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A novel measure of corporate carbon emission disclosure, the effect of capital expenditures and corporate governance

Abstract

The UK's 2050 net-zero emission target is one of the most ambitious goals in the world. Organisations should play a vital role by communicating a sufficient level of carbon emission information with the stakeholders. Motivated by the necessity of measuring the level of carbon disclosure, this paper provides a unique carbon emission disclosure measurement based on a sample of UK firms from 2013 to 2019. We apply different methods to assess the validity and reliability of our developed measurement. The results suggest that our measurement captures the actual CO₂ emission, including scope 1, scope 2, and also captures the environmental, social and governance (ESG) score. Additionally, we explore the association between capital expenditure, corporate governance and the level of carbon emission disclosure. Further, the results show a positive relationship between capital expenditure and carbon emission disclosure. Also, there is a significant positive relationship between internal governance and carbon emission disclosure. Moreover, the analysis suggests that internal governance strengthens the relationship between capital expenditure and carbon emission disclosure. We also use quantile regression, and the findings show that capital expenditure and internal governance have a positive impact on carbon emission disclosure under all quantiles. Our data suggest that capital expenditure declines within the UK by around 53% over the last six years. Following the reduction in capital expenditure, the results demonstrate 39% decline in the CO₂ emission level. The results also indicate that for every \$1 million capital expenditure, approximately 2.75 Metric tons of carbon dioxide (MtCO₂) emissions increase. Business investment is around 70% of the UK's total investment. Therefore, the reduction in capital expenditure is one of the primary reasons that might explain the decrease in the UK's overall CO₂ emission level. The unique findings of this paper are relevant to the government, management and standard-setters.

Keywords: carbon emission disclosure; CO₂ emission; ESG score; capital expenditure, internal governance; textual analysis.

1. Introduction

Environmental pollution has become a debatable trend in recent years, as economic development should be based on protecting the environment (Meng et al., 2014; Gerged et al., 2020). Firms should consider the effect of their operations on the environment, especially the effect of carbon emission (Kalu et al., 2016; Bui et al., 2020). Therefore, there is a growing concern from the stakeholders for more information regarding the firm carbon emission behaviour (Liesen et al., 2015; Saha et al., 2020). This applies pressure on the management to disclose more information about environmental responsibility, particularly carbon emission disclosure (Baboukardos, 2017; Alsaifi et al., 2020). Additionally, there is a call from the regulators and policymakers in the UK to form a mandatory standard with detailed instructions for the firms to disclose more carbon emission-related information (Gov.uk. 2013). This carbon emission disclosure will reduce the information asymmetry between the management and the stakeholders (Elliott et al., 2014; Liesen et al., 2017).

The UK became the first major economy in the world to pass laws to end its effect on global warming. The target will require the UK to bring all greenhouse gas emissions to net-zero by 2050. This net-zero target is one of the most ambitious in the world and was recommended by the Committee on Climate Change. Thus, as policymakers in the UK target net-zero emission by 2050, organisations should play a vital role in providing a sufficient level of carbon information. However, the world largest companies combined market capitalisation is \$35 trillion (tn), which is twice the USA's GDP in 2015; therefore, companies can drive the changes for carbon emission faster than the governments (CDP, 2021). Carbon Development Project (CDP) estimated the global market for low-carbon service and goods is \$5.5tn, which is half of China's 2105 GDP. Therefore, business organisations have a crucial role in reducing carbon emission. Also, companies in the UK are required to disclose their Green House Gas (GHG) emissions mandatorily to the public (Secretary of State, 2013). Therefore, in our study, we focus on exploring the relationship between capital expenditure and carbon emission disclosure.

Firms' capital expenditures associate with more value relevant activity; thus, more carbon footprint in the environment. Any additional capital expenditure will lead to more carbon emission. In the meantime, stakeholders want to know whether their investments have any impact on the environment. The management will gain a strategic advantage by disclosing more information related to carbon emission to their stakeholders (Li et al., 2019). Thus, firms with more capital expenditure intend to provide more details of their carbon emission to increase transparency and reduce information asymmetry. However, when a firm does more carbon emissions, it is punished by the market, and the market reaction is more negative if firms do not disclose that information (Matsumura et al., 2014). Therefore, even capital expenditure causes more carbon emission; but firms disclose more information to avoid such negative market reactions.

