Financial Market Evaluation of Firms Greenhouse Gas Emissions

Submitted by Shan Hua to the University of Exeter as a thesis for the degree of
Doctor of Philosophy in Finance in February 2013

This thesis is available for Library use on the understanding that it is copyright
material and that no quotation from the thesis may be published without proper
acknowledgement.

I certify that all material in this thesis which is not my own work has been
identified and that no material has previously been submitted and approved for
the award of a degree by this or any other University.

Signature: Shan Hua
ABSTRACT

Climate change has been influenced more by human activities now than previously. These influences are largely attributed to industries, whose activities can potentially produce enormous amounts of carbon dioxide and other greenhouse gases, and exacerbate the speed of climate change.

This thesis examines how the financial markets evaluate corporations’ greenhouse gas emission performance. We consider various emission criteria, and distinguish between the better and worse performers in different emission policy regimes, including the US, the UK and the rest of the EU. The investigations have been conducted at three stages, presented in chapter 3, 4 and 5.

Firstly, in chapter 3 we examine the carbon effects at the portfolio-level, where total return indices are our main concern. By adopting the long-short strategy, we report that investors in the UK and EU markets, can make an arbitrage profit at the lower cut-off levels, when applying various carbon screening policies and forming equally-weighted portfolios. However, no such profit opportunities can be achieved in the US market. We further consider the reason for such arbitrage opportunities, which is the link between corporate governance/management efficiency and different levels of carbon constraint.

Secondly, in chapter 4, the carbon effects are investigated at firm-level, where firms’ financial market values act as the dependent variable. Our regression models are based on the Ohlson framework, which considers firms’ financial market value in relation to its accounting performance, and the ‘other information’, which in our case is the carbon emission performance. We find a significant relationship between the US firms’ values and their carbon emission performances; however, this relationship has been weakened for UK companies, and in fact becomes even unreliable for EU companies. Further, in order to explore the reason for this relationship, we have focused on energy efficiency and firms’ reputation that are associated with carbon reduction activities. The scale effects have also been discussed in this chapter, as the various deflators are adopted.

Finally, in chapter 5, again at firm-level, cash flow expectation and cost of capital have been considered to possibly be the source that drives firms’ value.
Cash flow expectation is measured at the short-, medium- and long- term, by profitability, earnings growth, and residual income growth rate, respectively. Two portfolios for each target parameters are constructed according to different carbon screening criteria at different cut-off levels, the differences between each pair of portfolios are then calculated and tested for significance. A sub-sample regression, which is based on the observations available from analysts’ earnings forecast, has been conducted for each of the three regimes. After matching the portfolio and regression results, we report that the implied cost of equity is only reduced for the less carbon emission firms, in regimes where more stringent carbon constraints are applied; whereas in regimes where less stringent carbon constraints exist, the less carbon emission firms have not gained any advantage through their implied cost of equity. Also, cash flow expectations indicate diverse outcomes for different time horizon and regimes.

Furthermore, various market participants, such as governments, investors, distributors and clients etc, who could possibly influence firms’ carbon behaviour, have also been considered in association with their roles in reducing greenhouse gas emissions. Our work contributes to the existing literature through a wide ranging examination of major financial evaluation methods relating to emerging carbon emission issues.

**Keyword:** Greenhouse gases (GHGs), Carbon emissions, Climate change, Firm valuations, Portfolio analysis, Cost of capital
ACKNOWLEDGEMENTS

It would not have been possible to write this doctoral thesis without the help and support of the kind people around me, to only some of whom it is possible to give particular mention here.

First of all, I wish to express my sincere thanks to my supervisors; foremost among them is Prof. Alan Gregory. I have benefited not only from his invaluable guidance, suggestions, comments and references, but also from his encouragement and trust. I wish to thank my supervisors Julie Whittaker and Rajesh Tharyan, whose advice has always been enlightening. I have appreciated enormously their enthusiasm directed towards this research. I want to place on record my gratitude also to Paul Cox for his help in the early stages of this work.

I am grateful to the Trucost Company, provider of the emission data, for untiring commitment to this research and whose staffs’ practical advice has always been invaluable throughout.

I would like to acknowledge the financial, academic and technical support of the School of Business, University of Exeter, from its staff, in providing me with all the necessary facilities over the last four years, to help ensure the completion of this work.

I owe a huge gratitude to my proofreaders Joseph Harvey and Dr Vivian Trewin, for their exceptional service in proofreading my manuscript and their constant encouragement.

