and researchers in Asian countries should put more effort into enhancing the understanding that the public and stakeholders have of ESG issues. Our findings also show that mandatory reporting of carbon emission per se may not be sufficient to motivate companies to reduce their carbon emissions, and that regulators, especially those in countries where the understanding of the concepts of CSR and ESG are underdeveloped (e.g., in Asia), should implement more effective policies (e.g., a cap on carbon emissions, a carbon tax, and reward systems) to achieve the goals set by the Paris Agreements and the SDGs of the UN (2015). Finally, our findings can also be used to remind managers in various countries that they should carefully consider the characteristics of investors when making decisions associated with carbon emissions disclosures.

Despite its many contributions, this study also has some limitations. For example,

Taiwanese firms are not required to disclose their carbon emissions in the MOPS; thus, our firm-year observations with carbon emissions only account for 9.1 percent of the total number of observations. Although we apply a two-stage model to control for the endogeneity problem, the generalizability of our results is still subject to certain limitations. This aligns with the idea found in prior studies and in the action plan of the EU for financing sustainable growth that there is a need to further enhance the transparency of carbon emissions reporting in order to allow stakeholders to better understand the relevant risks (Busch, Johnson, Pioch, and Kopp 2018; European Commission 2018). In addition, we also acknowledge that our results should be interpreted with caution since the carbon emissions data from Bloomberg, CDP, ISS or MSCI are not included in our analyses.

This study shows that investors in Asia (or at least those in Taiwan) and in Western countries act very differently in reaction to the disclosure of carbon emissions. Further research using data from other countries would be of great benefit to the advancement of our knowledge of investors' reactions and of corporate decisions regarding carbon emissions. We also encourage future studies to reexamine this issue by using the aforementioned international data.

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Appendix I. Timeline of carbon emission-related regulations in Taiwan

2012	**Government announced the 'Management Regulations Governing Greenhouse Gas Emissions Reporting'.** This specified mandatory reporting from all companies to the government (through the GHG Registry), except firms whose carbon emissions are lower than 25,000 metric tons for five consecutive years, or lower than 15,000 metric tons for three consecutive years. This reporting is nonpublic and is required to be certified. **- Article 2** 6. Registration means reporting emissions, sinks, allocations, reductions, auctions, sales or transactions of CO2e to the national registry (Registry) designated by the central competent authority. **7.** Verification is an independent assessment by interview, document review, data analysis, inspection, or testing to determine the validity and reliability of the GHG inventory and emission reduction (and sink) by the verification body.
2015	**Government announced the 'Greenhouse Gas Reduction and Management Act'**, to better adapt to climate change and to ensure the sustainable development of the country. The government defined the emission caps, trading allowances and emission allowances, but did not set specific caps. The first time that the concept of 'total amount control' for carbon emissions was proposed by the government. **-Article 3** 17. Cap refers to the total permitted amount of emissions for a specific period of time under the cap-and-trade scheme. 18. Allowance trading means to exchange emission allowances domestically or internationally in compliance with the designated cap under the cap-and-trade scheme. 19. Emission allowance refers to the allowance distributed by designated authorities from government allocation, auction, sale, Early Action, the GHG Offset Project, EPS, or allowance trading under the cap-and-trade scheme. One unit of emission allowance equals one metric ton of CO_2e.

2016	**Government announced the 'Enforcement Rules'**, following the 2015 'Greenhouse Gas Reduction and Management Act'. These regulations replaced the 2012 ones, from 2016 onwards. **Government released a list of the first group of firms subject to mandatory reporting of carbon emissions**, following the 2015 'Greenhouse Gas Reduction and Management Act'. This list focused on carbon-intensive industries and companies with carbon emissions higher than 25,000 metric tons.
Note	The above mandatory reporting refers to the reporting to the government through the GHG Registry, which is not available to the public. The carbon emissions data used in this paper are collected from the Taiwan MOPS which allows public access, and are voluntary disclosures.

Appendix II. Literature on Carbon Emissions and Firm Value

Year	Authors	Sample country(ies)	Sample period	Disclosure	MKT(Return) vs. GHG emissions
2013	Chapple, Clarkson, and Gold	Australia	2007	Voluntary	Negative
2014	Matsumura, Prakash, and Vera-Muñoz	USA	2006-2008	Voluntary	Negative
2015	Clarkson, Li, Pinnuck, and Richardson	Europe[18]	2006-2009	Mandatory	Negative
2017	Griffin, Lont, and Sun	USA	2006-2012	Voluntary	Negative
2017	Liesen, Figge, Hoepner, and Patten	Europe[19]	2005-2009	Voluntary or Mandatory	Insignificant
2018	Cooper, Raman, and Yin	USA	2010-2014	Mandatory	Negative
2018	Hassan and Romilly	45 countries	2006-2014	Voluntary or Mandatory	Negative

[18] Clarkson et al. (2015) use a sample of European firms including those in Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, and United Kingdom.

