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Voluntary Disclosure, Greenhouse Gas Emissions and Business Performance: Assessing the First Decade of Reporting

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ABSTRACT

This study explores patterns in the voluntary disclosure of greenhouse gas (GHG) emissions and empirical relationships between GHG emissions and an extensive range of business performance measures for UK FTSE-350 listed firms over the first decade of such reporting and highlighting the level of consistency among these measures. Despite the popular and policy generated environmental imperatives over this period, an extensive pattern of non-reporting of such emissions is apparent by year and sector. Accordingly, a two-stage (Heckman type) selection model is used to analyse the emissions-performance nexus conditional upon the firm choosing to report, using bootstrap inference to further ensure robustness of the results. The results demonstrate firstly that emissions reporting are not directly influenced by the social/governance disclosure attitudes of a firm, thus suggesting that firms disassociate environmental responsibility from social responsibility. Additionally it is demonstrated that for those firms that do report, there is a clear non-linear relationship, initially increasing with firm performance and then decreasing.

Key Words: voluntary disclosure, carbon emissions, business performance, environmental reporting

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David C. Broadstock[a], Alan Collins[b], Lester C. Hunt[c] and Konstantinos Vergos[d]

Introduction

Since before climate change had become a recurring central policy issue there has been a long-standing research imperative to better understand the relationship between pollutant emissions and economic activities. Hitherto, empirical investigation into the relationship between activity and emissions has been conducted at the household-level (see, for example, Kahn 1998 and Cox *et al* 2012), but more extensively at the sectoral and economy-wide level (see, for example, the considerable range of such studies surveyed in Dinda 2004, Stern 2004 and Nahman and Antrobus 2005a). With the exception of Konar and Cohen (2001) (who analyse the relationship between U.S. toxic chemical release data and stock market value) and Hsu and Wang (2013) (who analyse the impact of U.S. *mandatory* greenhouse gas reductions on stock market value), relatively little methodologically comparable research, nor similarly extensive and direct investigation of emissions exists at the firm-specific level. More indirectly, however, there are many studies framed in terms of analysing environmental management activities, environmental innovation, technology adoption and other environmental performance measures, alongside participation in particular environmental programmes requiring mandatory or voluntary compliance (see, for example, Wagner *et al.*

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2002, Brunnermeier *et al.* 2003, Cole *et al.* 2006, Frondel *et al.* 2008, Carrión-Flores and Innes 2010, Kassinis and Vafeas 2006, Wagner 2010). Horváthová (2010) undertakes an extensive review of this work and reports on a meta-regression of 64 outcomes from 37 empirical studies in the "firm-environmental performance nexus" and finds,

> "….that the likelihood of finding a negative link between EP (*environmental performance*) and FP (*financial performance*) significantly increases when using the correlation coefficients and portfolio studies. On the other hand, the use of multiple regressions and panel data technique has no effect on the outcome. This suggests that it is important to account for omitted variable biases such as unobserved firm heterogeneity. The results also suggest that appropriate time coverage is important in order to establish a positive link between EP and FP. This suggests that it takes time for environmental regulation to materialise in financial performance." p.56.

Horváthová's (2010) review also seems to point to a paucity of robust, extensive empirical GHG emissions-performance studies over a reasonable time frame at the firm-level. This is despite numerous lobby group, media and Government policy-led exhortations to, and initiatives for, firms to reduce their level of GHG emissions. These are generally framed as parts of various concerted actions to combat climate change and encourage permanent adoption of more environmentally sustainable modes of production.

Thus, this study explores the empirical relationship between a very extensive range of the most typically reported and deployed business performance measures and reported GHG emissions (all readily accessible via the Bloomberg (2013) database) for UK FTSE-350 listed firms over the period 2000 to the end of 2011.

The remainder of this paper is organized as follows. The next section provides some background to the basis, advantages and limitations of the most common business performance indicators used. A brief retrospect on the guiding theoretical and empirical literature pertaining to emission-firm performance linkages is then presented which informs the choice of key hypotheses investigated. Data issues and the modelling strategy employed are considered in the following two sections. The results are then presented and discussed with a summary of findings and some concluding remarks proffered in the final section.

Measuring Performance

It is important to consider a comprehensive range of different accepted measures of performance, as businesses have many stakeholders (such as shareholders, bankers, employees, and tax authorities) whose interests in the firm differ (Johnston and Pongatichat, 2008). Shareholders, for instance, may focus more on profits, whilst bankers focus on both cash-flow-related performance metrics, such as operating cash flows and capital structure (Leverage). On the contrary, tax authorities may focus on profit before tax and employees on sales. Besides, accounting policies (e.g. depreciation method) or differences on capital structure or financing decisions (e.g. leasing) induce performance asymmetries in the short run that necessitate the need to account for alternative performance measures. The broad range of business performance measures used in this study are *Sales*, *Net Income, Operating Profits, Before Tax Profits, Market Capitalisation, Stock price*, *Asset, Equity, ROA (Return on Assets), ROE (Return on Equity)*, *Tobin's Q* and *EBITDA (Earnings Before Interest, Tax, Depreciation and Amortization*), and *Leverage* is examined as a capital structure measure. Definitions and a brief explanation of the examined measures are set out in Table 1.