I am indebted to my parents for their great understanding and kind consideration at a very challenging time in my career. Last but not least, I should not fail to express my immense thanks to all my friends for their ingenuity and unselfish contribution to this work and the continued motivation they have provided.
Contents
ABSTRACT ................................................................................................................................. 2
ACKNOWLEDGEMENTS ......................................................................................................... 4
Chapter 1 Theoretical Concepts ............................................................................................ 17
  1.1 Development of corporate social responsibility ............................................................. 17
  1.2 Measurement of corporate environmental performance and corporate carbon performance .......................................................................................................................... 18
  1.3 Structure .......................................................................................................................... 23
Chapter 2 Motivations .............................................................................................................. 24
  2.1 International Climate Change Policy ............................................................................. 24
  2.2 Governments’ Response ................................................................................................ 26
    2.2.1 EU Emission Trading Scheme (ETS) .................................................................. 26
    2.2.2 USEPA and Chicago Climate Exchange (CCX) ................................................ 27
    2.2.3 UK Climate Change Levy (CCL) .......................................................................... 29
  2.3 Influences on Corporations ............................................................................................ 31
    2.3.1 Abatement Costs .................................................................................................... 31
    2.3.2 Potential Benefits ................................................................................................. 33
  2.4 Stakeholder vs Shareholder ........................................................................................... 36
References ................................................................................................................................ 40
Chapter 3 Portfolio Based Financial Market Evaluation ..................................................... 48
  3.1 Introduction ..................................................................................................................... 48
  3.2 Evidence of SRI performance ...................................................................................... 52
    3.2.1 US SRI Performance .............................................................................................. 52
    3.2.2 EU excluding UK SRI Performance ..................................................................... 57
    3.2.3 UK SRI Performance .............................................................................................. 60
    3.2.4 Implication of Climate Changing Policy at Portfolio-Level ................................ 63
  3.3 General Methodology Review ...................................................................................... 65
    3.3.1 Jensen’s alphas, Sharpe ratio and Treynor ratio ..................................................... 65
    3.3.2 Capital Asset Pricing Model (CAPM) Framework .............................................. 68
    3.3.3 Fama-French Three Factors Model (FF3F) Framework ................................... 69
    3.3.4 Carhart Four Factors Model (CH4F) Framework ............................................... 69
  3.4 Data and Methodology Description ............................................................................. 71
    3.4.1 Methodology ............................................................................................................ 71
    3.4.2 Corporate Environmental Data ........................................................................... 75
    3.4.3 Corporate Financial Data ...................................................................................... 77
    3.4.4 Diversification and screening policy .................................................................. 78
List of Figures

Figure 2-1 Relationship between each party reacting to climate changing policy ........ 25
Figure 2-2 schematic presentation of this neoclassical view of the firm in society .... 37
Figure 2-3 schematic presentation of this socio-economic view of the firm in society .. 37

List of Chapter 3 Tables

Table 3-1-1 Summary Number of Companies for Each Market ......................... 109
Table 3-1-2 Summary Correlation between Environment/Carbon Information, US .... 109
Table 3-1-3 Summary Correlation between Environment/Carbon Information, UK ..... 109
Table 3-1-4 Summary Correlation between Environment/Carbon Information, EU ..... 110

Table 3-2-1 Summary Environment/Carbon Information, US .......................... 110
Table 3-2-2 Summary Environment/Carbon Information, UK .......................... 111
Table 3-2-3 Summary Environment/Carbon Information, EU .......................... 111