Legitimacy theory also supports that firms with more capital expenditure will disclose more carbon-related information to avoid future legislations (Kalu et al., 2016). Moreover, internal governance, i.e. board independence and board gender diversity, positively associate with carbon reduction motives. Also, internal governance-based compensation policy is positively associated with carbon reduction disclosure (Haque, 2017). Thus, this paper raises the following questions: What is the carbon emission disclosure level within the UK annual reports? What is the effect of capital expenditure and corporate governance on the level of carbon emission disclosure? What is the role of corporate governance in the relationship between capital expenditure and carbon emission disclosure?

Therefore, the objectives of our paper are three-fold. We aim to develop a unique measurement for carbon emission disclosure in the annual reports using automated textual analysis. Second, we examine the effect of capital expenditure on the level of carbon emission disclosure. Third, we investigate the role of corporate governance on the relationship between capital expenditure and carbon emission disclosure in the UK.

We contribute to the current literature in several ways. From a methodological perspective, we provide a unique, comprehensive measurement using automated textual analysis to capture the level of carbon emission disclosure based on the narrative sections of annual reports. Our measurement captures actual CO₂ emission, including scope 1, scope 2, and also capture the ESG score. It is essential for regulators to force a detailed guideline for companies to disclose

carbon emission information; therefore, this measurement is the first step to construct such a detailed guideline for corporate carbon disclosure. Second, to the best of our knowledge, this paper is the first in this domain to explore the effect of capital expenditure on firms' carbon emission disclosure level. Third, firms' governance mechanism is a barrier between the actual carbon emission and carbon emission disclosure. Our sample consists of UK FTSE All-Share companies, where firms exhibit a strong governance mechanism. Therefore, our measure for carbon emission disclosure captures actual carbon emission. Further, we provide evidence that strong corporate governance will lead to a better relationship between capital expenditure and carbon emission disclosure. Better internal governance will ensure that any carbon emission caused by the capital expenditure will be communicated to the stakeholders.

Our analysis shows that capital expenditure is positively associated with actual carbon emission, which was predicted from the primary analysis, as our carbon disclosure measure captures the actual carbon emission. Also, existing literature supports that economic output increases carbon emission (Chen et al., 2020). Moreover, in the Chinese housing sector, floor space per capita is related to carbon emission (Ma et al., 2020). Floor space created by the capital expenditure and also the economic activity driven by the capital expenditure. Therefore, capital expenditure is a leading indicator of carbon emission. The UK government claims that reducing carbon emission over the last few years is in the recent shift in coal to sustainable energy production (Gov.UK, 2021). However, the evidence shows that the reduction is primarily because of the reduction in capital expenditure. It is expected that after the current uncertain period, business organisations will seek growth, and therefore they might increase the capital expenditure. That will might increase carbon emission, which is against the UK government current goal. Therefore government should have some regulation regarding the business organisation capital expenditure.

The rest of the paper is structured as follows: section 2 literature review and hypotheses development, section 3 research method, section 4 empirical results and robustness check, then section 5 provide conclusion and implications.

2. Literature review

2.1 Capital expenditure and carbon emission disclosure

Managers' incentives to change narrative reporting could be explained through signalling theory (Beyer et al., 2010). Companies disclose information about their pro-active strategy related to the environmental activities to signal in the market. Companies' capital expenditure impacts the GHG emission because more capital expenditure will increase more value relevant activity. Therefore, firms will have an increase in their carbon footprint. All the stakeholders worldwide are concerned about global climate change; thus, companies try to gain strategic advantages by disclosing information about their expenditure impact on the environment (Li et al., 2019).

Companies with higher capital expenditure intend to send a signal to the market regarding the environmental impact of their activities. This can be done by providing more information about their environmental responsibilities, particularly regarding carbon emissions. This signal mitigate the negative impact of their carbon emission related activities perceived by the stakeholders.