Table 1. Measures of Business Performance and Capital Structure

Measure	Variable name	Definition and Explanation
Money metric based performance measures		
Sales (also called *Turnover*)	SALES	Direct measure of business performance, because indicates business generating activity, and emission generating activity
EBITDA 'Earnings Before Interest Tax Depreciation and Amortization	EBITDA	Operating Profits before the deduction of non-cash items Depreciation and Amortization. Company performance measure. EBITDA margin is a measure of the profitability and short-term company performance.
Net Income, also known as After tax Profits	PROFITS	Profit of the firm, after Tax deductions. Important for shareholders because a proportion of Net Income is given to shareholders as dividends.
Operating Profits, is also known as Earnings Before Interest and Tax.	OPROF	Profits before interest and taxation. Proxy of company performance, and proxy of company's operating cash flows.
Before Tax Profits, is the Profit before tax charges.	BTPROF	Profits before taxation. Proxy of company performance.
Market Capitalisation is the value of the firm in capital markets.	MCAP	Market Capitalisation is the number of shares outstanding times the share price. Measure of value and hence performance independent of the firms' accounting policy. Measure of the company size, as well.
Asset, denotes the Total Assets at the end of the period.	ASSETS	Measure of the size of the firm.
Equity, denotes Total Equity at the end of the period.	EQUITY	Equity is a measure of the size of the firm, of the capital resources devoted to the firm by the shareholders and is a rough proxy of the liquidation value of the company.
Ratio based performance measures / measures that cannot be scaled by number of staff		
Stock price	PRICE	Reflects company performance as evaluated by the shareholders, scaled by the number of shares.
Leverage, denotes the financial leverage,	LEV	Measured by the ratio of Debt over Equity. Proxy of capital structure.
ROA - Return on Assets	ROA	Net Income over Average Total Assets. Average Total Assets denote the average Assets during a Fiscal Year. It is a measure of profitability when all the sources of capital, Equity and Debt, are taken into account.
ROE - Return on Equity	ROE	Net Income over Average Equity. Average Equity denotes the average Equity during a Fiscal Year. It is a measure of profitability from the perspective of the Shareholders.
Tobin's Q	TOBQ	Market Value of the company over the Replacement Value of its assets. Tobin Q over Total Assets is indication of long-term performance

Firm Performance and Polluting Emissions: Brief Theoretical Retrospect and Key Research Hypotheses

The analysis of pollution by firms, particularly in economic theory has a long and distinguished history and its chronological context is set out in Kula (1998) and Pearce (2002). Early contributions set out what has emerged to serve as a very durable stylized picture of the profit maximizing firm treating the atmosphere and other environmental media, such as seas and river basins, as essentially free goods in which to emit or dispose waste. Economic theory therefore suggests that these free goods would be over-consumed by such firms to the material detriment of other firms and households. This was expected to become manifest in terms of the external costs (negative externality) of pollution being imposed on others through clean-up costs, deleterious health effects etc. Such simple stylized thinking, supplemented by analyses of property rights (see, for example, Coase 1960, Dales, 1968) has informed the structuring and application by environmental regulators of a range of command and control instruments (total bans, emission standards, fines) as well as of economic incentive instruments (taxes, subsidies, tradable permits); for an overview see Baumol and Oates (1988). These were intended to reduce or optimize the level of polluting emissions and were justified with reference to various measures or indicators of societal preferences.

In principle, however, such regulatory interventions would still need to be mindful of the neoclassical economic implication of profit maximization that firms would only expend the minimum cost necessary to comply with any given regulatory intervention and even weigh up the net cost implications of bypassing such interventions if monitoring, enforcement and punishment were weak.

Another theoretical strand, however, drawing initially and principally on case study evidence, recasts this body of theory premised on the assertion that increasing regulatory stringency may actually be profitable rather than costly (Porter 1991, Porter and van der Linde 1995). This argument, generally labelled 'the Porter hypothesis' is explained in terms of the stimulus to innovation afforded by tighter mandatory environmental regulations prompting cost-saving productive efficiencies. The conceptual and empirical basis for the hypothesis has been contested and augmented for testing in 'weak', 'narrow' and 'strong' forms (see, for example, Palmer *et al* 1995, Jaffe and Palmer 1998, Lanoie et al 2011, Ambec *et al* 2013). In weak form it is simply asserted that environmental regulations can stimulate innovation. The narrow form suggests that flexible environmental policy regimes can better incentivise innovation than less flexible environmental policy regimes and the strong form suggests that well designed regulation can induce cost-saving innovations outweighing the costs of compliance with such regulations.

In a related vein, further theoretical strands of the firm-pollution emission discourse have also explored the motivations and scope for actually fostering voluntary over-compliance – i.e. abating emissions some way above the minimum (statutory) requirement (Arora and Gangopadhyay, 1995 Anton *et al.* 2003). The very existence of this practice might appear to pose a serious challenge to neoclassical economic conceptions of firm practice. This arises since the required information to voluntarily indicate or demonstrate over-compliance entails (i) disclosure of potentially strategically valuable information to competitors and regulators and (ii) voluntarily incurring the costs of collecting the emissions information. At the very least, such economic theory might be recalled to support the view that the practice would not be widespread and perhaps related to distinct competitive environmental strategies where signalling 'green' or climate change combative credentials offer 'legitimacy' (see, for example, Cho and Patten, 2007) or has market value. Indeed in some other theoretical studies voluntary over-compliance has simply been conceptualized as exercises in 'greenwash' i.e. simply augmenting marketing spend (see, for example, Kim and Lyon 2011, Mahoney *et al.* 2013).

In other cases the undertaking of voluntary over-compliance has simply been related to differences in regulatory stringency across countries and thereby offering, for example, some foreign direct investing firms competitive advantages by default, simply through their experience in their host country. Essentially, if regulatory stringency is expected to be on an upward trajectory in the country being invested in, then this intrinsic competitive advantage could be reinforced via green branding and marketing tactics and also accentuated as domestic firms struggle (in cost terms) to comply with tougher regulations. However, over-compliance may also arise for both foreign direct investing and domestic firms due to a desire to exploit cost-saving efficiency improvements that raise resource productivity by the firm, i.e. leading to the generation of less waste or emissions per unit of natural resource inputs used in production. This may emerge from resource productivity improvements in the mainstream production process of the firm or the greater use of the waste by-products in new or other production lines. Nevertheless, it remains an open empirical question in different market contexts, whether or not more efficient firms spend more or less on pollution abatement than less efficient firms. For instance, there are conspicuous contrasts in the efficiency-pollution abatement spending relationship for the UK metal manufacturing and chemical industries presented in Collins and Harris (2002 and 2005).