Table 3-3-1 Portfolio Return Regressions on US IP, 10% cut-off ........................ 112
Table 3-3-2 Portfolio Return Regressions on US IP, 20% cut-off ........................ 114
Table 3-3-3 Portfolio Return Regressions on US IP, 30% cut-off ........................ 116
Table 3-3-4 Portfolio Return Regressions on US IP, 50% cut-off ........................ 118
Table 3-3-5 Portfolio Return Regressions on US FF, 10% cut-off ...................... 120
Table 3-3-6 Portfolio Return Regressions on US FF, 20% cut-off ...................... 122
Table 3-3-7 Portfolio Return Regressions on US FF, 30% cut-off ...................... 124
Table 3-3-8 Portfolio Return Regressions on US FF, 50% cut-off ...................... 126
Table 3-3-9 Portfolio Return Regressions on US DF, 10% cut-off ...................... 128
Table 3-3-10 Portfolio Return Regressions on US DF, 20% cut-off .................... 130
Table 3-3-11 Portfolio Return Regressions on US DF, 30% cut-off .................... 132
Table 3-3-12 Portfolio Return Regressions on US DF, 50% cut-off .................... 134
Table 3-3-13 Portfolio Return Regressions on US CF, 10% cut-off .................... 136
Table 3-3-14 Portfolio Return Regressions on US CF, 20% cut-off .................... 138
Table 3-3-15 Portfolio Return Regressions on US CF, 30% cut-off .................... 140
Table 3-3-16 Portfolio Return Regressions on US CF, 50% cut-off .................... 142
Table 3-4-1 Portfolio Return Regressions on UK IP, 10% cut-off .......................... 145
Table 3-4-2 Portfolio Return Regressions on UK IP, 20% cut-off ......................... 147
Table 3-4-3 Portfolio Return Regressions on UK IP, 30% cut-off ......................... 149
Table 3-4-4 Portfolio Return Regressions on UK IP, 50% cut-off ......................... 151
Table 3-4-5 Portfolio Return Regressions on UK FF, 10% cut-off ......................... 153
Table 3-4-6 Portfolio Return Regressions on UK FF, 20% cut-off ......................... 155
Table 3-4-7 Portfolio Return Regressions on UK FF, 30% cut-off ......................... 157
Table 3-4-8 Portfolio Return Regressions on UK FF, 50% cut-off ......................... 159
Table 3-4-9 Portfolio Return Regressions on UK DF, 10% cut-off ......................... 161
Table 3-4-10 Portfolio Return Regressions on UK DF, 20% cut-off ....................... 163
Table 3-4-11 Portfolio Return Regressions on UK DF, 30% cut-off ....................... 165
Table 3-4-12 Portfolio Return Regressions on UK DF, 50% cut-off ....................... 167
Table 3-4-13 Portfolio Return Regressions on UK CF, 10% cut-off ....................... 169
Table 3-4-14 Portfolio Return Regressions on UK CF, 20% cut-off ....................... 171
Table 3-4-15 Portfolio Return Regressions on UK CF, 30% cut-off ....................... 173
Table 3-4-16 Portfolio Return Regressions on UK CF, 50% cut-off ....................... 175

Table 3-5-1 Portfolio Return Regressions on EX IP, 10% cut-off ......................... 177
Table 3-5-2 Portfolio Return Regressions on EX IP, 20% cut-off ......................... 179
Table 3-5-3 Portfolio Return Regressions on EX IP, 30% cut-off ......................... 181
Table 3-5-4 Portfolio Return Regressions on EX IP, 50% cut-off ......................... 183
Table 3-5-5 Portfolio Return Regressions on EX FF, 10% cut-off ......................... 185
Table 3-5-6 Portfolio Return Regressions on EX FF, 20% cut-off ......................... 187
Table 3-5-7 Portfolio Return Regressions on EX FF, 30% cut-off ......................... 189
Table 3-5-8 Portfolio Return Regressions on EX FF, 50% cut-off ......................... 191
Table 3-5-9 Portfolio Return Regressions on EX DF, 10% cut-off ......................... 193
Table 3-5-10 Portfolio Return Regressions on EX DF, 20% cut-off ....................... 195
Table 3-5-11 Portfolio Return Regressions on EX DF, 30% cut-off ....................... 197
Table 3-5-12 Portfolio Return Regressions on EX DF, 50% cut-off ....................... 199
Table 3-5-13 Portfolio Return Regressions on EX CF, 10% cut-off ....................... 201
Table 3-5-14 Portfolio Return Regressions on EX CF, 20% cut-off ....................... 203
Table 3-5-15 Portfolio Return Regressions on EX CF, 30% cut-off ....................... 205
Table 3-5-16 Portfolio Return Regressions on EX CF, 50% cut-off ....................... 207
List of Chapter 4 Tables

