Reports on Economics and Finance, Vol. 5, 2019, no. 1, 61 - 70
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ref.2019.933

Carbon Management Systems and Carbon Emissions: The Role of Carbon Accounting

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Abstract

Corporate carbon management systems has become increasingly vital in controlling greenhouse gas emissions, thus whether and how corporate carbon management systems will influence carbon emissions is our ultimate focus. This paper follows the method used by Tang and Luo (2014) and data from multinational firms that participate in the carbon disclosure projects to compute the quality of carbon management systems. The empirical results show that: (1) Consistent with the law of Material Balances, the quality of carbon management systems is negatively correlated with carbon emissions, while the interaction effect is not immediate. Rather, the negative relationship will become much more obvious after two delayed periods. (2) Of the elements of carbon management system, GHG Accounting, Target, Project and Disclosure are four key factors driving the quality of CMSs.

Keywords: Carbon management systems Carbon emissions Law of Material Balances

1. Introduction

There is growing scientific evidence that carbon emission is the main factor for global warming, seriously threating the quality of human lives. Howard-Grenville et al. (2014) argue that the increase of organizations and industrialized production has amplified the process of climate change. Therefore, how to reduce carbon emissions effectively has become the focus of all firms. More and more corpora-

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tions are towards environmental self-regulation. “Business-led” initiatives such as development of firm-structured carbon management systems (CMSs), participation in trade association programs emphasizing codes of carbon management, and adoption of international certification standards for carbon management, such as the International Standards Organization are becoming widespread.

Based on current carbon practices and fundamental concepts from the environmental management literature, we considered ten essential elements of a CMS just as that in Tang and Luo (2014). These elements are as follows: (1) board function; (2) carbon risk and opportunity assessment; (3) staff involvement; (4) reduction targets; (5) policy implementation; (6) supply-chain emission control; (7) greenhouse gas (GHG) accounting; (8) GHG assurance; (9) engagement with stakeholders; and (10) external disclosure and communication. Each of these factors denotes a distinctive characteristic or perspective of a CMS and is recognized as the basis of its function in enabling the management planning convenient and in evaluating, detecting and notifying climate change concerns. To implement our quantitative examinations, we also construct ten indicators to work as proxies for each factor.

The present study contributes to the literature in several aspects. First, Tang and Luo (2014) only studied the top firms in Australia, which the sample size was small and limited. Therefore, our sample cover 45 countries spaning 2011 to 2015 five years, which can produce much more persuasive results between carbon emission and carbon management system. Second, we apply data collected from the largest provider of organizational carbon data to institutional investors and stakeholders (i.e., the CDP) to create firms’ distinctive CMS quality score. The merits of CDP data mainly lie in these information are from the corporate responses to a standard questionnaire, which reduces dramatically biases rising from the self-selection of the carbon items that are disclosed by the reporting organizations. Third, our studies suggest that firms who use much more proactive mechanisms, renewable resources and prioritise actions are much more inclined to obtain better outcome. These findings may also help managers to implement the unique carbon management standards except the existing common environmental standards.

The rest of this paper proceeds as follows. The research design is presented in Section 2 and Section 3 discusses the empirical results. The final section is our conclusions.

2. Research Design

2.1 How to Measure the Quality of CMS

We measure the overall quality of carbon management system through utilising the ten key factors. Each of these elements represents a unique dimension and is computed according to its charateristics in designing climate change policies. Data are from firms' Carbon Disclosure Project (CDP) reports. See Tang and Luo (2014) for the details. The variable CMSQUALITY (overall quality of carbon management systems) is measured as the average of equally weighted and normalized values of ten elements, and it improves with the increase of the elements. The equation is as follows:

$$CMSQUALITY = \frac{1}{10}\sum_{i=1}^{10} S_{Element_i}$$

Of which $S_{Element_i}$ represents the normalized value of the ith factor. We choose CMSQUALITY to measure the quality of CMS, mainly because it is a reasonable indicator reflecting most perspectives concerning with carbon management systems, involving carbon governance, risk management, incentives, targets, project implementation, accounting, auditing, the supply chain, policy engagement, communication and disclosure.