At the heart of this question lies an extensive related thread of literature concerned with establishing the veracity or otherwise of the 'Jevons Paradox' and its more contemporary evocation as 'the rebound effect' (Saunders 1992, Turner and Hanley 2011). Jevons conjectured that technological progress leading to greater resource productivity (in his context, more efficient use of coal) actually provided the scope and means for increasing coal demand. Saunders (1992) assessed the gains specifically from energy resource efficiency within the context of various economic growth assumptions and found that some level of rebound effect was present. That energy resource efficiency may actually be a less environmentally successful strategy than commonly thought has provided a source of fierce academic contention centring on the extent to which energy efficiency improvements in some individual firms and markets are technically connected to sectoral and economy-wide energy resource consumption

Among the extant literature there also features a voluminous number of studies focusing on a conjecture termed the environmental Kuznets curve (EKC). This literature postulates with various implicit and/or explicit assumptions and conditions that the rate of emissions reduces with the scale of activity, but, moreover, after a certain level of activity, that the level of emissions may also reduce in absolute terms (Dasgupta *et al.* 2002, Dinda 2005, Kijima *et al.* 2010).

Contradictory evidence has been found affirming and disputing the presence of curves at different levels of aggregation (see, for example, Perman and Stern 2003, Millimet *et al.* 2003, Dinda 2004, Bertinelli and Strobl, 2005, Chimeli and Braden 2005, Fernández *et al.* 2012). Nevertheless, some extension of this thinking into the corporate sector might have been expected to systematically investigate the potential widespread (cross-sectoral) existence of such curves with respect to GHGs at the firm-level, even though more difficult questions do arise as to the appropriate choice of a particular activity measure. In the related literature at the macro, sectoral and household level, income is generally used as the measure of activity. However, it would be reasonable to assert that business performance metrics are the more appropriate activity indicator at the firm level. Firms who perform better have arguably greater flexibility to invest in emissions-reducing activities, noting that these are sometimes both high upfront cost investments as well as low direct return investments.

Firms that are not performing so well will have less financial scope to take such emission abating actions. However, measuring performance is itself a difficult task, and arguably there is no clear single specific measure of performance for a firm. The main reason for this is that firms have different stakeholders who are interested in different objectives, and also that multinational firms may well have similar stakeholders from different geographic regions that may well place more or less importance on the same objectives.

In the light of this theoretical and empirical discourse and particularly that situated in the business performance-emissions nexus, three simple but key hypotheses warranting empirical investigation are posited:

Hypothesis 1*: Firms' Greenhouse gas emissions are dependent on firm performance and more specifically are subject to an environmental Kuznets-type curve.*

Hypothesis 2: *Business performance measures are not related to emissions identically.*

Hypothesis 3: *Voluntary disclosure of greenhouse gas emissions affects the nature of the emissions-business performance relationship.*

Data

The data are taken from the Bloomberg (2013) database and include all firms listed in the FTSE 350 index since 2000, and includes all available data up to the end of 2011. In principle, this data allows for several thousand firm-year observations, however, a significant amount of non-reporting of emissions among firms substantially reduces the sample sizes. Table 2 presents descriptive statistics for the FTSE 350 data, including measures for the firms that report emissions, selected statistics for those that do not report and also for the full sample. Taking the ROA of a firm as an example, these are generally firms whose primary business activity is in the UK, though most of the firms on the list are multinational firms, hence, the data encapsulates exposure to international business practices and standards/regulations.

The main variable of interest is the self-reported levels of emissions, which include all greenhouse gas emissions reported by the business that were created by the activity of the business. This includes a basket of gases that includes, but is not restricted to carbon dioxide emissions. The definition of business activity is quite general and does potentially incorporate both direct and indirect emissions, whereby the direct emissions are those which the reporting firm has direct control over, and the indirect emissions are those in which the firm has little or no direct control over, for instance elements of the wider supply chain.[e]

Modelling Strategy

The empirical model connecting firm level emissions and the various performance indicators is based upon the type of models observed in the environmental Kuznets curve (EKC) literature, in which the model allows for a non-linear relationship in the form of a quadratic curve (see, for example, Kijima et al (2010). Equation 1 depicts the equation to be estimated:

$$e_{it} = \alpha + \beta_1 p_{it} + \beta_2 p_{it}{}^2 + \sum_{i=2}^{I} \delta_i D_i + \sum_{t=2}^{T} \delta_t D_t \qquad (1)$$

[e] There is a possible concern that since firms have proxy over their reporting standards, they may not report perfectly comparable pollutant levels. There is no way for this to be confirmed with the available data, though it is assumed that the reporting practices will be, by and large, consistent and hence comparable across firms.

Where e is the greenhouse gas emissions divided by the number of staff, and p is the performance indicator. The performance indicators are of two types, some are money metrics, and others are ratios: the money metric performance measures are divided by the number of staff, while the remaining measures (stock price, leverage, ROA, ROE and TOBQ) are not. D_i and D_t are dummy variables to control for industry specific and time specific effects, where the model intercept α represents the base industry and base time period. Firm specific fixed effects were considered, but limitations in data reporting preclude this as being viable. β_1 and β_2, which are the coefficients describing the existence and nature of relationship between firm performance and emissions, are the main parameters of interest.

To provide the most robust estimates possible, and ensure that parameter inference is robust to any heteroskedasticity the linear equations in (1) are estimated using a non-parametric Bootstrap. The (residual based) bootstrap procedure provides inference upon a statistical model by using the ordinary least squares (OLS) residuals to represent the empirical distribution of shocks. These residuals are recorded, and re-ordered across the observations to allow any given observation to be subject to a different error, subsequently the model is re-estimated by OLS and the coefficients are recorded as individual runs of a bootstrap. Thus, the bootstrap process evaluates how stable the estimated coefficients are to different data, where the differences in data are based on observed (unexplainable) variability. This is in effect the purpose of conventional (asymptotic) inference, but no longer depends on either normality of the residuals nor large sample sizes. See Efron and Tibsharini (1993) and Davison and Hinkley (1997) for further detailed discussion of non-parametric regression by least squares. The results reported in the following section concentrate on the mean coefficient value and the 95% confidence interval from 1,000 bootstrap replications.