[19] Liesen et al. (2017) use a sample of European firms including those in Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden, and United Kingdom.

Appendix III. Variable definition

Variable		Definition
Disclosure-Choice Model		
DISC_CO2	=	1 if a firm voluntarily discloses its carbon emissions, and 0 otherwise;
LnTA	=	the natural logarithm of total assets;
BM	=	the book value divided by the market value;
LEV	=	total liabilities divided by total assets;
II	=	the proportion of a firm's shares held by institutional investors;
LagDISC_CO2	=	1 if a firm voluntarily discloses its carbon emissions in the previous year, and 0 otherwise;
EnvISO	=	1 if the firm has obtained ISO certification for its production of greenhouse gases, and 0 otherwise;
EnvIrreg	=	1 if the firm is involved in irregular environmental activities, and 0 otherwise;
FRNSALE	=	foreign sales divided by total sales;
IndVolDisc	=	the proportion of firms in a particular industry that voluntarily disclose their carbon emissions;
EPA	=	1 if a firm is on the list of the companies in the first group to mandatorily report their carbon emissions or if the carbon emissions it discloses in the MOPS are higher than 25,000 metric tons, and 0 otherwise;
Firm-Value Model		
MKT	=	the market value of a firm;
TCO2	=	carbon emissions in thousands of metric tons;
ASSET	=	total assets;
LIAB	=	total liabilities;
OPINC	=	operating income;
IMR	=	the inverse Mills ratio estimated with the disclosure model;
TCO2REV	=	carbon emissions divided by total sales;
TCO2GM	=	carbon emissions divided by gross margins;
TCO2OPINC	=	carbon emissions divided by operating income;
TCO2NI	=	carbon emissions divided by net income.

Table 1

Sample Selection and Distribution

Sample Selection Process	**Carbon Emission Disclosure**		
	No	Yes	Total
Total non-financial firm-year observations from 2012 to 2016	7,490	674	8,164
Less: Observations with missing financial data	(809)	(5)	(814)
Final sample of firm-year observations	6,681	669	7,350

Table 2
Descriptive Statistics

Panel A: Firm-Value Model

	Full Sample (N = 669)					*EPA* = 1 (N = 358)		*EPA* = 0 (N = 311)			
Variable	**Mean**	**Q1**	**Median**	**Q3**	**Std. Dev**	**Mean**	**Median**	**Mean**	**Median**	**t-stat Pr.**	**Wilcon. Pr.**
MKT	41,441.24	5,180.00	10,842.00	39,738.00	68,551.97	61,265.38	21,241.50	18,621.15	6,186.00	*<0.01*	*<0.01*
TCO2	737.74	5.83	36.74	252.59	2,361.86	1,372.59	224.45	6.96	4.87	*<0.01*	*<0.01*
ASSET	69,146.69	6,163.09	15,211.06	69,453.15	112,000.76	100,722.09	42,335.81	32,799.45	7,409.64	*<0.01*	*<0.01*
LIAB	35,458.60	1,931.40	6,725.63	34,423.60	58,578.01	50,707.57	22,161.31	17,905.13	2,693.43	*<0.01*	*<0.01*
OPINC	2,632.78	169.17	668.77	2,336.79	5,012.14	3,786.62	1,133.77	1,304.55	439.04	*<0.01*	*<0.01*