Providing more carbon emission disclosure impacts firm valuation positively by reducing the information asymmetry, and those firms that reduce their carbon emission outperform the market (CDP, 2021). But firm carbon emissions are ultimately penalised by the market, and non-disclosure makes this penalty more severe (Matsumura et al., 2014). So, producing more carbon emission information minimises the negative impact of the firm value. However, capital expenditure might increase carbon emission unless it is a green investment. Thus, if firms' make a green investment, it will increase the firm value as the market will perceive that as a quality investment (Chung et al., 1998; Clarkson and Richardson, 2004), and investment that related to increases in carbon emission will reduce the firm value (Nishitani and Kokubu, 2012). But, Lee et al. (2015) provided evidence that the market consistently penalises the firms for their negative environmental performance than rewards for positive performance. However, consistent with the argument provided by Matsumura et al. (2014), firms disclose more information regarding their carbon emission to minimise the negative impact.

Therefore, to gain competitive advantages in the market, firms with higher capital expenditure will communicate more information with the stakeholders. This communication will also include environmental impact information on this capital expenditure. In addition to that, the business organisation promotes their environmental activity to convey a positive image to their stakeholder to improve the trustworthiness of the organisation, build a reputation and gain competitive advantage (Broadstock et al., 2018; Zheng et al., 2020; Chen et al., 2021). So, we argue that a firm with more capital expenditure will likely disclose more carbon-related information; therefore, we hypothesise:

H1: There is a positive association between the firm capital expenditure and carbon emission disclosure in their annual report.

2.2 Internal governance and carbon emission disclosure

Given that the primary role of internal corporate governance is to monitor management decisions includes the investment decision. Thus, internal corporate governance plays a crucial role in the capital expenditure decision. Enhancing corporate disclosure transparency includes carbon disclosure, is also one of the pillars of internal corporate governance. So, strengthening the governance power will lead to more mature capital expenditure decisions and a higher level of carbon disclosure in the annual reports to satisfy the stakeholders' needs. There are many factors that enhance internal governance. In general, strong internal governance improves decision-making (Husted and Sousa-Filho, 2018), including strategies about capital expenditure and carbon emission disclosure. Good internal governance helps increase the different opinions and the quality of the discussion related to the decision-making process (Albitar et al., 2020), which is essential for quality capital expenditure decision. Internal governance is related to many corporate governance elements, such as board size, board independence, gender diversity, audit committee independence, and audit committee size. A larger board in the firm is associated with better governance because it will mitigate agency conflict. From agency theory, a larger board will be intended to disclose more information to the stakeholders to reduce the information asymmetry (Allegrini and Greco, 2011; Buerter et al., 2020). Because board size is one of the most leading corporate governance mechanisms (Allini et al., 2016; Gerged et al., 2021). Also, Existing literature found an association between

the board size and the corporate narrative disclosure (Elshandidy and Neri, 2015; Allini et al., 2016). The independence of the board moderates the relationship between the large board and narrative disclosure. Because independent directors have no financial benefit from the companies apart from the fixed director salary (Abrahamson and Park, 1994); therefore, their presence will increase board independence, thus voluntary disclosure (Allini et al., 2016; Elshandidy et al., 2015; Shan, 2019). Gender diversity also has an essential impact on firm internal governance. Female directors are more concerned about stakeholder ethical practice and environmentally responsible behaviour (Jain and Jamali, 2016). Therefore, more diversified boards will likely improve environmental disclosure. Along with that, the audit committee also has an impact on the firm internal governance mechanism. Moreover, audit committee independence and expertise also affect firm internal governance; thus, sustainability disclosure (Al-Shaer and Zaman, 2018).

Existing literature argues that corporate governance is a vital factor in monitoring firms sustainability reporting (Akben- Selcuk, 2019); better governance will ensure more transparent disclosure (Mallin et al., 2013). Management is pressured to disclose their Green House Gas (GHG) emission and their long-term carbon emission reduction (Flammer, 2013). Because of the global climate change, stakeholders are demanding transparent, consistent and more disclosure about the firms' approach to carbon disclosure (Qian and Schaltegger, 2017). Effective internal governance reflects that message by forcing managers to promote credible environmental/ sustainability disclosure (del Miras-Rodríguez and Di Pietra, 2018). A firm with better internal governance will be forced to publish comprehensive and informative sustainability information because of the legitimacy pressure (Albitar et al., 2020). Therefore, we assume that firms with better internal governance will disclose more information related to carbon disclosure. Thus, we hypothesise:

H2: There is a positive relationship between the firm internal governance and carbon emission disclosure.