Table 2: Descriptive statistics

Performance measure:	Estimation data (reporting firm-years) means	max	min	sd	skew	kurtosis	observed	missing	All firm-years means	sd	observed	missing	Non-reporting firm-years means	sd	observed	missing
CO2_FULL	4211.789	73200.012	0.000	12436.529	3.929	16.395	258	0	4282.502	12399.385	262	3643				
GHG_FULL	4264.028	73220.012	1.400	12486.620	3.913	16.253	256	2	4334.774	12448.334	260	3645				
SALES	14824.250	361143.000	-10269.000	45611.762	5.195	28.923	258	0	7194.593	33260.774	2895	1010	6445.903	31732.560	262	1010
EBITDA	2082.072	41761.000	-28.313	6461.635	4.665	22.347	225	33	1098.727	4791.594	2697	1208	1009.772	4602.792	2470	1173
PROFITS	1015.762	22341.000	-21916.000	3825.226	2.661	19.538	258	0	526.382	2580.945	2821	1084	477.177	2417.994	2559	1084
OPROF	1546.383	30776.000	-105.391	4744.114	4.623	22.087	221	37	796.419	3540.513	2666	1239	729.027	3405.378	2443	1200
BTPROF	1544.610	34642.000	-14853.000	5308.517	4.265	21.285	258	0	831.646	4174.039	2907	998	762.585	4042.633	2647	996
PRICE	701.798	4392.390	13.500	634.405	2.072	6.423	258	0	622.151	1587.580	3464	441	616.102	1641.253	3202	441
MCAP	10827.872	127864.500	69.742	24359.872	3.282	10.151	258	0	6108.832	16931.425	3010	895	5669.910	16006.155	2748	895
LEV	4.815	61.215	-103.105	11.928	-1.852	28.646	258	0	3.923	88.554	2512	1393	3.823	93.441	2252	1391
ASSETS	79550.060	2527465.000	120.755	337292.601	6.096	37.685	258	0	25521.614	154516.483	2815	1090	20083.747	120553.341	2555	1088
EQUITY	8975.501	154915.000	-533.600	24628.408	3.779	14.228	258	0	3734.995	14950.305	2815	1090	3207.282	13497.118	2555	1088
ROA	6.363	52.767	-37.364	8.868	0.107	6.481	258	0	5.897	11.507	2735	1170	5.847	11.752	2475	1168
ROE	24.939	682.653	-103.731	61.425	8.208	80.044	241	17	18.780	39.107	2712	1193	18.182	36.180	2469	1174
TOBQ	1.593	5.339	0.638	0.748	1.857	4.600	258	0	1.615	2.243	2762	1143	1.617	2.344	2502	1141
ind_1	0.004	1.000	0.000	0.062	15.876	251.023	258	0	0.054	0.225	3905	0	0.057	0.232	3643	0
ind_2	0.240	1.000	0.000	0.428	1.209	-0.542	258	0	0.172	0.377	3905	0	0.167	0.373	3643	0
ind_3	0.097	1.000	0.000	0.296	2.709	5.362	258	0	0.062	0.241	3905	0	0.060	0.237	3643	0
ind_4	0.287	1.000	0.000	0.453	0.937	-1.126	258	0	0.166	0.372	3905	0	0.157	0.364	3643	0
ind_5	0.186	1.000	0.000	0.390	1.604	0.576	258	0	0.161	0.367	3905	0	0.159	0.365	3643	0
ind_6	0.004	1.000	0.000	0.062	15.876	251.023	258	0	0.065	0.246	3905	0	0.069	0.254	3643	0
ind_7	0.000	0.000	0.000	0.000	NA	NA	258	0	0.023	0.148	3905	0	0.024	0.154	3643	0
ind_8	0.035	1.000	0.000	0.184	5.040	23.496	258	0	0.025	0.157	3905	0	0.025	0.155	3643	0
ind_9	0.050	1.000	0.000	0.219	4.087	14.761	258	0	0.023	0.148	3905	0	0.021	0.142	3643	0

Note: SALES, EBITDA, PROFITS , OPROF, BTPROF, MCAP, ASSETS, EQUITY are in million British pounds. ROA, ROE in percentage terms, PRICE in British Pounds

Correcting for self-reporting bias

To account for possible selection bias, the emissions function is re-estimated as a Heckman type selection problem. The latent system equations can be written as:

$$e_{it}^{S*} = \alpha^S + \beta_1^S Disclosure_{it}$$

$$e_{it}^{O*} = \alpha^O + \beta_1^O p_{it}^O + \beta_2^O p_{it}^{O^2} + \sum_{i=2}^{I} \delta_i^O D_i^O + \sum_{t=2}^{T} \delta_t^O D_t^O \qquad (2)$$

Where:

$$e_{it}^{O} = \begin{cases} 0 & \text{if } e^{S*} = 0 \\ e_{it}^{O*} & \text{Otherwise} \end{cases}$$

That is to say that the emissions for any given firm are only observed when the selection variable e^{S*} is positive. The Bloomberg database includes proprietary measures of environmental disclosure (ED), social disclosure (SD) and governance disclosure (GD), which are a natural choice of instruments for the selection equation:

$$e_{it}^{S*} = \alpha^S + \beta_1^S ED_{it} + \beta_2^S SD_{it} + \beta_3^S GD_{it}$$

Results and Discussion

This section presents and discusses the main results, taking each of the aforementioned hypotheses in turn.

Hypothesis 1*: Firms' Greenhouse gas emissions are dependent on firm performance and more specifically are subject to an environmental Kuznets-type curve. If either of the linear or squared emissions terms is insignificant, then the Kuznets relationship can be rejected. This implies the following null hypothesis:*

$H1^{(1)}: \text{Both } \beta_1 \text{ and } \beta_2 \neq 0$

Tested against the null hypothesis that either one of these are equal to zero. This can be evaluated using individual coefficient significance testing procedures.

Tables 3 and 4 report the estimation results for CO2 and GHG emissions respectively based on Equation (1). Across the columns of these tables it is evident that there is a broad dichotomy between the two types of performance measures. For each of the alternative money metric based performance measures, with the exception of SALES, give strong evidence of a non-linear inverted U-shape relationship between performance and emissions. For SALES the coefficient values broadly support the idea of an inverted U-shape, however the 95% confidence interval for the quadratic term passes through zero i.e. the confidence interval includes both positive and negative values, but whose range is predominantly negative. The absolute values of the coefficients in each of the columns vary, but this is to be expected given the different definitions of performance.