2.2 Econometrical Model

We specify a fixed effect regression model in Eq.(1) using panel data:

$$\begin{aligned} INTENSITY_{it} &= \alpha_0 + \alpha_1 CMSQUALITY_{it} + \alpha_2 SIZE_{it} + \alpha_3 ROA_{it} + \alpha_4 LEV_{it} + \alpha_5 TOBINQ_{it} \\ &+ \alpha_6 CAPITAL\_\mathrm{INTENS}_{it} + \alpha_7 CAPINT_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

The dependent variable INTENSITY is defined as the ratio of total emissions (scope1 and scope2) to total sales, this measure is more suitable across companies than those based on absolute emissions (Hoffmann and Busch, 2008). In the model, we also consider some variables which are commonly used in the environmental accounting researches and that possibly could be correlated with the quality of carbon management systems.

Large-scale enterprises face much more pressure from the outsiders and thus are much more inclined to create and implement a higher-quality carbon management system to reduce carbon emission and encourage stakeholder to be engaged (Anton et al., 2004). Therefore, the variable SIZE represents firm size, and is proxied by the natural logarithm of total assets. Dowell et all.(2000) found that implementing more stringent environmental standards is positively correlated with firm’s Tobin Q. Therefore, we utilize TOBINQ as a variable to represent the managers' creative abilities, measured by the total market value of shares outstanding, plus preferred shares, book value of long-term debt, and current liabilities, divided by book value of total assets at the end of fiscal year. LEV is explained by total debt divided by total assets at the end of fiscal year (Luo et al.,2012). Return on assets (ROA) could indicate whether a firm is profitable and healthy, measured through net income before extraordinary items/preferred dividends divided by total assets (Clarkson et al., 2008). We employ capital intensity (CAPINT) as an indicator to measure a firm’s reliance on capital markets and thus a variable to reflect the pressures from common market participants (Anton et al.,2004). CAPINT is measured as property, plant, and equipment divided by total assets. In order to measure a firm's efficiency in deployment of its assets, we use an indicator named CAPITAL_INTENS which is computed as a ratio of the capital expenditures to sales revenue generated over a given period, which also indicates how much money is invested to produce one dollar of sales revenue (Ioannou et al., 2015).

2.3 Sample selection and data

The initial data consisted of 7991 firms that participated voluntarily in the CDP from 2011 to 2015, total 25796 firm-year observations. We excluded 1371 repeatable observations and deleted 914 observations that did not have a Carbon Disclosure Leadership score, which is necessary to construct the CMSs. Then 2256 observations were eliminated due to the missing values for the independent variables. Furthermore, we consider the logarithmic form of dependent variable to eliminate the influence of heteroscedasticity. Finally, only 45 countries which had more than 10 observations were kept for studies (Luo and Tang, 2016). Notice that firms in our sample are relatively bigger, and we choose them because bigger companies often have urgent emission problems.

3. Empirical Results

3.1 Descriptive statistics

Table 1 reports descriptive statistics for the dependent and independent variables used in Eq.(1). The average value of carbon emissions is 3314591 mtons, the lowest firm is 0 and the highest is 1243614 mtons, indicating a large variation in the carbon emissions intensity across the countries. The mean natural logarithm of total assets (SIZE) is 15.21, indicating that our sample are generally formed with bigger companies. On average, ROA is almost 5% of total assets. The mean TOBINQ is 1.94, and the average LEV is 23.93% of total assets.

Table 2 provides both Spearman and Pearson pair-wise correlation coefficients in the upper and lower triangle, respectively. SIZE is negatively correlated with the INTENSITY (Spearman coefficient -0.0482 and Pearson coefficient -0.0831; both of which are significant at 0.01 level) indicating that the bigger firms tend to emit much less greenhouse gas every unit sale. We find that the carbon management system firstly produce the immediate and positive impact on carbon emissions (Spearman coefficient is significantly 0.0566, while Pearson coefficient is significantly 0.0331), indicating that the contemporaneous negative effect CMS on INTENSITY is not very obvious, which is also the main point we try to explore. The Spearman correlation coefficient on Lev (0.2239) and the Pearson correlation coefficient on INTENSITY (0.1820) both show that they are significantly and positively associated with the carbon emission. In fact, those firms whose financial status are bad are inclined to endure high debts and emit much more greenhouse gas, while other financial market-related variables such as CAPITAL_INTENS, TOBINQ, ROA, CAPINT are also significantly correlated with INTENSITY. This indicates that these variables could reflect the level of financial market pressure or the information demanded for market participants, which are critical for executives in the carbon emission decisions.