3. Research design

3.1 Data collection and sample selection

We use computerised textual analysis for scoring the carbon emission disclosure level in the annual reports. The initial sample of this study includes all UK FTSE All-share non-financial firms over the period from 2013 to 2019. We exclude financial firms due to the differences in the disclosure regulation. To develop the disclosure index, we downloaded the firms' annual report from their website. Also, we collected other financial and ESG data from Eikon database.

3.2 The construction of carbon emission disclosure measurement

The developed carbon emission disclosure index is based on three main sources; the first reference is all the sustainability reports for FTSE all-share non-financial firms. Then we use The GRE standards 305/2016. The environmental guidance published by the UK government on streamlined energy and emission reporting use as a third source to increase the richness of the word choice. We review the carbon emission disclosure literature and investigate the extent of carbon emission disclosure by reading a randomly selected sample of UK corporate annual reports. Disclosure wordlist measures the extent of the corporate disclosure by counting the word/words' frequency.

We use Nvivo 12 Pro to find the most frequent words on the annual reports for FTSE all-share non-financial firms, 'The GRE standards 305/2016' and ENV guidance on streamlined energy emission reporting. We did this step individually, and we crossed check our word choice and agreed on the shared word choice. We further use LancsBox software to search the words back into the main body text; to ensure that words are at least capture 75% of carbon emission disclosure, and they are frequent to an extent. The same software use to develop 2/3 words together to avoid the disadvantage of relying on one word when disclosure quality was assessed, as explained in the literature.

3.3 Scoring the corporate annual reports

CFIE 2019, a software developed by Lancaster university been used (El-Haj et al., 2019). The software allows the researchers to score annual reports based on the developed wordlist across the sample. After scoring the annual reports, we checked five random annual reports and compared the software outcome with the actual carbon emissions disclosure section in these annual reports. We found there is an association between the score given by CFIE 2019 and the cross-checked carbon emission narrative disclosure. The software has been used to score the whole sample of the UK FTSE all-share non-financial firms.

3.4 Regression model

The paper uses a multivariate regression model to investigate the relationship between capital expenditure, corporate governance and the level of carbon emission disclosure in the annual reports. To eliminate the industry and year effect, we control the industry fixed effect and year effect. The model is as follow:

$$\text{Carbon emission disclosure} = \beta_0 + \beta_1 \text{Capex} + \beta_2 \text{Internal_gov} + \beta_3 \text{Capex} \# \text{Internal_gov} + \beta_4 \text{Total_assets} + \beta_5 \text{Asset_turnover} + \beta_6 \text{Beta} + \text{Industry Fixed Effects} + \text{Year Fixed Effects} + \varepsilon \quad (1)$$

Capex (Capital expenditure): Capital expenditure measure as the firm annual capital expenditure at t-1. We used the measure t-1 because this year's capital expenditure will impact the carbon emission next year. Therefore, it will also have an impact on next year carbon disclosure.

Internal gov (Internal governance): We capture the internal governance by combining the variables (Board size, board independence, audit committee independence, gender diversity, audit committee expertise) through a principal component analysis (PCA) (Mallin et al., 2013; Arena et al., 2015). The PCA helps aggregate variables associated with each determinant into a single composite score and avoid multicollinearity and reduce measurement error (Arena et al., 2015).

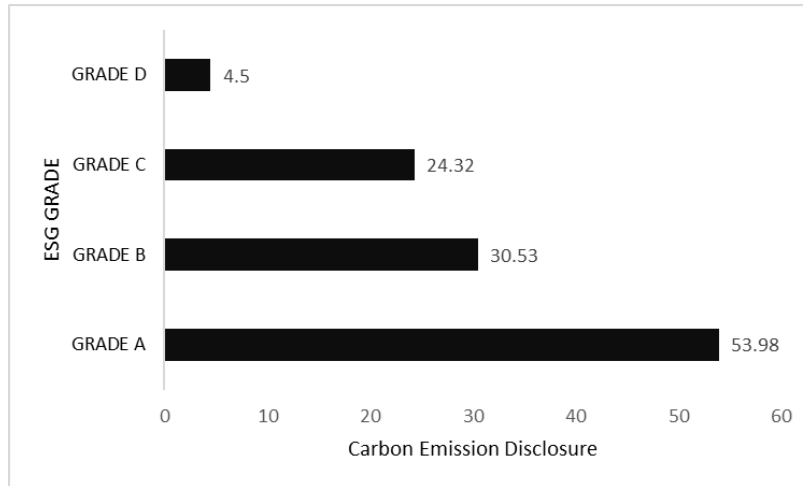
We also controlled the firm's systematic risk using beta, firm size measured as the firm's total asset and asset turnover to measure firm efficiency.