For the performance measures that are based on ratios, a slightly different picture emerges. There are five measures falling into this category. Three of these measures, LEV, ROA and TOBQ appear to have no direct relationship with the emissions of a firm, neither for CO2 or GHG. The remaining two measures are related to emissions but not in the same way: for PRICE there is U-shape relationship e.g. with low stock prices a firm should expect higher emissions per-employee, gradually decreasing until some optimal point, and then increasing again after that; for ROE there is a an inverted U-shape relation with CO2 while only the linear performance measure is significant in the GHG equation.

Table 3: CO2—*95% bootstrap confidence interval in brackets*.

	Money metric performance measures (per employee)								Ratio based performance measures				
Performance measure:	SALES	EBITDA	PROFITS	OPROF	BTPROF	MCAP	ASSETS	EQUITY	PRICE	LEV	ROA	ROE	TOBQ
Level term	**1.2177**	**6.4327**	**0.7243**	**9.4551**	**0.9017**	**0.7022**	**0.1736**	**0.3190**	**-0.0017**	-0.0083	0.0490	**0.0203**	0.5261
	(0.3863, 2.7728)	(2.4922, 12.8939)	(0.1510, 2.8319)	(3.8567, 17.9529)	(0.1741, 3.3687)	(0.3561, 1.4423)	(0.0937, 0.3759)	(0.1209, 0.6376)	(-0.0031, -0.0010)	(-0.0347, 0.0338)	(-0.0256, 0.1584)	(0.0035, 0.0544)	(-0.5240, 1.7700)
Squared term	-0.0901	**-1.4598**	**-0.0250**	**-2.9177**	**-0.0339**	**-0.0244**	**-0.0026**	**-0.0086**	**3.3505**	0.0001	0.0007	**-2.9913**	-0.0793
	(-0.3443, 0.0182)	(-3.3483, -0.4009)	(-0.3955, -0.0055)	(-6.0103, -0.9592)	(-0.4842, -0.0062)	(-0.0555, -0.0112)	(-0.0077, -0.0012)	(-0.0187, -0.0020)	(1.8680, 6.4953)	(-0.0006, 0.0008)	(-0.0012, 0.0083)	(-9.0557, -2.4330)	(-0.2963, 0.1133)
Observations	258	225	258	221	258	258	258	258	258	258	258	241	258

Note: SALES, EBITDA, PROFITS , OPROF, BTPROF, MCAP, ASSETS, EQUITY are in million British pounds. ROA, ROE in percentage terms, PRICE is in British Pounds

Table 4: Greenhouse gases—*95% bootstrap confidence interval in brackets*.

	Money metric performance measures (per employee)								Ratio based performance measures				
Performance measure:	SALES	EBITDA	PROFITS	OPROF	BTPROF	MCAP	ASSETS	EQUITY	PRICE	LEV	ROA	ROE	TOBQ
Level term	**1.0420**	**6.2785**	**0.7218**	**9.1225**	**0.8926**	**0.6869**	**0.1496**	**0.3185**	**-0.0016**	-0.0156	0.0486	**0.0189**	0.7906
	(0.2643, 2.3456)	(2.4785, 12.5038)	(0.1758, 2.8179)	(3.7405, 17.6866)	(0.1932, 3.2490)	(0.3383, 1.3782)	(0.0656, 0.2916)	(0.1249, 0.6069)	(-0.0031, -0.0009)	(-0.0502, 0.0112)	(-0.0130, 0.1559)	(0.0019, 0.0545)	(-0.1028, 2.1528)
Squared term	-0.0669	**-1.4140**	**-0.0257**	**-2.7893**	**-0.0344**	**-0.0235**	**-0.0021**	**-0.0083**	**3.1551**	0.0001	0.0006	-2.7920	-0.1247
	(-0.2584, 0.0329)	(-3.2457, -0.4062)	(-0.3893, -0.0069)	(-5.8159, -0.9177)	(-0.4459, -0.0070)	(-0.0521, -0.0105)	(-0.0045, -0.0006)	(-0.0171, -0.0018)	(1.5882, 6.2846)	(-0.0004, 0.0009)	(-0.0012, 0.0079)	(-8.6675, 3.9839)	(-0.3695, 0.0355)
Observations	256	224	256	220	256	256	256	256	256	256	256	239	256

Note: SALES, EBITDA, PROFITS , OPROF, BTPROF, MCAP, ASSETS, EQUITY are in million British pounds. ROA, ROE in percentage terms, PRICE is in British Pounds

The U-shape finding for PRICE stands out clearly among the various performance measures. Compared with the other performance measures PRICE is arguably more exogenous to the firm, with the actions and choices of financial analysts and investors being the primary determinant of stock prices, but also recognizing that the wider stability or otherwise of the financial market will also in part determine PRICE. An interesting implication of this finding is that environmentally conscious investors might have a preference towards mid-priced stocks, where ‘mid’ is loosely used here to refer to the region of the optimum on the U-shaped curve. Taking the results together, the evidence strongly supports the first hypothesis stating that emissions are functionally dependent on firm performance.

As discussed, Tables 3 and 4 suggest that a relationship between emissions and firm performance does exist and moreover is broadly in favour of a non-linear Kuznets-type relationship, albeit one that is slightly sensitive to the definition of performance. The performance measures considered here have been grouped into two types, based on their ability to be scaled by the number of firm employees. The difference between these two groups therefore can be attributed in part to the scale effect embedded in the per-employee transformation. In light of this the findings have one rationale being that when the physical scale of a firm is taken into account, it is much more likely that a relationship with emissions will be revealed. A complementary interpretation to this is that the ratio-based performance measures do not take sufficient account of the physical operations of the firm and their associated emission rates. Since these latter performance measures are arguably framed more towards illuminating financial performance/stability than the other measures, then this might indicate that financial stability or instability need not be a justification for sustaining yet higher levels of emissions.