3.2 The relationship between INTENSITY and the quality of CMS

The results of four FE panel models Eq.(1), using panel data are presented in Table 3.Model (1) to Model (2) use carbon emission intensity as the dependent variable, the difference is that Model (2) contains a new variable CMSQUALITY, all the control variables are same. Model (2) shows that there is a positive connection between carbon emissions and the quality of CMS, which indicates that the adoption of carbon emission systems doesn't have an instant negative effect on carbon emission. After two periods, just as showed in Model (4), we find that L2.CMSQUALITY is significantly negative with carbon emissions. The explanation is that if suitable management systems are in place, better carbon environmental performance will increasing occur (Potoski and Prakash, 2005). Adopting a CMS could direct the firms' attention and energy to improve their carbon environmental influence, helping firms increase opportunities to amplify performance (Hart, 1995).What's more, the R-square in Model (4) increases a lot than that of Model (2), indicating that the quality of CMS does really impact the carbon emissions.

SIZE is found to be negative with INTENSITY, indicating that larger firms tend to have much less carbon emission intensity, which is consistent with previous studies. Possible explanation is that large-scale enterprises face much more pressure from the outsiders and thus are much more inclined to create and implement a high-quality carbon management system to reduce carbon emission and encourage stakeholder to be engaged (Anton et al., 2004). The financial market pressure indicator (LEV) is positive for all models, which indicates that the financial market pressure will affect the carbon emission, but not very significant. Similarly, consistent with our expectation, the coefficient of ROA is negative (as is showed in model (4)), indicating a profitable firm might be less restricted by financial capital in making green decisions, are much easier to expansion or other changes such as restructuring or reengineering, and more inclined to invest low carbon projects and carbon management systems, thus leading to decreased carbon emissions. What's more, CAPITAL_INTENS is positively correlated with INTENSITY, which is because that firms with higher capital intensity tend to have high carbon emissions intensity, possibly setting a lower carbon emissions target in the future, since for such firms reducing carbon emissions might be much more difficult (Ioannou et al., 2015). In terms of the control variables, we find that the coefficient estimates for TOBINQ, CAPINT are not significant, suggesting that they do not play a meaningful role in determining the carbon emission. Theoretically, we predict a negative association between TOBINQ and INTENSITY, but empirically the coefficient of TOBINQ is not statistically significantly different from zero. A possible reason is that the significance of TOBINQ is diluted (or substituted) when we include other factors, such as firm size, external pressures in the model.

3.3 The relationship between INTENSITY and ten elements of CMS

To further investigate the effect the quality of CMS on INTENSITY, we respectively explore the ten elements of CMS, as indicated in table 4. Model (1) to

Model (10) include all the same control variables. Except that there is a positive association in Model (2), Model (6), Model (8), the remaining models all show the negative relationship among elements of CMS and carbon emissions intensity. What's more, we find that GHG ACCOUNTING, TARGET, PROJECT and DISCLOSURE all have significant and negative effect on carbon emission intensity, indicating that these are dominant factors determining the relationship between the quality of CMS and INTENSITY. GHG ACCOUNTING, TARGET, PROJECT and DISCLOSURE these four elements constitute the carbon accounting, suggesting the role of accounting in environmental issues.

According to Tang and Luo (2014), carbon management systems includes four major dimensions: (1) carbon governance, (2) carbon operation, (3) emission tracking and reporting, and (4) engagement and disclosure. Each of these critical dimensions possesses its specific contribution to the overall quality of carbon management systems. In addition, how these dimensions and components are arranged and combined in a particular firm can affect emissions reductions. Just as showed in table 4, we find the latter three perspectives remain the main determinant and statistically significant. Different from the results in Tang and Luo(2014), we find that Accounting have the negative and significant effect on carbon emissions. On one hand, an essential part of carbon management is the calculation of the CO_2 footprint and inventory, in which accounting plays an indispensable role. On the other hand, a comprehensive carbon accounting system would also assist managerial planning and encourage a manager to care much more about climate-related measures.

4. Conclusions

According to Tang and Luo (2014), the framework of a CMS is consisted of four dimensions and 10 components. Our results provide further evidence about how companies in different countries would solve climate issues during the transitional period towards a green economy. We have proved that companies with a higher quality CMS will tend to reduce their carbon emissions, which means that firms with proactive mechanisms will be likely to devote resources and prioritise actions, conforming to the law of Material Balances.