Table 4-1-1 Summary Environment and Carbon Performance for Each US Industry. 281
Table 4-1-2 Summary Financial Statistics for the US ............................................................... 282
Table 4-1-3 Correlation between each two share-number-deflated variables for the US ................................................................................................................................................... 283
Table 4-1-4 Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the US ........................................................................................................................................ 284
Table 4-1-5 Regression of Share Price on Environment/Carbon and Financial Variables from Barth et al. (1998) Model for the US ........................................................................................................................................ 285
Table 4-1-6 Regression of Share Price on Environment/Carbon and Financial Variables from Collins et al. (1999) Model for the US ........................................................................................................................................ 286
Table 4-1-7 Regression of Share Price on Environment/Carbon and Financial Variables from Rees (1997) Model for the US ........................................................................................................................................ 287
Table 4-1-8 Regression of Share Price on Environment/Carbon and Financial Variables from Hands & Landsman (2005) for the US ........................................................................................................................................ 289
Table 4-1-9 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 1 for the US ........................................................................................................................................ 291
Table 4-1-10 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 2 for the US ........................................................................................................................................ 292
Table 4-1-11 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 3 for the US ........................................................................................................................................ 293
Table 4-1-12 Correlation between each two sales-deflated variables for the US .............. 295
Table 4-1-13 Regression of Share Price on Environment/Carbon and Financial Variables, Composite Model with sales deflated for US ........................................................................................................................................ 296
Table 4-1-14 Regression of Share Price on Environment/Carbon and Financial Variables from H & L (2005) for Profit Firms for the US ........................................................................................................................................ 298
Table 4-1-15 Regression of Share Price on Environment/Carbon and Financial Variables from H & L (2005) for Loss Firms for the US ........................................................................................................................................ 300
Table 4-1-16 Regression of share price from composite model for Profit Firms for the US ........................................................................................................................................ 302
Table 4-1-17 Regression of share price from composite model for Loss Firms for the US ........................................................................................................................................ 304
Table 4-3-1 Summary Environment and Carbon Performance for Each EU exclude UK (EX) Industry ....................................................................................................................................... 336
Table 4-3-2 Summary Financial Statistics for the EX .......................................................................................................................... 338
Table 4-3-3 Correlation between each two share-number-deflated variables for the EX ................................................................................................................................................... 339
Table 4-3-4 Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the EX .......................................................................................................................... 340
Table 4-3-5 Regression of Share Price on Environment/Carbon and Financial Variables from Barth et al. (1998) Model for the EX ....................................................................................................................................... 342
Table 4-3-6 Regression of Share Price on Environment/Carbon and Financial Variables from Collins et al. (1999) Model for the EX ....................................................................................................................................... 343
Table 4-3-7 Regression of Share Price on Environment/Carbon and Financial Variables from Rees (1997) Model for the EX ....................................................................................................................................... 344
Table 4-3-8 Regression of Share Price on Environment/Carbon and Financial Variables from Hands & Landsman (2005) for the EX ....................................................................................................................................... 345
Table 4-3-9 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 1 for the EX ....................................................................................................................................... 348
Table 4-3-10 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 2 for the EX ....................................................................................................................................... 349
Table 4-3-11 Correlation between each two sales-deflated variables for the EX .......................................................................................................................... 351
Table 4-3-12 Regression of Share Price on Environment/Carbon and Financial Variables, Composite Model with sales deflated for the EX ....................................................................................................................................... 352
Table 4-3-13 Regression of Share Price on Environment/Carbon and Financial Variables from H & L (2005) for Profit Firms for the EX ....................................................................................................................................... 354
Table 4-3-14 Regression of Share Price on Environment/Carbon and Financial Variables from H & L (2005) for Loss Firms for the EX ....................................................................................................................................... 356
Table 4-3-15 Regression of share price from composite model for Profit Firms for the EX ....................................................................................................................................... 358
Table 4-3-16 Regression of share price from composite model for Loss Firms for the EX ....................................................................................................................................... 360
Table 4-3-17 Regression of Share Price (pre-ETS period) on Environment/Carbon and Financial Variables, Composite Model 1 for EX ....................................................................................................................................... 362
Table 4-3-18 Regression of Share Price (ETS phase I) on Environment/Carbon and Financial Variables, Composite Model 1 for the EX ....................................................................................................................................... 363
Table 4-3-19 Regression of Share Price (ETS phase II, 2008) on Environment/Carbon and Financial Variables, Composite Model1 for EX.......................................................... 364

Table 4-4-1 Summary Environment and Carbon Performance for Each EU include UK (EA) Industry ........................................................................................................................... 366
Table 4-4-2 Summary Financial Statistics for the EA .............................................................. 368
Table 4-4-3 Correlation between each two share-number-deflated variables for the EA ........................................................................................................................................... 369
Table 4-4-4 Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the EA ................................................................. 370
Table 4-4-5 Regression of Share Price on Environment/Carbon and Financial Variables from Barth et al. (1998) Model for the EA ........................................................................ 372
Table 4-4-6 Regression of Share Price on Environment/Carbon and Financial Variables from Collins et al. (1999) Model for the EA ................................................................. 373
Table 4-4-7 Regression of Share Price on Environment/Carbon and Financial Variables from Rees (1997) Model for the EA ........................................................................................................ 374
Table 4-4-8 Regression of Share Price on Environment/Carbon and Financial Variables from Hands & Landsman (2005) for the EA ........................................................................ 376
Table 4-4-9 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 1 for the EA ................................................................. 378
Table 4-4-10 Regression of Share Price on Environment/Carbon and Financial Variables from Composite Model 2 for the EA .................................................................................... 379
Table 4-4-11 Correlation between each two sales-deflated variables for the EA ........ 381
Table 4-4-12 Regression of Share Price on Environment/Carbon and Financial Variables, Composite Model with sales deflated for EA ................................................................. 382
Table 4-4-13 Regression of Share Price on Environment/Carbon and Financial Variables from H&L (2005) for Profit Firms for the EA ................................................................. 384
Table 4-4-14 Regression of Share Price on Environment/Carbon and Financial Variables from H & L (2005) for Loss Firms for the EA ................................................................. 386
Table 4-4-15 Regression of share price from composite model for Profit Firms for the EA ................................................................................................................................. 388
Table 4-4-16 Regression of share price from composite model for Loss Firms for the EA ................................................................................................................................. 390
List of Chapter 5 Tables