Hypothesis 2: *Business performance measures are not related to emissions identically.*

Each of the performance measures are defined in different metrics, which is a direct result of their unique purposes. For example, TOBQ is a ratio intended to reflect an eclectic snapshot of overall firm performance and has a fundamentally different metric to SALES, with the latter being expressed in an easy to understand money metric. It stands to reason that their relationships with emissions should differ. To evaluate this hypothesis requires comparing in some way the same coefficients from the same model structures, but with different performance measures included on the right hand side. There are a number of ways that such hypotheses could be formulated, but a pragmatic approach is taken here.

As discussed with regard to the previous hypothesis, there are some substantial differences in how performance measures of different types are related to emissions. The fact that some illustrates significant Kuznet's-type curves, and others do not, is sufficient evidence so as to be unable to reject hypothesis 2. No effort is made here to reconcile such differences; rather the purpose here is to highlight their existence. These differences pose interesting concerns for environmental impact management, inasmuch as firms pursuing different performance objectives may be reasonably able to justify several alternative emissions levels as being admissible. Although not a focus of the present paper, it is abundantly clear that to reconcile their differences is a pressing priority for future study.

Hypothesis 3: *Voluntary disclosure of greenhouse gas emissions affects the nature of the emissions-business performance relationship.*

This hypothesis is evaluated using the coefficient values from a Heckman selection type model which makes corrections for self-selection into emissions reporting.

The results to this point provide compelling evidence that a firm-level environmental Kuznet-curve does exist, but that it can be sensitive to the choice of performance measure used. The aim here is to consider the possibility that the conclusions so far might be sensitive to possible bases that can arise when modelling data involving self-selection (or pre-determined choices). Table 2 highlights the level of attrition in the dataset regarding the reporting of emissions, with only 256 observations being available from an initial sample of over 3,500 observations in principle. For the performance measures used, there is virtually full and complete data either from the stock market or from the mandatory company accounts. Hence, the level of attrition in reported emissions is due to self-selected non-reporting. In general over the sample period there has been no specific requirement on firms to report their emissions; however, some firms have chosen to adopt transparency principles as part of their corporate social responsibility activities. Giving a transparent view of emissions levels potentially serves as a signal to stakeholders of the integrity of a given firm, which could in turn generate some intangible added-value for the firm in terms of environmental warm-glow and/or customer and investor loyalty. An alternative view is that it simply provides another basis to question management performance in a difficult to control area such that widespread withholding of GHG data or deliberate neglect to measure GHG emissions may be implicitly deemed preferable.

The results of the selection models are reported in Tables 5 and 6 respectively. The results in Tables 5 and 6 compare fairly closely with Tables 3 and 4, suggesting that the possible concerns that self-selection in to reporting may not be a source of major bias. Two notable differences come from the insignificance of the ASSETS and EQUITY performance measures under the selection model, although if a 20% significance level is seen as acceptable, then they both support the EKC hypothesis. Taken together the implications of this are that there are some bias affects that arise from the non-reporting, that appear to relate to the uncertainty in the relationship i.e. the variance on the estimated parameters.

For CO2 emissions, as given in Table 5, the performance measures SALES, ASSETS and EQUITY do not demonstrate evidence of a Kuznets-type curve. Furthermore, ASSETS and EQUITY now no longer have even a linear relationship, thereby making the relationship between EQUITY, ASSETS and emissions non-functional. The remaining money-metric based performance measures do show evidence of an inverted ‘u’ shape relationship. Controlling for the selection bias therefore has some impact on the observed relationship. For the ratio based performance measures the results are quite similar whether the selection model is used or not with the exception that for ROE both the linear and quadratic terms are significant and positive. The results for GHG are qualitatively very similar to those for CO2.

Overall, mitigating against the possible bias incurred from self-selection into emissions reporting, the confidence in the results is greatly increased, and hence is the confidence in the existence of a firm-level Kuznets-type curve. Regarding the fourth hypothesis, the evidence supports that voluntary disclosure does have some effect on the relationship between firm performance and emissions. Broadly speaking though, the evidence is not strong enough to suggest the EKC does not exist at the firm level.

Table 5: CO2 with control for sample selection—*asymptotic p-value in brackets*.

	Money metric performance measures (per employee)								Ratio based performance measures				
Performance measure:	SALES	EBITDA	PROFITS	OPROF	BTPROF	MCAP	ASSETS	EQUITY	PRICE	LEV	ROA	ROE	TOBQ
Selection equation													
Environmental disclosure	**0.034**	**0.029**	**0.034**	**0.029**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Social disclosure	-0.004	0.001	-0.004	-0.001	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
	0.36	0.81	0.36	0.89	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.31	0.36
Governance disclosure	-0.004	-0.009	-0.004	-0.008	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.002	-0.004
	0.49	0.16	0.49	0.20	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.71	0.49
Stage 1 observations	908	908	908	908	908	908	908	908	908	908	908	908	908
Emissions equation													
Level term	**1.229**	**6.488**	**0.728**	**9.682**	**0.906**	**0.701**	**0.175**	0.320	**-0.002**	-0.008	0.049	**0.020**	0.523
	0.02	0.00	0.06	0.00	0.02	0.00	0.07	0.13	0.03	0.83	0.35	0.03	0.63
Squared term	-0.088	**-1.467**	**-0.025**	**-2.965**	**-0.034**	**-0.024**	-0.003	-0.009	0.000	0.000	0.001	**0.000**	-0.081
	0.27	0.00	0.07	0.00	0.02	0.00	0.12	0.18	0.20	0.81	0.64	0.06	0.71
Stage 2 observations	258	225	258	221	258	258	258	258	258	258	258	241	258

Note: SALES, EBITDA, PROFITS , OPROF, BTPROF, MCAP, ASSETS, EQUITY are in million British pounds. ROA, ROE in percentage terms, PRICE is in British Pounds

Table 6: Greenhouse gasses with control for sample selection—*asymptotic p-value in brackets*.