3.5 The validity of carbon emission disclosure measurement

Graph 1 illustrates the mean of the carbon emission disclosure score across the ESG grade. It is evident that; the weighted average means of carbon score disclosure gradually decrease with

the ESG grade of the industry. ESG score reflects the companies' performance over the environmental, social and governance factors. Therefore, those companies that perform better in ESG grade are expected to provide more carbon emissions information. Graph1 shows that; the higher the ESG grade, the higher the level of carbon emission disclosure. This shows that our unique measure of carbon emission disclosure is valid.

Graph 1: Weighted Average Carbon Score Distribution by ESC Grade.



To validate our unique carbon score measure, we regressed the carbon score with different ESG pillars using OLS, Fixed Effect and Tobit. We used the fixed-effect model to ensure that; there is no omitted variable bias. Also, Tobit regression was used because our measure of carbon score is truncated to the lowest value zero. Table 1 shows that the result remains positively significant at 99% level. The table suggests that; firm with high social, environmental, and governance will disclosure more carbon information. As previously explained, if the environmental, social, and governance pillar score is high, firms tend to disclose more carbon-related information. So, our result is consistent with our expectation.

VARIABLES	OLS Carbon_Disclosure	Fixed Effect Carbon_Disclosure	Tobit Carbon_Disclosure	OLS Carbon_Disclosure	Tobit Carbon_Disclosure
Environment_pillar_score	0.201*** (0.0412)	0.147*** (0.0550)	0.201*** (0.0411)		
Social_pillar_score	0.183*** (0.0462)	0.161*** (0.0508)	0.183*** (0.0461)		
Governance_pillar_score	0.135*** (0.0362)	0.121*** (0.0357)	0.135*** (0.0361)		
CO2_emission				1.927*** (0.345)	1.927*** (0.344)
ESG_score				0.366*** (0.0490)	0.366*** (0.0490)
Constant	3.754* (2.224)	7.881** (3.139)	3.754* (2.220)	-10.38*** (3.453)	-10.38*** (3.448)
Observations	1,045	1,045	1,045	999	999
R-squared	0.143	0.053		0.149	

*** p<0.01, ** p<0.05, * p<0.1

We also used further analysis to investigate whether our measure of carbon emission disclosure captures the actual CO2 emission by the firms. This provided additional validation of our measure. Table 1 also demonstrates that; our measure is significant at 99% level for actual CO2. That means firms with a higher carbon footprint associated with a higher level of carbon emission disclosure. Moreover, the result suggested, the ESG score also positively associated with our measure. The result presents using both OLS and Tobit regression, as mentioned before.

We run the regression for direct and indirect carbon emission scope. This conducted to assess how our measurement associated with different scope. Scope1 is the direct emission, and scope 2, and scope 3 is the firms' indirect emission. It can be noted that all the three scopes are positively associated with our unique carbon emission disclosure measurement are positively significant at 99% interval level (Table 2). We run three separate regression to avoid multicollinearity issues. The outcome of the analysis is according to our expectation. It also shows that; our unique developed measure captures the textual carbon emission disclosure in the annual reports and the actual carbon emission. This result is further validation of our index for carbon emission disclosure measurement.

Table 2: Carbon emission disclosure by the Scope

VARIABLES	Carbon_Disclosure	Carbon_Disclosure	Carbon_Disclosure
Scope1 Direct Emission	2.820*** (0.270)		
Scope2 Indirect Emission		3.849*** (0.355)	
Scope3 Indirect Emission			3.929*** (0.416)
Constant	1.543 (2.882)	-8.502** (3.697)	-1.370 (4.476)
Observations	927	918	419
R-squared	0.105	0.113	0.176