These findings have important implications for further research. We need to explore the impact of corporate carbon control on firm market value, namely, an effective CMS is expected to minimise CO_2 pollution and amplify shareholder wealth simultaneously. The forthcoming and increasingly stringent government regulations may have massive financial implications across the entire economy.

Acknowledgements. This research is partially supported the Ministry of Education of Humanities and Social Science project of China under grant No. 18YJC790238. And also, sincerely thanks for the guidance of Professor Qingliang Tang and Lecturer Laura Luo.

References

[1] W.R.Q. Anton, G. Deltas, M. Khanna, Incentives for environmental self-regulation and implications for environmental performance, *Journal of Environmental Economics and Management*, **48** (2004), no. 1, 632-654. https://doi.org/10.1016/j.jeem.2003.06.003

[2] P.M. Clarkson, Y. Li, G.D. Richardson, Florin P. Vasvari, Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis, *Accounting, Organizations and Society*, **33** (2008), no. 4-5, 303-327. https://doi.org/10.1016/j.aos.2007.05.003

[3] G. Dowell, S. Hart, B. Yeung, Do corporate global environmental standards create or destroy market value?, *Management Science*, **46** (2000), no. 8, 1059-1074. https://doi.org/10.1287/mnsc.46.8.1059.12030

[4] S.L. Hart, A natural-resource-based view of the firm, *Academy of Management Review*, **20** (1995), no. 4, 986-1014. https://doi.org/10.5465/amr.1995.9512280033

[5] V.H. Hoffmann, T. Busch, Corporate carbon performance indicators: Carbon intensity, dependency, exposure, and risk, *Journal of Industrial Ecology*, **12** (2008), no. 4, 505-520. https://doi.org/10.1111/j.1530-9290.2008.00066.x

[6] J. Howard-Grenville, S.J. Buckle, B.J. Hoskins, G. George, Climate change and management, *Academy of Management Journal*, **57** (2014), 615-623. https://doi.org/10.5465/amj.2014.4003

[7] I. Ioannou, S.X. Li, G. Serafeim, The effect of target difficulty on target completion: The case of reducing carbon emissions, *The Accounting Review*, **91** (2015), no. 5, 1467-1492. https://doi.org/10.2308/accr-51307

[8] L. Luo, Y.C. Lan, Q. Tang, Corporate incentives to disclose carbon information: Evidence from the CDP Global 500 report, *Journal of International Financial Management & Accounting*, **23** (2012), no. 2, 93-120. https://doi.org/10.1111/j.1467-646x.2012.01055.x

[9] L. Luo, Q. Tang, Determinants of the quality of corporate carbon management systems: An international study, *The International Journal of Accounting*, **51** (2016), no. 2, 275-305. https://doi.org/10.1016/j.intacc.2016.04.007

[10] M. Potoski, A. Prakash, Green clubs and voluntary governance: ISO 14001 and firms' regulatory compliance, *American Journal of Political Science*, **49** (2005), no. 2, 235-248. https://doi.org/10.1111/j.0092-5853.2005.00120.x

[11] Q. Tang, L. Luo, Carbon management systems and carbon mitigation, *Australian Accounting Review*, **24** (2014), no. 1, 84-98.
https://doi.org/10.1111/auar.12010

Table 1. Descriptive statistics

Variable	Mean	Median	SD	Min	Max	P25	P75
SCOPE1	2800182	54481	9845329	0	70900000	6793	542037
SCOPE2	539770	98724	1268242	0	8727000	20464	410519
SCOPE	3314591	217579	10400000	0	79700000	41000	1243614
INTENSITY	-4.1221	-3.8215	2.9021	-16.2455	8.4322	-5.8681	-2.2446
CMSQUALITY	0.0015	-0.0805	0.3148	-1.8255	1.6557	-0.0805	0.1315
SIZE	15.2061	15.1584	1.8419	10.9472	20.1068	13.9921	16.3898
LEV	0.2393	0.2188	0.1945	0	2.1926	0.0811	0.3538
CAPITAL_INTENS	0.2056	0.0195	3.3656	0	305.2293	0.0016	0.0632
TOBINQ	1.9378	1.0891	9.0315	0	520.9174	0.8011	1.6570
ROA	0.0502	0.0385	0.5013	-2.8301	73.3686	0.0117	0.0775
CAPINT	0.3021	0.2363	0.2664	0	1.9147	0.0689	0.4780

Note: SD=standard deviation.