	Money metric performance measures (per employee)								Ratio based performance measures				
Performance measure:	SALES	EBITDA	PROFITS	OPROF	BTPROF	MCAP	ASSETS	EQUITY	PRICE	LEV	ROA	ROE	TOBQ
Selection equation													
Environmental disclosure	**0.034**	**0.029**	**0.034**	**0.029**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**	**0.034**
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Social disclosure	-0.004	0.001	-0.004	-0.001	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
	0.42	0.81	0.42	0.90	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.37	0.42
Governance disclosure	-0.005	-0.009	-0.005	-0.009	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.003	-0.005
	0.39	0.13	0.39	0.16	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.59	0.39
Stage 1 observations	908	908	908	908	908	908	908	908	908	908	908	908	908
Emissions equation													
Level term	**1.052**	**6.328**	**0.723**	**9.329**	**0.894**	**0.689**	0.150	0.319	**-0.002**	-0.016	0.049	**0.019**	0.791
	0.04	0.00	0.06	0.00	0.02	0.00	0.12	0.13	0.04	0.68	0.34	0.04	0.46
Squared term	-0.066	**-1.421**	**-0.026**	**-2.832**	**-0.035**	**-0.024**	-0.002	-0.008	0.000	0.000	0.001	**0.000**	-0.124
	0.40	0.00	0.06	0.00	0.02	0.00	0.19	0.19	0.23	0.74	0.69	0.07	0.56
Stage 2 observations	256	224	256	220	256	256	256	256	256	256	256	239	256

Note: SALES, EBITDA, PROFITS , OPROF, BTPROF, MCAP, ASSETS, EQUITY are in million British pounds. ROA, ROE in percentage terms, PRICE is in British Pounds

Summary and Concluding Remarks

The aim of this paper has been to examine the extent of UK firms' emissions reporting over the first decade of the 21^{st} century and to test whether firm performance and emissions levels are related to each other. Additionally whether the kinds of functional relationships discussed in the empirical environmental literature have some validity at the firm level are considered. A wide range of performance measures are considered, to help validate the generality of the conclusions, as well as two definitions of emissions CO2 and the more encompassing measure of GHG. The measures are split into two types: money metric performance measures such as PROFITS or EQUITY, and ratio based performance measures such as LEV and TOBQ. A clear inverted U-shape is found when benchmarking against money metric based performance measures, while the evidence is less strong when using ratio based performance measures. These patterns are consistent across both types of emissions considered, albeit stronger for CO2 than GHG, and are also robust to possible biases that might arise from self-reporting.

To some degree the results pose questions regarding the role of environmental performance management and the possible conflict that may arise from environmental targets that can be potentially benchmarked against a range of alternative business performance measures. A more specific quandary emerging from the analysis, deserving of future study, relates to the apparent sensitivity of the results to money-metric versus ratio based measures of firm performance. TOBQ could arguably conflate several aspects of performance, making it more difficult for a stable result to emerge using this measure, but other ratios such as LEV and ROA are more difficult to defend. The model here embeds simple linear specifications, implying one of two things, either these performance measures share no relation with emissions, or on the other hand, maybe a relationship does exist, but is non-linear of a higher order than a simple inverted U-shape can handle. Both options are worth exploring further, though perhaps the former holds greater weight, since these two measures in particular are arguably more uniquely connected to the financial wealth of a firm, whereas the other performance measures more closely reflect, to a greater or lesser degree, the physical operations which will ultimately be the source of the emissions.

References

Ambec, S, Cohen, M.A., Elgie, S. and Lanoie, P. 2013. 'The Porter hypothesis at 20: Can environmental regulation enhance innovation and competitiveness' *Review of Environmental Economics and Policy*, online, doi: 10.1093/reep/res016.

Anton, W.R.Q., Deltas, G. and Khanna, M. 2004. 'Incentives for environmental self-regulation and implications for environmental performance', *Journal of Environmental Economics and Management* 48(1): 632–654.

Arora, S. and Gangopadhyay, S. 1995. 'Towards a theoretical model of voluntary over compliance', *Journal of Economic Behavior and Organization*. 28(3): 289-309.

Baumol, W. and Oates. W. (1988). *Theory of Environmental Policy* (Second edition) Cambridge: Cambridge University Press.

Bertinelli, L.T., and Strobl, E. 2005. 'The Environmental Kuznets Curve semi-parametrically revisited", *Economics Letters* 88(3): 350–357.

Bloomberg L.P. 2013. Accounting/corporate data. Retrieved Mar. 1, 2013 from Bloomberg database.

Brunnermeier, S.B. and Cohen, M.A. 2003. "Determinants of environmental innovation in US manufacturing industries", *Journal of Environmental Economics and Management* 45(2): 278–29.

Carrión-Flores, C.E., and Innes, R. 2010. "Environmental innovation and environmental performance", *Journal of Environmental Economics and Management* 59(1): 27–42.

Chimeli, A.B. and Braden, J.B. 2005. 'Total factor productivity and the environmental Kuznets curve", *Journal of Environmental Economics and Management* 49(2): 366–380.

Cho, C.H, and Patten, D.M. 2007. "The role of environmental disclosures as tools of legitimacy: A research note". *Accounting, Organizations and Society*. 32(7–8): 639–647.

Coase, R.H. 1960. 'The problem of social cost', *Journal of Law and Economics* 3(1): 1-44.

Cole, M.A., Elliott, R.J.R. and Shimamoto, K. 2006. "Globalization, firm-level characteristics and environmental management: A study of Japan", *Ecological Economics* 59(3): 312-323.

Collins, A., and Harris, R.I.D. 2002. "Does plant ownership affect the level of pollution abatement expenditure?", *Land Economics* 78(2): 171-189.

Collins, A., and Harris, R.I.D. 2005. 'The impact of foreign ownership and efficiency on pollution abatement expenditure by chemical plants: Some UK evidence", *Scottish Journal of Political Economy* 52(5): 747-768.

Cox, A., Collins, A, Woods, L. And Ferguson N. 2012. "A household-level environmental Kuznets curve? Recent evidence on transport emissions and household income", *Economics Letters* 115(2): 187-189.

Dales, J.H. 1968. *Pollution, Property & Prices: An Essay in Policy-Making and Economics*. Toronto: University of Toronto Press.