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4. Empirical results

4.1 Descriptive statistics

Table 3 shows the sample distribution by the industry and year with our measured carbon score mean. It is evident from the table that carbon emission disclosure s are varying across the industry. For example, the Utilities sector has the highest amount of carbon emission disclosure. The reason behind that, because energy usually produced from burning fossil fuel

or coal. For instance, in the USA, electricity production is the highest contributor to greenhouse gas emission (United States Environmental Protection Agency, 2020). Therefore, the consumers in this industry are more concern about the carbon effect on global climate change. The energy sector has the highest Scope 3 emission, which is the second-highest in Table 3. For example transportation sector heavily relies on fossil fuel or other forms of energy. Transportation is another significant contributor to CO2 emission. It is also evident that the Health Care sector carbon emission disclosure increases significantly over the last couple of years. The reason is that NHS England is committed to delivering to net-zero health services in the UK and is currently contributing 5.4% of the UK greenhouse gas (BMJ, 2020). Therefore, to achieve the net-zero target, companies are providing more information and transparency. Also, Consumer Discretionary carbon emission disclosure is the lowest in Table 3. However, this sector trend of carbon emission disclosure is upward because companies in this sector compete to achieve greenwash and attract more consumer (The consumer goods, 2020). Also, it is evident that; the sum of the carbon emission disclosure means increasing year by year. This shows that all the business discloses more information about carbon footprint to satisfy the stakeholder concerns about global climate change.

Table 3: Carbon emission disclosure Mean by the Industry and Year

	Year							Total
	2013	2014	2015	2016	2017	2018	2019	
Communication Services	20.44	19.73	20.00	20.92	21.62	22.75	27.83	21.52
Consumer Discretionary	12.24	14.98	16.81	17.76	19.21	21.28	23.53	18.08
Consumer Staples	16.21	22.07	24.28	20.44	20.77	23.40	17.60	21.13
Energy	34.44	31.56	40.50	42.40	53.78	54.00	16.00	42.28
Health Care	10.89	17.64	15.67	24.08	28.93	31.77	39.33	23.68
Industrials	23.28	26.75	27.00	24.21	22.88	29.97	32.05	26.24
Information Technology	18.18	21.46	24.93	24.53	29.33	21.43	32.11	24.45
Materials	25.14	38.86	38.76	42.04	37.12	43.71	40.00	37.94
Real Estate	15.04	20.58	22.42	22.81	29.39	31.10	41.00	25.89
Utilities	50.00	55.60	47.83	51.00	43.17	56.00	90.00	53.61
Total	225.87	269.23	278.20	290.19	306.18	335.41	359.46	294.82

4.2 Correlation matrix

The matrix shows the correlation between carbon emission disclosure, internal governance, capital expenditure and other control variables (Table 4). Our primary explanatory variable internal governance and capital expenditure, is positively significant at 99% level. This result validates the statistical relationship between the dependent and independent variables and whether signs of collinearity may be present. We check whether our variables are highly correlated and caused the multicollinearity issue in the regression. We did not find any problem with multicollinearity.

Table 4: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Carbon_Disclosure	1.000						
(2) Internal_gov	0.164*	1.000					
	(0.000)						

VARIABLES	Carbon emission disclosure	Carbon emission disclosure
Capex	0.00154** (0.000625)	0.00154** (0.000623)
Internal gov	1.325** (0.623)	1.325** (0.621)
c. Capex_exp #c. Internal_gov	0.00677*** (0.000812)	0.00677*** (0.000809)
Total assets	3.030*** (0.522)	3.030*** (0.520)
Current ratio	1.826*** (0.396)	1.826*** (0.395)
Asset_turnover	-1.505* (0.844)	-1.505* (0.840)
Beta	-0.972 (1.141)	-0.972 (1.136)
Constant	3.039 (4.318)	3.039 (4.301)
Observations	1,037	1,037
R-squared	0.414	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Our result shows that more capital expenditure will increase carbon disclosure in the annual reports because capital expenditure leaves more carbon footprint on the climate. Thus we assume that more carbon emission will negatively affect the firm value. Therefore, to test the assumption and validate the result, we run OLS regression for carbon emission disclosure and actual carbon emission (in megaton) with the firm value measured by TobinQ (Table 6). Our result shows that carbon emission is negatively affecting TobinQ. Also, carbon disclosure information is negatively significant with TobinQ.

As discussed earlier, firms disclose more information to avoid the adverse market reaction. The coefficient of the disclosure - 0.00382 is lower than the coefficient of the actual carbon - 0.0222- which means that disclosing carbon-related information decreases the negative impact on firm value.