Table 2. Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INTENSITY (1)	1.0000	0.0566***	-0.0482***	0.2239***	0.7425***	0.1300***	0.0732***	0.4920***
CMSQUALITY (2)	0.0331**	1.0000	0.3438***	0.1121***	0.0032	-0.0582***	-0.0654***	0.0839***
SIZE (3)	-0.0831***	0.3319***	1.0000	0.0887***	0.0284*	-0.3961***	-0.2588***	-0.1970***
LEV (4)	0.1820***	0.0900***	0.0570***	1.0000	0.2488***	-0.0125	-0.1834***	0.3521***
CAPITAL_INTENS (5)	0.1911***	-0.0136	-0.0371**	0.0959***	1.0000	0.1311***	0.1051***	0.4424***
TOBINQ (6)	-0.1115***	-0.0194	-0.0993***	0.0353**	-0.0211	1.0000	0.6291***	0.1453***
ROA(7)	0.0073	-0.0242	-0.1612***	-0.1794***	-0.0128	0.0874***	1.0000	0.0317*
CAPINT (8)	0.4324***	0.0517***	-0.1838 ***	0.3335***	0.3404***	0.0270	-0.0645***	1.0000

Note: Pearson (Spearman) correlation coefficients are below (above) the diagonal.
***,**,* , Correlation is significant at 0.01,0.5,0.1 levels, respectively (two-tailed).
Among the variables, CMSQUALITY with two order lags.

Table 3. The relationship between INTENSITY and the quality of CMS

Variables	Dependent variable: INTENSITY			
	(1)	(2)	(3)	(4)
CMSQUALITY		0.0724		
		(1.31)		
L.CMSQUALITY			-0.0146	
			(-0.40)	
L2.CMSQUALITY				-0.0702**
				(-2.09)
SIZE	-0.1492*	-0.1594**	-0.2415***	-0.2053***
	(-1.95)	(-2.11)	(-3.63)	(-3.23)
LEV	0.1652	0.1618	0.2730	0.1663
	(0.88)	(0.86)	(1.54)	(1.03)
CAPITAL_INTENS	-0.0132	-0.0124	0.0722***	0.0744***
	(-0.63)	(-0.59)	(2.83)	(2.99)
TOBINQ	0.0031	0.0030	-0.0027	-0.0025
	(1.34)	(1.32)	(-1.12)	(-1.14)
ROA	0.3713	0.3753	-0.0650	-0.2892
	(1.32)	(1.34)	(-0.29)	(-1.15)
CAPINT	-0.1606	-0.1619	-0.0985	0.1174
	(-0.63)	(-0.63)	(-0.46)	(0.67)
Constant	-1.7195	-1.5653	-0.1865***	-0.7598***
	(-1.40)	(-1.29)	(-0.17)	(-0.74)
Observations	7052	7052	5112	3593
R-square	0.0045	0.0054	0.0119	0.0176

Note: The table reports FE coefficient estimates. T statistics based on robust standard errors are in parentheses.*, ** and *** represent significance at the 0.1,0.05 and 0.01 levels,respectively(two-tailed).All variables were winsorized at the 1st and 99th percentiles. Financial data are in millions of US dollars.

Table 4. The relationship between INTENSITY and ten elements of CMS

Variables	Dependent variable: INTENSITY									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
L.BOARD	-0.0026									
	(-0.20)									
L.RISKMANAGE		0.0074								
		(0.53)								
L.INCENTIVE			-0.0072							
			(-0.58)							
L.TARGET				-0.0212*						
				(-1.75)						
L.PROJECT					-0.0124***					
					(-2.87)					
L.SUPPLYCHAIN						0.0103				
						(0.80)				
L.GHG ACCOUNTING							-0.0368*			
							(-1.65)			
L.ASSURANCE								0.0248***		
								(4.15)		
L.POLICYENGAGE									-0.0355	
									(-1.60)	
L.DISCLOSURE										-0.0265*
										(-1.83)
Control Variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	5071	5071	5071	5071	4424	5069	5088	5023	2379	4994
R-square	0.0125	0.0127	0.0125	0.0135	0.0140	0.0128	0.0145	0.0164	0.0075	0.0120

Note: The table reports FE coefficient estimates. T statistics based on robust standard errors are in parentheses.*, ** and *** represent significance at the 0.1,0.05 and 0.01 levels, respectively(two-tailed).All variables were winsorized at the 1st and 99th percentiles. Financial data are in millions of US dollars.

Received: March 17, 2019; Published: April 18, 2019