Dasgupta, S., Laplante, B., Wang, H. and Wheeler, D. 2002. "Confronting the Environmental Kuznets Curve", *Journal of Economic Perspectives* 16(1): 147-168.

Davison, A.C., and Hinkley, D.V. 1997. *Bootstrap Methods and Their Application*, Cambridge, MA: Cambridge University Press.

Dinda, S. 2004 "Environmental Kuznets curve hypothesis: a survey", *Ecological Economics* 49(4): 431–455.

Dinda, S. 2005. "A theoretical basis for the environmental Kuznets curve", *Ecological Economics* 53(3): 403– 413.

Efron, B and Tibshirani, R.J. 1993. *Introduction to the Bootstrap*, Boca Raton Florida: Chapman& Hall/CRC

Fernández, E., Peréz, R. and Ruiz, J. 2012. 'The environmental Kuznets curve and equilibrium indeterminacy", *Journal of Economic Dynamics & Control* 36(11): 1700–1717.

Frondel, M., Horbach, J. and Rennings, K. 2008. "What triggers environmental management and innovation? Empirical evidence for Germany", *Ecological Economics* 66(1): 153-160.

Galeotti, M., Lanza, A. and Pauli, F. 2006. "Reassessing the environmental Kuznets curve for CO2 emissions: a robustness exercise", *Ecological Economics* 57(1): 152– 163.

Grant II, D.S., Bergesen, A.J. and Jones, A.W. 2002. "Organizational size and pollution: the case of the U.S. chemical industry", *American Sociological Review* 67(3): 389-407.

Hartman, R. and Kwon, O-S. 2005. "Sustainable growth and the environmental Kuznets curve", *Journal of Economic Dynamics & Control* 29(10): 1701–1736.

He, J. 2006. "Pollution haven hypothesis and environmental impacts of foreign direct investment: the case of industrial emission of sulfur dioxide (SO2) in Chinese provinces", *Ecological Economics* 60(1): 228-1736.

Horváthová, E. 2010. "Does environmental performance affect financial performance? A meta-analysis", *Ecological Economics* 70(1): 52–59.

Jaffe, A.B. and Palmer, K. 1997. "Environmental regulation and innovation: a panel data study", *Review of Economics and Statistics* 79(4): 610-619.

Johnston, R. and Pongatichat, P. 2008. "Managing the tension between performance measurement and strategy: coping strategies", *International Journal of Operations & Production Management* 28(10): 941-967.

Kahn, M.E. 1998. "A household level environmental Kuznets curve", *Economics Letters* 59(2): 269–273.

Kassinis, G. and Vafeas, N. 2006. "Stakeholder pressures and environmental performance", *Academy of Management Journal* 49(1): 145-159.

Kijima, M., Nishide, K. and Ohyama, A. 2010. "Economic models for the environmental Kuznets curve: a survey", *Journal of Economic Dynamics & Control* 34(7): 1187–1201.

Kim, E.H., and Lyon, T. 2011. “When does institutional investor activism increase shareholder value?: the carbon disclosure project”, *The BE Journal of Economic Analysis & Policy* 11online doi: 10.2202/1935-1682.2676

Konar, S. and Cohen, M.A. 2001. “Does the market value environmental performance?”, *Review of Economics and Statistics*, 83(2): 281-289.

Kraus A., Litzenberger R.H. 1973. “A State-preference model of optimal financial leverage”, *Journal of Finance* 28(4): 911-922.

Kula, E. 1998. *History of Environmental Economic Thought*, London: Routledge.

Lanoie, P., Laurent-Lucchetti, J., Johnstone, N. and Ambec, S. 2011. “Environmental policy, innovation and performance: New insights on the Porter hypothesis”, *Journal of Economics & Management Strategy* 20(3): 803-842.

Mahoney, L.S., Thorne, L., Cecil, L., LaGore, W. 2013. “A research note on standalone corporate social responsibility reports: Signaling or greenwashing?”, *Critical Perspectives on Accounting*, 24(4-5): 350-359.

Millimet, D.L., List, J.A. and Stengos, T. 2003. ‘The environmental Kuznets curve: real progress or misspecified models?”, *Review of Economics and Statistics* 85(4): 1038–1047.

Nahman, A. and Antrobus, G. (2005a). ‘The environmental Kuznets curve: a literature survey”, *South African Journal of Economics* 73(1): 105–120.

Nahman, A. and Antrobus, G. (2005b). “Trade and the environmental Kuznets curve: Is South Africa a pollution haven?”, *South African Journal of Economics* 73(4): 803-814.

Pearce, D. 2002. “An intellectual history of environmental economics”, *Annual Review of Energy and the Environment* 27: 57-81.

Perman, R. and Stern, D.I. 2003. “Evidence from panel unit root and cointegration tests that the environmental Kuznets curve does not exist”, *Australian Journal of Agricultural and Resource Economics* 47(3): 325–347.

Porter , M.E. 1991. “America’s green strategy”, *Scientific American*, 264: 168.

Porter, M.E,. and van der Linde, C. 1995. “Toward a new conception of the environment-competitiveness relationship”, *Journal of Economic Perspectives,* 9(4): 97-118.

Shadbegian, R.J. and Gray, W.B. 2005. “Pollution abatement expenditures and plant-level productivity: a production function approach”, *Ecological Economics* 54(2-3): 196–208.

Stern, D. 2004 “The rise and fall of the environmental Kuznets curve”, *World Development* 32(8): 1419–1439.

Turner, K. and Hanley, N. 2011. “Energy efficiency, rebound effects and the environmental Kuznets curve”, *Ecological Economics*, 33(5): 709-720.

Wagner, M. 2010, “The role of corporate sustainability performance for economic performance: a firm-level analysis of moderation effects”, *Ecological Economics* 69(7): 1553–1560.

Wagner, M., Van Phu, N., Wehrmeyer, W. and Azomahou, T. 2002. “The relationship between the environmental and economic performance of firms: an empirical analysis of the European paper industry”, *Corporate Social Responsibility and Environmental Management,* 9(3): 133–146.

Wen-Hsin Hsu, A., and Wang, T. 2013. “Does the market value corporate response to climate change?”, *Omega* 41(2): 195-206.

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