Table 6: Effect of CO2 emission and carbon disclosure on firms value.

VARIABLES	TobinQ	TobinQ
CO2_emission	-0.0222*** (0.00491)	
Carbon_Disclosure		-0.00382*** (0.00132)

Constant	1.248*** (0.0375)	1.298*** (0.0464)
Observations	1,001	1,526

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Total CO2 Emission measured in a million tons and tobinQ estimated as the market capitalisation at the year-end divided by the firms' total asset.

From the result (Table 6), it is evident that market reaction to capital expenditure is adverse. Some firms may have green investment. However, this green investment effect on firm value could be negative in the short term because the market does reward for green investment. These findings are consistent with the literature that firms get punished for poor carbon performance and not rewarded for the green investment by the market (Lee et al., 2015). Therefore, to avoid an opposing market reaction, managers should do more green capital expenditure.

There is a decline in CO2 emission in the UK by 41% since 1990 (Gov.UK, 2021). The assumption that the main reduction in CO2 is due to the shift in coal to renewable energy sources. However, the energy sector is only responsible for around 26% (90.1MtCO2/351.5 MtCO2) CO2 emission as of 2019 (Gov.UK, 2021). Our data shows that one of the main reduction in CO2 is because of the decline in capital expenditure. The mean of capital expenditure in UK FTSE companies declines by around 53% from 2013 to 2018 (Table 7). This reduction is because of the recent political uncertainty in the UK around the Brexit referendum (Financial Times, 2019). Following the reduction in the capital expenditure, the sample data demonstrate 39% decline in the mean CO2 emission in UK FTSE companies. Our sample indicates that for every \$1 million capital expenditure, there is an increase of approximately 2.75 MtCO2 emissions (Table 8). Therefore, a reduction in capital expenditure was one of the primary reason for the decrease in the UK CO2 emission. It was estimated that business investment is around 70% of the UK's total investment (Financial Times, 2019). Therefore, reductions in capital expenditure were one of the primary reasons for the decrease in the UK's overall CO2 emission; along with the energy intensity, economic output promotes (suppress) carbon emission growth per capita (Chen et al., 2020). Ma et al. (2020) also reveal that floor space per capita and energy intensity in the Chinese housing sector are the most crucial factor for CO2 emission. More floor space is a lagging indicator of more capital expenditure.

Table 7: Mean of CO2 emission and capital expenditure.

Year	CO2_emission Mean (Million tonns)	Capex Mean (\$mm)	Frequency
2013	2.76	638.17	123
2014	2.41	674.02	128
2015	2.03	521.35	157
2016	1.72	393.29	173
2017	1.64	308.80	180

2018	1.68	296.57	177
2019	0.26	64.58	63

Table 8: Association between capital expenditure and CO2 emission.

VARIABLES	CO2 Emission Total (ton)
Capex	2,745*** (71.10)
Constant	701,328*** (151,424)
Observations	1,001
R-squared	0.599

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.4 Robustness check and additional analysis

Further, we use quantile regression to test the heterogeneity of the effect of both capital expenditure and internal governance on carbon emission disclosure at different levels. This provides a more accurate examination of capital expenditure and internal governance impact on the overall conditional distribution of carbon emission disclosure. Capital expenditure and internal governance significantly impact carbon emission disclosure under all quantiles (Table 9). The coefficient of capital expenditure and internal governance increases from the 25th percentile to 50th percentile and 75th percentile. The increase in the capital expenditure coefficient indicate that; the higher amount of capital expenditure will drive more carbon emission disclosure. Each 1% increase in capital expenditure will increase the carbon score by 0.4% for the 25th quantile, 50th quantile rose by 0.6%., 75th quantile rose by 0.9%. It is also evident that there is a simultaneous increase in the internal governance in all the quantile. That means a higher level of expenditure alone drives more disclosure, but the increase in internal governance played a significant factor in firms' carbon-related disclosure. A higher level of corporate governance will ensure that firms provide a sufficient level of carbon-related information to the stakeholder because a higher level of governance will reduce the information asymmetry.