Panel B: Disclosure-Choice Model

	Full Sample (N = 7,350)					*DISC_CO2* = 1 (N = 669)		*DISC_CO2* = 0 (N = 6,681)			
Variable	**Mean**	**Q1**	**Median**	**Q3**	**Std. Dev**	**Mean**	**Median**	**Mean**	**Median**	**t-stat Pr.**	**Wilcon. Pr.**
LnTA	15.35	14.36	15.14	16.14	1.44	16.83	16.54	15.20	15.03	*<0.01*	*<0.01*
BM	1.90	0.83	1.40	2.21	2.36	1.80	1.48	1.91	1.39	*0.07*	*0.05*
LEV	0.40	0.27	0.40	0.53	0.18	0.42	0.42	0.40	0.40	*<0.01*	*<0.01*
II	0.38	0.20	0.36	0.55	0.23	0.49	0.49	0.37	0.35	*<0.01*	*<0.01*
LagDISC_CO2	0.08	0.08	0	0	0.27	0.68	1	0.02	0	*<0.01*	*<0.01*
EnvISO	0.01	0	0	0	0.11	0.04	0	0.01	0	*<0.01*	*<0.01*
EnvIrreg	0.02	0	0	0	0.14	0.05	0	0.02	0	*<0.01*	*<0.01*
FRNSALE	0.25	0.25	0	0	0.38	0.09	0	0.27	0	*<0.01*	*<0.01*
IndVolDisc	0.04	0.04	0.03	0.04	0.03	0.05	0.06	0.04	0.04	*<0.01*	*<0.01*
EPA	0.07	0.07	0	0	0.25	0.54	1	0.02	0	*<0.01*	*<0.01*

The variable definition can be found in Appendix III.

Table 3

Correlation Analyses

	MKT	*TCO2*	*ASSET*	*LIAB*	*OPINC*
MKT		0.491	0.836	0.752	0.886
		<0.01	*<0.01*	*<0.01*	*<0.01*
TCO2	0.532		0.550	0.509	0.344
	<0.01		*<0.01*	*<0.01*	*<0.01*
ASSET	0.883	0.588		0.960	0.773
	<0.01	*<0.01*		*<0.01*	*<0.01*
LIAB	0.815	0.561	0.976		0.720
	<0.01	*<0.01*	*<0.01*		*<0.01*
OPINC	0.750	0.333	0.645	0.604	
	<0.01	*<0.01*	*<0.01*	*<0.01*	
N	669				

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Spearman's rank correlation coefficients are below the diagonal, and Pearson correlation coefficients are above the diagonal.
The variable definition can be found in Appendix III.

Table 4

Firm-Value Effects of Carbon Emissions

Panel A: Probit Regression

DISC_CO2	**Full Sample**			***EPA* = 1**			***EPA* = 0**		
Variable	**Coefficient**	**Wald Chi²**	**p-value**	**Coefficient**	**Wald Chi²**	**p-value**	**Coefficient**	**Wald Chi²**	**p-value**
LnTA	0.143	17.54	*<0.01*	0.210	5.12	*0.02*	0.118	9.17	*<0.01*
BM	-0.122	13.81	*0.00*	-0.393	12.84	*<0.01*	-0.071	4.60	*0.03*
LEV	-0.282	1.36	*0.24*	1.078	2.04	*0.15*	-0.361	1.90	*0.17*
II	-0.297	2.81	*0.09*	-1.546	6.97	*0.01*	-0.096	0.25	*0.62*
LagDISC_CO2	2.687	689.04	*<0.01*	2.398	96.69	*<0.01*	2.745	593.47	*<0.01*
EnvISO	0.210	0.41	*0.52*	0.223	0.22	*0.64*	0.315	0.48	*0.49*
EnvIrreg	-0.323	2.05	*0.15*	-0.650	2.24	*0.13*	-0.729	2.70	*0.10*
FRNSALE	0.043	0.06	*0.81*	0.348	0.17	*0.68*	0.043	0.05	*0.82*
IndVolDisc	21.152	54.22	*<0.01*	10.614	1.93	*0.16*	22.112	34.33	*<0.01*
EPA	2.053	323.96	*<0.01*						
Pseudo R^2	0.6355			0.6527			0.4890		
N	7,350			509			6,841		

The variable definition can be found in Appendix III.

Panel B: OLS Regression

MKT	**Full Sample**			***EPA* = 1**			***EPA* = 0**		
Variable	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**
TCO2	2.839	5.75	*<0.01*	1.940	3.00	*<0.01*	59.572	0.52	*0.60*
ASSET	0.440	11.79	*<0.01*	0.453	9.11	*<0.01*	-0.135	-1.84	*0.07*
LIAB	-0.521	-8.41	*<0.01*	-0.509	-5.87	*<0.01*	0.200	1.95	*0.05*
OPINC	8.144	25.13	*<0.01*	8.197	18.98	*<0.01*	10.755	19.11	*<0.01*
IMR	*controlled*			*controlled*			*controlled*		
Adj. R^2	0.8879			0.8829			0.8948		
N	669			358			311		

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The variable definition can be found in Appendix III.