Table 5-1-1 Estimation of Implied Cost of Capital for the US ........................................ 438
Table 5-1-2 Estimation of Implied Growth Rate for the US I ........................................ 439
Table 5-1-3 Estimation of Implied Growth Rate for the US II ...................................... 440
Table 5-1-4 Estimation of Implied Growth Rate for the US III .................................... 441
Table 5-1-5 Analysts' Medium Term (Yr3-5) Earnings Growth Estimates for the US .... 442
Table 5-1-6 Analysts' Short Term Return on Equity Forecasts for the US I .................. 443
Table 5-1-7 Analysts' Short Term Return on Equity Forecasts for the US II ................. 444
Table 5-1-8 Subsample Financial Statistics Summary for the US ................................. 445
Table 5-1-9 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the US ........................................ 446
Table 5-1-10 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from H&L (2005) for the US ................................................. 448
Table 5-1-11 Subsample Regression of Price on Environment/Carbon and Financial Variables, Ohlson Model with sales deflated for US .................................... 450
Table 5-1-12 Subsample Regression of Share Price on Environment/Carbon and Financial Variables, HL Model with sales deflated, US ........................................ 452

Table 5-2-1 Estimation of Implied Cost of Capital for the UK ........................................ 454
Table 5-2-2 Estimation of Implied Growth Rate for the UK I ...................................... 455
Table 5-2-3 Estimation of Implied Growth Rate for the UK II .................................... 456
Table 5-2-4 Estimation of Implied Growth Rate for the UK III .................................. 457
Table 5-2-5 Analysts' Medium Term (Yr3-5) Earnings Growth Estimates for the UK .. 458
Table 5-2-6 Analysts' Short Term Return on Equity Forecasts for the UK I ............... 459
Table 5-2-7 Analysts' Short Term Return on Equity Forecasts for the UK II .............. 460
Table 5-2-8 Subsample Financial Statistics Summary for the UK ............................... 461
Table 5-2-9 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the UK ........................................ 462
Table 5-2-10 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from H&L (2005) for the UK ............................................. 464
Table 5-2-11 Subsample Regression of Price on Environment/Carbon and Financial Variables, Ohlson Model with sales deflated, UK .................................... 466
Table 5-2-12 Subsample Regression of Share Price on Environment/Carbon and Financial Variables, HL Model with sales deflated, UK ........................................ 468
Table 5-3-1 Estimation of Implied Cost of Capital for the EX .............................................. 470
Table 5-3-2 Estimation of Implied Growth Rate for the EX I ............................................ 471
Table 5-3-3 Estimation of Implied Growth Rate for the EX II ......................................... 472
Table 5-3-4 Estimation of Implied Growth Rate for the EX III ........................................ 473
Table 5-3-5 Analysts’ Medium Term (Yr3-5) Earnings Growth Estimates for the EX .. 474
Table 5-3-6 Analysts’ Short Term Return on Equity Forecasts for the EX I ................. 475
Table 5-3-7 Analysts’ Short Term Return on Equity Forecasts for the EX II ............... 476
Table 5-3-8 Subsample Financial Statistics Summary for the EX ................................. 477
Table 5-3-9 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from Ohlson (1995) Model for the EX ........................................ 478
Table 5-3-10 Subsample Regression of Share Price on Environment/Carbon and Financial Variables from H&L (2005) for the EX ......................................................... 480
Table 5-3-11 Subsample Regression of Price on Environment/Carbon and Financial Variables, Ohlson Model with sales deflated, EX ........................................... 482
Table 5-3-12 Subsample Regression of Share Price on Environment/Carbon and Financial Variables, HL Model with sales deflated, EX ......................................... 484