Table 9: Robustness Check

VARIABLES	25 th Percentile Carbon_Disclosure	50 th Percentile Carbon_Disclosure	75 th Percentile Carbon_Disclosure
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Capex	0.00367*** (0.000281)	0.00583*** (0.000378)	0.00869*** (0.000515)
Internal_gov	0.872* (0.509)	1.452** (0.685)	2.250** (0.932)
ln_tasset	0.836* (0.437)	2.090*** (0.588)	4.087*** (0.801)
Current_ratio	2.128*** (0.333)	2.707*** (0.448)	2.759*** (0.609)
Asset_turnover	0.348 (0.708)	-1.034 (0.952)	-1.000 (1.296)
Beta	0.433 (0.958)	0.135 (1.289)	-0.743 (1.754)
Constant	4.061 (3.620)	4.808 (4.870)	0.764 (6.627)
Observations	1,037	1,037	1,037

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

This paper aims to develop a unique index to measure carbon emission's narrative disclosure in the annual reports by using automated textual analysis based on a sample of the UK FTSE all-share non-financial firms across the years from fiscal 2013 to fiscal 2019. Further, it explores the relationship between capital expenditure, internal governance and the level of narrative carbon emission disclosure. We also assess the role of internal governance in the relationship between capital expenditure and carbon emission disclosure. Our measurement is valid and reliable as it is in line with the outcomes using different measurement for the carbon being used in the literature. However, our unique measurement captures actual CO₂ emission, including scope 1, scope 2, and it also captures the ESG score, ESG grade and considers the narrative section used by the management to primary communicate the carbon-related information with the stakeholders.

Furthermore, there is a positive relationship between capital expenditure, internal governance and carbon emission disclosure. Our results also suggest that internal governance captured by PCA strength the relationship between capital expenditure and carbon emission disclosure. We also suggest that the level of capital expenditure are negatively associated with firm value. Our data shows both the level of capital expenditure and the level of carbon disclosure are declining in the UK. This might be because of the uncertainty around Brexit since 2013. We argued that the market will decline the high carbon emission and will not reward the green investment. We provide evidence that the level of capital expenditure will positively be associated with the level of carbon disclosure, and both of them are negatively affected by the firm value in the market. This highlights the importance of management to pay more attention to carbon emission. We also found that capital expenditure and internal governance positively impact carbon emission disclosure under all quantiles (25th percentile to 50th percentile and 75th percentile). A higher level of expenditure alone drives more disclosure; the increase in internal governance plays a significant factor in disclosing more carbon-related information.

Our paper is extremely important for the stakeholders. For instance, managers are encouraged to provide more carbon-related information and communicate it with the stakeholders to maximise the firm value. As policymakers and regulators in the UK target net-zero emission by 2050, they have to play a vital role in enhancing the engagement in providing detailed guidance to enhance more carbon information in the annual report. Our index can help the regulators force the management to disclose more carbon emission disclosure to achieve the target. The standard-setters can use our unique measurements as guidance for the level of carbon information. Also, policymaker should enhance the governance standards as they contribute to the level of carbon emission disclosure in the annual reports.

Main results:

- 1- Our paper provides a unique carbon emission disclosure measurement that effectively captures the actual level of carbon emission and the actual level of ESG score.
- 2- Our measurement captures actual CO₂ emission, including scope 1, scope 2, and also captures the environmental, social and governance (ESG) score.
- 3- There is a significant positive relationship between capital expenditure and carbon emission disclosure.
- 4- Our results show a positive association between capital expenditure and the level of carbon emitted.
- 5- There is a positive relationship between the actual CO₂ emission, ESG pillar and the level of carbon disclosure.
- 6- There is a significant positive relationship between internal governance and carbon emission disclosure.
- 7- The internal governance measured by PCA strengthen the relationship between capital expenditure and carbon emission disclosure.
- 8- Both CO₂ emission and carbon disclosure have a negative association with the firm value, which reflect that the market does not tolerate any increase in the level of disclosure.
- 9- The market will punish firms with environmental behaviour but will not appreciate firms reducing the level of carbon emitted or carbon emission disclosure.
- 10- Due to Brexit and the uncertainty in UK market, the level of capital expenditure has declined in the UK during the recent 7 years and this is associated with a decline in the level of carbon emitted.
- 11- We further use quantile regression, and the findings show that capital expenditure and internal governance have a positive impact on carbon emission disclosure under all quantiles.

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