Table 5

Firm-Value Effects of Decision to Disclose Carbon Emissions: Propensity-Score Matching

Panel A: Descriptive Statistics for Propensity Score Matching

Variable	Treatment Mean (1)	Control match 1 to 1 Mean (2)	Difference (1) - (2)	p-value	Control match 1 to 2 Mean (3)	Difference (1) - (3)	p-value	Control match 1 to 3 Mean (4)	Difference (1) - (4)	p-value
LnTA	16.825	16.721	0.104	*0.23*	16.791	0.034	*0.65*	16.638	0.187	*<0.01*
BM	1.804	1.513	0.291	*<0.01*	1.715	0.089	*0.15*	1.637	0.167	*<0.01*
LEV	0.423	0.391	0.032	*<0.01*	0.423	0.000	*0.97*	0.412	0.011	*0.16*
II	0.486	0.532	-0.046	*<0.01*	0.522	-0.036	*<0.01*	0.517	-0.031	*<0.01*
LagDISC_CO2	0.676	0.516	0.160	*<0.01*	0.483	0.193	*<0.01*	0.438	0.238	*<0.01*
EnvISO	0.043	0.028	0.142	*0.09*	0.019	0.024	*<0.01*	0.023	0.020	*0.02*
EnvIrreg	0.046	0.043	0.003	*0.79*	0.034	0.012	*0.21*	0.039	0.007	*0.45*
FRNSALE	0.087	0.055	0.032	*0.01*	0.065	0.022	*0.06*	0.069	0.018	*0.10*
IndVolDisc	0.054	0.054	0.000	*0.99*	0.054	0.000	*0.98*	0.054	0.000	*0.97*
EPA	0.535	0.250	0.285	*<0.01*	0.251	0.284	*<0.01*	0.273	0.262	*<0.01*

Panel B: Difference in Mean Firm Values of Propensity Score-Matched Firms

Variable	Mean (1)	Mean (2)	Difference (1) - (2)	p-value	Mean (3)	Difference (1) - (3)	p-value	Mean (4)	Difference (1) - (4)	p-value
MKT	41,441.23	44,672.29	-3231.06	*0.41*	41,291.69	149.54	*0.96*	34,592.42	6,848.81	*0.02*
N	669	669			1,337			2,005		

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The variable definition can be found in Appendix III.

Table 6

Firm-Value Effects of Carbon Emissions

MKT	**Full Sample**			***EPA* = 1**			***EPA* = 0**		
Variable	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**
TCO2REV	15.190	0.72	*0.47*	20.846	0.75	*0.45*	404.815	1.40	*0.16*
Control variables	*controlled*			*controlled*			*controlled*		
Adj. R^2	0.8822			0.8800			0.8954		
TCO2GM	5.872	2.43	*0.02*	5.506	1.83	*0.07*	15.464	0.51	*0.61*
Control variables	*controlled*			*controlled*			*controlled*		
Adj. R^2	0.8832			0.8810			0.8948		
TCO2OPINC	0.978	1.39	*0.17*	0.810	0.93	*0.35*	0.146	0.07	*0.95*
Control Variables	*controlled*			*controlled*			*controlled*		
Adj. R^2	0.8825			0.8802			0.8947		
TCO2NI	0.155	0.56	*0.57*	0.099	0.29	*0.77*	-2.159	-0.66	*0.51*
Control variables	*controlled*			*controlled*			*controlled*		
Adj. R^2	0.8822			0.8798			0.8948		
N	669			358			311		

The variable definition can be found in Appendix III.

Table 7

Change Analysis of Firm-Value Effects of Carbon Emissions by the EPA

D_MKT	**Full Sample**			***EPA* = 1**			***EPA* = 0**		
Variable	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**
D_TCO2	15.859	4.17	*<0.01*	16.493	3.33	*<0.01*	8.136	0.74	*0.46*
D_ASSET	0.659	4.96	*<0.01*	0.618	3.43	*<0.01*	0.807	3.41	*<0.01*
D_LIAB	-0.277	-1.59	*0.11*	-0.222	-0.94	*0.34*	-0.582	-1.78	*0.08*
D_OPINC	2.111	8.07	*<0.01*	2.173	6.20	*<0.01*	1.518	3.52	*<0.01*
Adj. R^2	0.4633			0.4769			0.2846		
N	449			251			198		

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The variable definition can be found in Appendix III.